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My interests lie primarily with the energy behind the design of products. In pursuing the question of that energy and its potential, it has become clear to me that prior to any claims regarding transferability it is vital to first document and analyze the components that comprise the whole of design energy. Design Energy, in this case, is the creativity and intellect behind the process of design, from idea generation to production. I have focused on the creation of a method for documenting the design process that incorporates scans and images and other process data by utilizing AutoCAD, 3DMax, Photoshop, Morpheus, and various animation creating software. Through this method I re-visited my generative process in three phases; one by searching and selecting snapshots of my creative work, two by manipulating these found images using morphing software, and three by comparing and mimicking aspects of other design processes as explained by Nigel Cross. By looking back at my process I was able to reevaluate my steps through comparing them to other processes and through my analysis method of using morphing software which led to new idea generation.

SEARCHING FOR DESIGN ENERGY: RE-VISITING MY GENERATIVE PROCESS

USING SELECTION, EVALUATION, AND MORPHING

TO GENERATE NEW IDEAS

by

Brandon King Jones

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Committee Chair

APPROVAL PAGE

This thesis has been approved by the following committee of the Faculty of the Graduate School at The University of North Carolina at Greensboro.

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CHAPTER I

INTRODUCTION

My interests lie primarily with the energy behind the design of products. In pursuing the question of that energy and its potential, it has become clear to me that prior to any claims regarding transferability it is vital to first document and analyze the components that comprise the whole of design energy. So in my further study the design energy, a self-made title, became a descriptor to encompass the creativity and intellect behind the process of design, from recognition of problem to idea generation to production. I have focused on the creation of a method for documenting the design process that incorporates process data by utilizing *AutoCAD*, *3ds Max*, *Photoshop*, *Morpheus*, and various other programs for creating animations. This has given me a way to analyze the design method and, more importantly, a way to repeat it by putting snapshots of the creation process into a morphing animation, creating “in between” data to inspire new design or to improve existing design. Idea generation is the first step in the design process and is a big part of design energy. Can idea generation be simulated like light, wind, and other environmental factors by using computers and software?

The recognition of my first design studio problem came when I looked at the car’s shape and style in search of aesthetics, ergonomics, culture, anthropomorphics, comfort, and scale, I got early inspiration for how to capture design energy, which led me to early idea generation. By mimicking Lewin’s steps in auto design, comparing and manipulating the steps according to Cross's research, I was starting to show ways in which design energy could reinterpreted and reused to design and help develop the design process.

In combining the use of different computer software to create a template for myself, a model that would assist in reimagining and enhancing their previous design methods, I created a way to compare these steps to other progressions. This came from my documentation of the design process that occurred during my studio projects, wherein I explored the relationships between my processes learning from and evolving from the design steps I had taken.

The analysis of the generative process and the morphing of snap shots of progress led to the creation of ideas. The idea generation comes from the action of selecting and evaluating the appropriate snapshots and from the creation and study of tween images. The relooking of the images of the process, then isolating the ones that best self-describe my chronological steps, created new ideas to change or improve parts of the process. When the method I created is reuse I could choose to include more snapshots, create more tweens, and extend the animation length, it all depends on the design or designer and how much and what type of information to give to software.

The design process is where the rethinking and redirecting of design energy should start and be concentrated in order for me to understand the components that comprise design energy. Design energy, being the innovation, creativity, intellect, idea generation, and or the process/production, has and can be recycled, reused, reinterpreted, refabricated, or rematerialized for the use in making and designing new furniture. These components are transferred through putting snapshots into the method developed from documenting, analyzing, and showing the design process. In the end I was able to create a method that gives me or maybe another designer a method to recreate and capture the evolution of the design process.

CHAPTER II

REVIEW OF LITERATURE

Design Process

Process Models

To analyze the design process in an attempt to rework the final output can be and maybe should be about redefining the actual process itself. What role does improvisation play in the design process? Gerber explores the connections between design and improvisation, questioning how design directly benefits from improvisation. She argues that improvisation can build on creative collaboration and can foster innovation and support spontaneity both through presenting ideas and error correction (Gerber, 2007, p. 1069). The value of improvisation is in the potential it holds to unleash creative action for individual designers and design teams.

> Improvisation teaches designers to fail cheerfully, easing the disappointment of failing, saving more attention for learning from failures, and readying designers to move on with confidence and energy. Improvisation also encourages spontaneity and breaks familiar patterns of thought and behavior. Improvisation teaches that creativity comes, paradoxically, not from trying harder to be clever and unique, but by "being obvious" with a fellow designer
> (Dumitrescu & Vergeest, 2004, p. 1072).

In the early phases of design development, during idea generation and sketching, does the designer not jump from one inspiration to the other, and does he or she switch from pencil to pen or change paper or jump to the computer? “Improvisers suggest that being obvious may actually support innovation, [which] devotes less effort to being unique, [leading to someone observing] what is needed based on the real-world context, [and] one’s perception of what is obvious appears original to others” (Gerber, 2007, p. 1070).

In the beginning of designing it is improvising, but towards the end, during prototype making, when designers question material, color, scale, or plain aesthetics, is the process not also partially to improvisation? Improvisation similar to design work appears to be a social activity and the improvisers tend to work in tandem with fellow designers. These designers work hand and hand as well with the researcher, marketer, salesperson, and engineer. A process can be more structured and still maintain dependence on improvisation; the amount depends on the practicing professional. Apparently both the design and improvisation rely heavily on interdependent practices as well as structures (Gerber, 2007, p. 1070).

Is there energy behind design or the process of design? Can this energy be reused or reinterpreted to design furniture? Is this energy transferable from product to product? “Innovations can evolve from within a process or be transferred from other processes through assimilation, mimicry, or wholesale revolution. We demand transfer” (Kieran & Timberlake, 2004, p. 173). Inspiration and improvisation are connected, whether indirectly or directly, they are mingled throughout the process of design. Dick Hebdige describes inspiration and improvisation and their connection further:

> Improvisation in its sublime modalities takes us to the luscious, thither scary side of communicable sense, where coded utterance gives way to pure sound inspir-(uh)-ation. Every work of art involves a frame… A frame of some kind is precisely what distinguishes a painting, a poem, a musical composition, a play, a dance, or a piece of sculpture from the rest of the world (Hebdige, Winter, pp. 338-339).

Computers are programmed to effectively decipher "what if" scenarios; examples of this have been done with forecasting software, such as structural longevity performance software for buildings (Gibson, 2007, p. 42). In an attempt to create a method to stimulate idea generation, Gibson developed and studied a procedure involving individuals and teams, who experience recursive and linear exploration, as well as manual and digital processes, while trying to generate ideas:

> Results from this case study found that: 1) digital creation was more linear when evaluated against traditional ideation output, 2) cyber-ideation had a positive impact on team dynamics, and 3) automated output possessed greater surface delineation when compared with subjects' manual sketching (Gibson, 2007, p. 41)

Gibson's research just morphed two objects and was limited to time constraints and lack of programming experience, so she really just starts to scratch the surface of reproducing idea generation (Gibson, 2007, p. 46).This is a good reason to use the computer and software such as Morpheus to help in the reuse and/or analysis of the "what if" happenings like inspiration and improvisation of idea generation.

> If virtual habitats formulate a meaningful testing ground for biological and evolutionary knowledge, can similar methods be useful to designers in their progressive search for new form and design solutions? Can computers extend the creative power of designers beyond traditional methods of thought and discovery (Gibson, 2007, p. 42)?

"In order to cope with the uncertainty of ill-defined problems, the designer has to have the self-confidence to define, redefine and change the problem as given, in the light of solutions that emerge in the very process of designing"(Cross, 1989, p. 17). Cross separates the design process into three model types: "descriptive, prescriptive, and systematic" (Cross, 1989, pp. 19-22-31). The descriptive model is "focused on early solution generation" and according to French can be put into four main stages consisting of, analysis of problem, conceptual design, embodiment of schemes, and detailing which are tied together by need, statement of problem, selected themes, and working drawings (Cross, 1989, pp. 19,20). (see Figure 1)

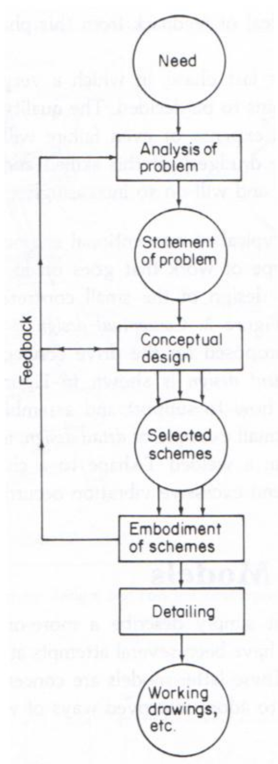


Figure 1. French's descriptive model

The prescriptive model "has been criticized in the design world because it seems to be based on a problem-focused rather than a solution-focused approach"(Cross, 1989, p. 28). Design is about creativity not problem-solving because creativity is making something you wish would come to be while problem solving is making something you do not like go away. Archer describes a prescriptive model to have six phases of activity which are:

1. *Programming.* Establish crucial issues; propose a course of action .
2. *Data collection.* Collect, classify and store data.
3. *Analysis.* Identify sub-problems; prepare performance (or design) specifications; reappraise proposed programme and estimate.

4. *Synthesis.* Prepare outline design proposals.
5. *Development.* Develop prototype design(s); prepare and execute validation.
6. *Communication.* Prepare manufacturing documentation (Cross, 1989, p. 24).
(see Figure 2)

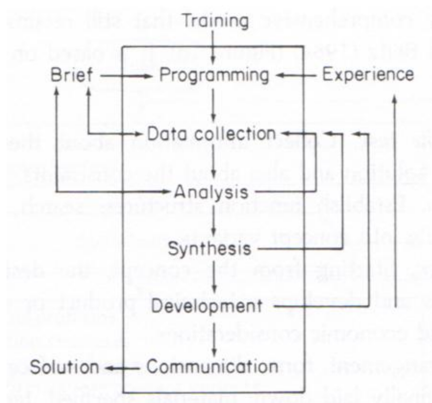


Figure 2. Archer's prescriptive model

March created a process model based on his study of the philosopher C.S. Peirce, which includes three main phases: induction, production, and deduction (Cross, 1989, pp. 29,30). (see Figure 3)

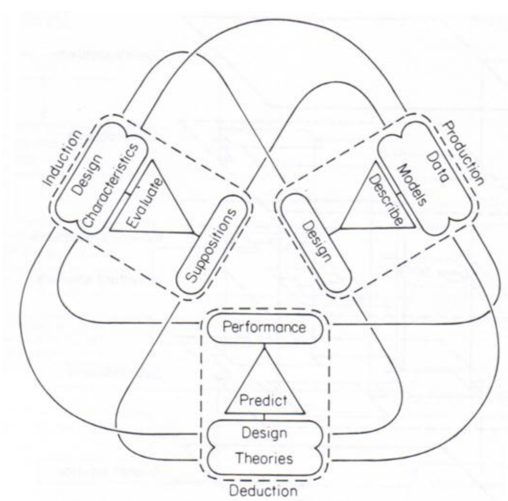


Figure 3. March's process model derived from C.S. Peirce's research

A systematic procedure can be achieved with team design, “dividing the overall problem into sub-problems, [which] means that the design work itself can be subdivided and allocated to appropriate team members” (Cross, 1989, p. 31). Fiksel developed a more systematic process of design called Design For Environment (DFE). DFE rules can be summed up into four categories: design for dematerialization, detoxification, revalorization, and capital protection and renewal. Implementing these steps leads the development of new tools and the promotion of needed partnerships with governments, industries, and the private sector (Fiksel, 2009, pp. 371-373). The main aspects are as follows:

- The focus is on how environmental excellence creates business value, although we touch on other aspects of sustainability, such as human capital and stakeholder engagement.
- The focus is mainly on *United States* institutions and enterprises, although we describe broader international developments that have influence U.S. practices.
- The focus is on the design engineering, although we discuss the roles of other functions, including R&D, marketing, logistics, communications, and information technology.
- The focus is on the design of products and associated processes, although we mention the major strides that have occurred cuss the roles of other functions, including R&D, marketing, logistics, communications, and information technology(Cross, 1989, p. xvi).

The ultimate purpose of DFE is to protect the capacity for humans and others organisms to flourish on earth (Cross, 1989, p. xvi).

Post Production

Post production as far as Fiskel's DFE, show discussions about how these design processes can be typed two ways, one which is focused on internal coherence and process, and the second which is focused on external implication and relational processes (Fiksel, 2009, pp. 371-373). Whether concerning the car or the chair, the lack to include post launch into the overall design process is connected to the wasting of not only material but design itself.

The processes discussed earlier do speak directly of what happens after the product's launch. The process of design and making, from low tech to high tech, involves steps or phases that ultimately lead to a market commodity. This commodity could last longer than three years or be reused if it was pre-planned to involve post production as part of the early phase of the design process. "To design an object involves problem-solving and creativity, but to produce that object, no matter how innovative, involves a routine or pre-planned process" (Hudson, 2008, p. 7) To study the process, to make it better, can lead to a way not only of better remaking a product but to a way of reusing, reinterpreting, and refabricating it. "Designing redirectively does not commence with the mobilization of a 'design process' – but from the position of the redirective limitations and capabilities of the designing subject" (Fry, 2009, p. 224). This idea of redirecting away from the limitations of the designer has opened my mind to make connections between the physical environment, whether inside the car or on a chair, and the human shape. These links can and have led me to the reinterpreting and reuse of design energy in other ways. Harnessing energy from designed products isn't simply about recycling; it also entails reusing the actual processes that went into the initial conception of the product, so that nothing—not even designer ingenuity—is wasted.

The significance of reinterpreting and reusing the design energy behind an existing product is that it gives us a chance to tap into a new renewable resource: the piles and piles of stuff no longer being used for their original design purpose. One industry that has invested a hundred-plus years of design energy by developing a great product is the automobile industry. The demand to increase sales and or buy new, directly relates to the lack of post launch consideration as but of the process of design. This industry produces millions of cars whose lifetimes come to an end faster and faster, adding to the long list of items being trashed—all to be able to sell the next best model. Areas in which the U.S. automotive industry should improve their recycling efforts are: better ways to reuse, easier ways to recover parts, enhanced use of plastics, and increased reusability of plastics (Graedel & Allenby, 1998, p. 159). When the Model T first rolled off the assembly line utilized a universal platform design that Henry Ford invented and to this day this platform still directly shapes modern car design. Mercedes –Benz has developed a more up to date reuse concept in which chassis can be swapped out in less than an hour only for multiple styles to be made in one location, but also increasing chances for post production reuse since multiple chassis use the same platform.

Alizon points to the genius of the one platform fitting up to multiple upper bodies, allowing extremely different models and styles to satisfy different customers, at the same time quickly producing one base for all. Not only has the Model T platform evolved into General Motors' current "skateboard" platform, but Alizon suggests that the universal setup can and should be adopted into other industries (Fabrice Alizon, Shooter, & Simpson, 2009, pp. 588-605). Providing a typical base for a line of similar furniture, or a family of furniture products, could ease waste, increase production speed, and possibly answers life cycle issues. The design process includes production and traditionally stops at upon products completion, but if the whole design cycle included the post production then reuse and or refabrication whould become easier to implement.

The automobile industry designs and produces a product that we all have seen, ridden in, or driven. This industry has interests in designing and making more efficiently. Automobiles should lead a second life in the form of furniture. "The study of automobiles from an industrial ecology perspective brings still another topic into the discussion: the infrastructure that support them," and "Inevitably, the decisions of automotive design engineers influence not only the automobile but its infrastructure as well" (Graedel & Allenby, 1998, p. 5). Automobile manufacturers are currently making efforts to be more environmentally sound and sustainable. General Motors is currently producing the all-electric Chevrolet Volt, reusing manufacturing waste by-products, and Volkswagen uses a new water-based automotive paint, which was developed by DuPont, in its new vehicles (Fiksel, 2009, pp. 370-371). J Mays, vice president of design at Ford Motor Company, says "Design is just the way of improving peoples' quality of life," and Shiro Nakamura, senior vice president in the design division of Nissan Motor Company, says "Design is the expression of passion and imagination by the creator in a visible way.

Henrik Fisker, design director, at Aston Martin, says “design is essentially the process of making function visually attractive” (Lewin, 2003, pp. 19,21,29). The designers talk about quality of life, attractive function, and passion and imagination, which I believe are all important parts of design energy. Plugging these design descriptors into any one of the steps in Lewin’s process would make sense. If you can recycle design energy, you can recycle quality and aesthetics—but can you recycle passion or imagination? You could use snapshots of a designer process all the way through the manufacturing of a product, then repeat the process to create your own product, in essence capturing the energy behind the previous product.

The user of a product can be part of the design process and in the end be part of the reuse of the product’s energy. Why does human behavior while using any product matter if the attention on the use of the product will not last? If the attention is carried over to other products, then the human behavior and its relationship to the product do matter. Design energy is the whole process from beginning to end, from product launch to use, to discarding it, to maybe reinterpreting it. I have tried to focus on the process of design and making, which is where the creative thinking starts. Creative thinking is a mix of lateral and vertical thinking, each sharing with each other, which differs from the standard approach from previous research which suggests that the curriculum directly responds to each: creativity, logical thinking, and critical thinking individually (Barak & Doppelt, 2000, p. 16). Creative thinking is essentially a large part of the energy behind design, and Moshe Barak and Yaron Doppelt suggest that analyzing a design student’s portfolio gives the student and potential new designers a way to reuse, this essential part, enhancing the thinking itself.

Lewin's information is based on what is being done now to design the car and does not explain which parts of the process, if any, speak to what happens after the product is launched and what happens after said product is traded in three years later. Nigel Cross studies multiple design methods, which show the nature of design by comparing different models, and even after giving advantages and disadvantages, suggests a better, more flexible approach to creating a well-designed product—but he does not offer or show how energy from one product could or should transfer to the design of another.

Process Documentation

Keeping a portfolio is away to document process, although it is usually a collection of the best examples of work, it is also a keeping a record chronologically. A student's portfolio is a presentation of the process: a record of learning showing what one thinks, questions, analyzes, synthesizes, produces, creates, and how one interacts intellectually, emotionally, and socially; a progress in their development (Barak & Doppelt, 2000, p. 17). "This metacognition or "thinking about thinking" enhances what they learn since learners are often not aware of their internal thinking processes… this allows the student to learn to direct their own thinking, and subsequently plan their learning processes" (Barak & Doppelt, 2000, p. 17). Similarly to Barak and Doppelt, I was able to look back at my process to enhance creative thinking. My method was to analyze these steps by morphing them through animation. The lineup of output (sketches, 3D models, photos) from my process, after being morphed, was created between frames (tweens) that were studied and used to inspire new design. Differently from the portfolio containing top picks, I chose data throughout the development of the design. Limiting the snapshots to just top picks would be to limiting. Longhitano and Testa researched how innovation can be created through collaboration with the use of advanced CAD systems combined with software simulators tools such as ICT (Information and Communication Technology), which create a virtual meeting place where designers and workers can engage. They found that collaboration is rarely deliberate but instead an incidental outcome of formal and informal changes, "systems, practices, design, learning and culture," such as serving new markets, enriching relationships, and constantly innovating process enhancement, thereby increasing the speed of new product launches (Longhitano & Testa, 2006, pp. 229,249). Collaboration to create innovation is part of what reinterpreting design energy is about.

Similar techniques are currently being explored, whether it is by industrial design students at Politecnico of Milan, by Weber, whose xylem project investigates the possibilities of digital fabrications controlled by potential customers (Weber, 2009)**,** or by Sinclair, a product designer from Finland, who studied feedback from participants going from sketching to modifying CAD models, trying to improve design through the process of modification (Sinclair, 2009). Shih-Wen Hsiao proposed shape morphing and image prediction method for product design using feature-based method to make 3-D CAD, then new ideations are made through shape and image morphing which is later analyzed using a modified gray theory (Hsiao & Liu, 2002, p. 533). Hsiao describes his attempt to use computer 3D model morphing as a method to generate design ideas as the following ten steps:

> (1) Decide the objective product to be designed. Morphing method for shape generation and image prediction 535
> (2) Collect the existing products in the market.
> (3) Analyze the product features based on the existing products.
> (4) Construct 3-D configuration models for the test samples based on the analyzed product features.
> (5) Select the adequate image words using questionnaires, and identify the images that consumers project onto the product by means of the semantic differential method.
> (6) Construct the morphing rules for shape design.
> (7) Build a database for the relationships between the morphed shapes and the image words.
> (8) Construct an image prediction formula using modified gray theory with Fourier residual correction based on the above-obtained data.
> (9) Construct a consultative program and the human–computer interaction interfaces for the CAD system for morphing a new shape and predicting its image.
> (10) Generate a product shape with a corresponding image from two different entries. (Hsiao & Liu, 2002, pp. 534-535).

Designers who preach a pure engineering method as the only sufficient and necessary means of producing environmental devices end ascribing iconic power to the creations of technology (Colquhoun, 1969, p. 72). Eliminating the human factor from the idea generation phase seems unlikely even if the computer prediction future form design since somewhere along the way a human population, focus group maybe, has to make decision that would or could change the final design.

Process Energy

Transferring design energy is transferring innovation. These are the essential questions that I explored, which led to me documenting and analyzing the components that comprise the whole of design energy.

> To understand design in its full complexity actually requires recognizing an intelligence, which is neither constituted within the modes of cognition of the sciences nor the liberal arts, this notwithstanding the efforts of design science or cultural theory… it is an exploration of how things come into being and act beyond their mere function as material or immaterial objects (Fry, 2009, pp. 11,12)

Can artists design architecture, or can building design directly influence the design of the art to be displayed inside? Robert Guillot, Vito Acconci, Siah Armajani, Niki Logis and Christopher Sproat are all artists interviewed by *Perspecta* to get their opinions on the influences, if any, of architecture on their work. The question is more about if one can create architecture rather than art or if their work can be described as architecture. The artist either sees it as collaboration or separate. Sculptors, painters, and photographers whose works seem to use or be compared to architecture in some way were asked similar questions about "Rather, they investigate architecture as a topic for study, as a metaphor for an internal quest, or as a means of commenting on contemporary life" (Armajani et al., 1982) This series of essays starts to answer in some ways how designers may learn from artists in their approach to share from, incorporate, connect to, or ignore architecture. The idea in which one can grab something from other designs to influence the creation of something else speaks directly to the reinterpretation of design energy. If capturing and redistributing the design energy is what reinterpreting is all about, and then the process is where the concentration should be. Since the research shows that design stops at production only to be repeated for further models or iterations, it only makes sense to start and end with the study of the design process because this, in my opinion, has given a new method, to the designer, by recreating and capturing design energy evolution. In this thesis, my research shows a redevelopment of the theoretical framework of design energy through the process of design itself.

> Commonly called design, composition is often thought of as a cosmic or spiritual sort of endeavor. Yet composition possesses a less abstract quality that is grounded in society's reality, whether it is the artisan's training, the influence of a printed design, or the development of new forms through the reorganization of older parts or through the adoption of new materials tool (Ward, 1988, pp. 121-122).

Design Future

Questioning the over-consumption of products and how to design in the future is how newly trained designers can help curb waste. "Car consumption is never simply about rational economic choices, but is as much about aesthetic, emotional and sensory responses to driving, as well as patterns of kinship, sociability, habitation and work" (Sheller, 2004, p. 222). As of April 30, 2009 there were 8.6 million salvaged vehicles in America's junkyards, and that data is drawn only from the 70% of junkyards reporting at that time (NMVTIS Program Office Bureau of Justice Assistance U.S. Department of Justice, n d). Since America's recovery from the Great Depression just before World War II was based on a "consumption-led economic recovery," it was only made since that style became streamlined, pushing new and newer products from planes and cars to toasters and telephones, essentially liberating the massive consumer demand society that we still live in today (Fry, 2009, p. 191). The future of design and/or design futuring are both very hot topics that speak directly to the core of design energy, not only of what design energy is but why and how the transfer of it so important.

> Workers in advanced capitalist countries can hardly remain content for long to slave at downscale wages producing upscale products that they have no hopes of purchasing. As the class obscuring ideology of mass consumption breaks down and exposes the dirty secret of an increasingly polarizing society, perhaps America's working people will once again organize and fight for their own interests, as they did in similar circumstances some sixty years ago (Gartman, 1994, p. 225).

Fry and Norman both speak of how things in the not-so-distant future should be thought about and influenced, whether from design or redesign aspects. Donald Norman speaks of things and their design in the future evolving from more than mere interaction; the next steps will involve a more intuitive relationship with the product. The next step from interaction and intuitiveness would be life—the everyday object is alive. Smart technologies can enhance pleasure, simplify and increase safety in our lives, if they would work without flaw and we all could learn to use them; soon this will not be an issue since the new technologies will be social, asking how they can improve, eliminating flaw and need to learn to use since they will operate themselves (Norman, 2009, pp. 157-158). Norman goes on to suggest that 3D printing will become inexpensive, allowing anyone to purchase a 3D printer for their homes, not unlike buying a refrigerator; so if you run out of something or need a new product and do not want to drive to the store, just download a 3D file from the internet and print it out. These future projects seem to be becoming more like humans, and the methods in which they are designed and produced seem to be becoming more interactive and intuitive as well. Just imagine the object telling you how to remake or redesign itself by remembering how it was designed and how it has been used and how it could be used. Tony Fry, in “Design Futuring : Sustainability, Ethics, and New Practice,” speaks to the thought that not only design itself is changing to become more ethically responsible, but a new way to practice is required. Regardless of the confusion, laziness, and tentativeness that some people may experience with the term futuring, we need to start thinking about our economy becoming something different from current symbolic and material exchange, overcoming the institutional force of “sustainable development” which stifles creative economic thought (Fry, 2009, p. 215).

Design Culture: Ergonomics, Anthropomorphism, and Emotion

“By comparing the use of chairs in Western culture to practices in cultures without chairs, we will find that chairs are true cultural artifacts, not, as we often imagine, mere extensions of our bodies” (Cranz, 1998, p. 16). For a product to be aesthetically pleasing, it must satisfy a culturally fed desire to feel good, look good, or even smell good. “Art (design) is an immensely expeditious and probably indispensable instrument for the transmission of culture, one far superior, I suspect, to any other cultural practice”(Carroll, Summer, p. 6). The ability to tap into human emotion and sensory perceptions, along with the familiarity with self, is inherently what an aesthetic is. Aesthetics can overload visual perceptions, intoxicating the user or buyer by distracting the senses, or anaesthetizing (Leach, 1999, p. 44). Design is interdependent on how one's culture describes the product's ability to be ergonomic, anthropomorphic, and emotional. An aesthetic evokes the opposite of this awakening of senses, in turn triggering a protection from overstimulation, working in tandem with aesthetics (Leach, 1999, p. 44). Designers, either in education or occupation, use a range of experiences and training that carry a model of need within them, indirectly reproducing the materiality and values of the culture they inherently are a part of, including its requirements of need—which drives the mode of design action (Fry, Spring, p. 42). The design culture of automobiles and furniture shares a lot in common; for my research I have concentrated on the ergonomic, anthropomorphic, and emotional qualities of design. The cultural influences of the car and the chair are many and varied, but they do share a common user, the human.

All levels of automobile culture are concerned with the personalization of cars, from engines upgrades to improved stereo systems. What makes this culture different from John Dewitt's "Kustom Kulture" and its widespread demand to redesign, alter, and even reinvent to the point that the vehicle becomes different and expressive far beyond mere accessorizing (DeWitt, 2002, p. xii). Fordism is the cultural influences and socio-economic phenomena that the Ford Motor Company has on the automobile and industrial design industries throughout the twentieth century. David Gartman questions and researched Fordism and how it has transformed the importance and order of visual sensibilities through its development of the assembly-line and mass production, and how it led to the efficiency of process, influencing all major industrial product manufacturing

(Gartman, 2009, p. 11). He links modern architecture “denigrating the tastes of the common people” to the “artificial differentiation of product on which Fordism rested” (Gartman, 2009, p. 263).

Whether it is scale or comfort or feeling, these products are as ingrained into our society and our behavior as food and water. Yes we can live with the chair and car, but the need to move and sit are still there—so why not use chairs like food and water, for a need-to-have basis only? The designer has this task, but what if he or she could develop a method to share the culture of the Cadillac with the Lazy Boy or of the Rolls Royse with Eames Lounge Chair, or just mixed them up?

From an early age people tend to assign or describe human characteristics to non human objects. Why it is so natural for things to appear human? Is it religious, cultural, or just assumption (Boyer, 1996, p. 83)? There is a strange parallel between humans ill from industrialized environments to animals ill from surplus production. They share an eerily similar, artificially-illuminated, assembly-line atmosphere reinventing the “quality of work, or enrichment of tasks, ultimately perceiving the psycho-sociological and human factory dimension” (Baudrillard, 1995, p. 131).The naturalness of anthropomorphism through cultural transmission is “because the intuitive domain-specific principles are roughly similar in all human subjects”—they result in similar occurrences in the ones exposed to them (Boyer, 1996, pp. 90,94). This transmission needs little to no help connecting gods or spirits in human form to the animal and or mountain shape (Boyer, 1996, pp. 90,94). Cars have been designed to be anthropomorphic, whether intentionally or not.

> In mature markets, a product's emotional value gains more and more in importance. In this regard, especially a product's appearance, i.e. its visual design, should be an important marketing tool to appeal to the consumers' emotions. Therefore, a new trend in product design is to create forms which look human-like (anthropomorphic), for example, car designers talk about the "face" of a car – headlights for eyes, grille for a mouth. Hereby, product designers tap into an innate human trait already known from psychology and anthropology: Human beings are highly sensitive to human forms and feel attracted by them (Miesler, 2010, p. 1).

Driving cars, in large industrialized parts of the world, has become a part of human nature, like the physical and emotional connections our society has made between dogs and their owners. These same connections have been made about humans and cars, from rugged 4x4 to snobby import, reflecting our self, economic status, and image (Safdie & Kohn, 1998, p. 137).

To make a connection to the human body, self, and scale as they relate to the automobile, I looked at the golden ratio in the same way Le Corbusier did in the development of The Modulor. This was done so that I could break down the form of three cars to analyze and get inspiration for new furniture design. In 1954 Le Corbusier discovered and invented a system of measurement called The Modulor: "It is a measurement tool based on the human body and on mathematics… the single unit, the double unit and the three golden sections" (The Modulor, 1977). Cars tend to be anthropomorphic, so I was able to find aesthetically pleasing forms to be used to shape a chair. I draw inspiration not only from pure anthropomorphic aesthetics but also from the automobile's shape after being inspired by Corb's Modulor in search of a human/car relationship. The middle range of vehicles that I have studied, from four-door sedans to SUVS, tends to be to human scale times four. That is width to width; further research comparing a person's height and depth to a car's length and height will have to be done to find scale similarities on all axes.

Turnbull argues that chairs are of a ontological curiosity for most of the modern intellectual traditions, which explains why chairs have a variety of intellectual meanings, shaping our understanding what many say is the "the world" of furniture (Turnbull, 2004, p. 156) Turnbull stresses the furniture world is not the *only* world, and "is more to the intellectual life than meditation on just epistemological importance", and that designers should critically reflect furniture thinking and its need not mere "intellectual fancy", because of its tendency to "immanent critique the intellectual" (Turnbull, 2004, pp. 170,171). He goes on to say further contemplating:

> Trapped at his or her desk, the modern intellectual is a hyper-scholastic who overlooks the basic ontological fact that the world is much more than a product of object-affordance but a more expansive and open… This is a plea for intellectual life in general—and philosophy in particular. If this were achieved, then intellectuals would realize that there is a world out there to be (re)discovered, and that much modern thinking is thinking enframed by a world of furniture that it has mistakenly taken for the world in-itself (Turnbull, 2004, pp. 170,171).

Cranz questions giving the power to ergonomics—instead it should be given to culture, ignoring the human by giving the control to the mechanics of movement (Cranz, 1998, p. 119). Because of this, when making a prototype, I took culture into consideration when developing the scale and shape of my furniture. After applying the vehicle shape studies to the design of a chair and other furniture, I looked to Cranz's work to help mold the human-space connection. Cranz states in *The Chair* this about ergonomics

> This is the study of the relation between people and the machines in their immediate environment, but somehow the people in this equation get left out… treating people as if they too were machines with interchangeable parts, but in reality our bodies are interdependent systems (Cranz, 1998, p. 119).

I have looked at anthropomorphism and ergonomics during early inspiration and later at the product development phase to show the part of design that could not only be regurgitated but the thinking in which it could be enhanced. Combining the car design studies I have already discussed leads me to Windhager's "Face to Face: The Perception of Automotive Designs," which was published in 2008. In it she discusses the connections between the car's front and the human face. I looked at her findings to further my understanding of the automobile's comparison to the human. She summarizes her hypothesis this way:

> The aim of the present study was to investigate whether people tend to perceive the world primarily in a social way. We wanted to see whether people ascribe certain traits to cars as they do to human faces, and if it is possible to extract the underlying shape information. Our main result was that people actually ascribe characteristics concordantly for most of the dimensions analyzed. First, car fronts possess cues from which we infer such characteristics as maturity, gender, attitudes, emotions, and personality... Second, shape contributes to the variation of attributions among cars (Windhager et al., 2008, p. 343.342).

The main groups of artifacts, usually described as material culture, are architecture and art; if they are especially responsive to formal analysis then they are separate from other artifacts such as tools, chairs, or mechanical devices (Prown, Autumn, p. 197). Does this apply to technologically more advanced products such as automobiles or computers? The opposite of how stylistic variables are used, function is the constant in most products. For example, the chair is limited in configuration by functional requirements but changes in appearance, giving the power back to aesthetics.

> Aesthetic theory of art (design) which maintains, roughly speaking, that something is an artwork if and only if it is designed with the primary intention of affording or having the capacity to afford experiences valuable for their own sakes; this theory of art might be diagnosed as a philosophical reflection of that wing of modernism called aestheticism (Carroll, Summer, p. 1).

The automobile definitely is sold on its function, but it's the style that keeps it fresh in the consumer's mind and the sales up. Culture speaks to style and aesthetics in most products designed to directly interact with human beings. Herbert Gans argues that culture itself can be biased to class, saying during the 1960's that "the United States possessed a variety of "taste cultures," sets of aesthetic values largely determined by class, that reflected legitimate needs and were equal in value" (Gartman, 2009, p. 263). *Measuring Culture outside the Head: a Meta-Analysis of Individualism–Collectivism in Cultural Products,* by Beth Morling and Marika Lamoreaux, measures cultural differences in "cultural products": tangible and/or public versions of culture are found mostly in the United States and these products are more individualistic than collectivistic cultures such as China or Mexico (Morling & Lamoreaux, 2008, p. 199). In the article "Urban Errands," Sarah S. Lochlann studies and questions how products such as the cell phone and automobile are adapting to, and causing adaptation of, cultural and gender roles in our current highly mobile world. Lochlann studies aspects of the topic from soccer moms in SUVs to home deliveries and school buses, and she theorizes that both mobility and technology are influenced by gender. In her study, she analyzes interviews covering the activities of two American women, examining how mobility as a social and material system allows for cell phones and how possibilities for civic life in social infrastructures work successfully (Jain, 2002, p. 385). She concludes:

> In these ways, negotiating space and technology through mutating arrangements among persons, objects, environments, routes and goals in the individual and collective creation of place and meaning constitutes mobility. In this article I have attempted to disentangle some of the ways that the cell phone joins collections of other gendered infrastructures, such as suburbs and office work. But while I have tried to be suggestive, the data I have collected are not sufficient to draw conclusions on such questions as whether the cell phone ultimately creates more work for feminized jobs (Jain, 2002, p. 385).

All cultures have subcultures, some of which contradict the typical cultural standards and sometimes succeed by becoming mainstream, by bringing similar people together who feel left out by typical socially accepted standards. If somehow by shear force subculture enters into everyday life, it can and has directly persuaded fashion, style, and design. One major subcultural influence can be seen in the 'punks' in the late 1970's in London. No one speaks more to this than Dick Hebdige ,who argued in *Subculture:The Meaning of Style*, that a subculture is subversive and can be, as to its nature, unfavorably judged; in most cases, "Subculture is, then, always in dispute, and style is the area in which the opposing definitions clash with most dramatic force" (Hebdige, 1981, p. 3). Punk aesthetics are shown in glam rock's implicit contradictions, because "working classness" and raw and dirty punk contradicted the elegance and arrogance of glam rock stars; but the two subcultures do share some common ground by speaking the language of white sad youth: “glam and glitter rock – ‘rendering’ working classness metaphorically in chains and hollow cheeks, ‘dirty’ clothing (stained jackets, tarty see-through blouses) and rough and ready diction” (Hebdige, 1981, p. 63). So does puck rock affect style and in turn affect design? Yes, depending on the product, culture, and subculture, it does directly influence design, whether from fashion, to music, or art.

Subculture in car design can be many things, from customizing, to class distinction to even those who do not drive. Gartman argues that there are three ages of automobile evolution throughout the 20th century: the age of class distinction, the age of mass individuality, and the age of subcultural difference. He states, “Each stage of the automobile has ultimately foundered due to the inability of this thing to satisfy human needs, to provide identity in sheet metal and autonomy in movement. So the contradictions pile up from one stage to the next, intensified and exacerbated but not solved” (Gartman, 2004). This explains further the styling of the automobile and its connection to the human need to have new and improved machines. As shown, effects of culture and subculture transfer from a state of reality to design. How does it transfer to the process to design and the energy behind?

The designer Ron Arad was influenced by the punk goings on during late 1970’s London, which was full of punks and destruction. The punk movement is still alive today, although watered down, and has inspired fashion, music, and art. It only makes sense that this subculture was such a force. After the popular *Rover Chair* in 1981, and the *Concrete Stereo* in 1983, Arad was soon labeled “the leader of a subversive school of design quite close in spirit to the “destroy” attitude cultivated by punks” (Burkhardt & Boissière, 1997, p. 12).

The emotions of cars are both the “kinaesthetic feeling of the car and the cultural and social affordances, circulation and distribution”(Sheller, 2004). Emotion in design can be a bit confusing; does it come into play during the process of making, during the idea generation, or even during the consumer interaction with the product’s style? I believe emotion can be part of multiple phases of the design process. It is based on a set of emotions that can be elicited specifically by product appearance. The emotion implemented early in the development of a product can carry over to the consumer and invoke emotion. In the article, “Darwinian Aesthetics Informs In Traditional Aesthetics,” by Randy Thornhill, aesthetic judgment is said to be the manifestation of a psychological adaptation which causally underlies most human emotions such as arousal, and creativity, and can learn or be interactive:

> Thornhill eloquently states: “We can conclude with great confidence that beauty and ugliness were important feelings in the lives of the evolutionary ancestors of hu-mans...A beautiful idea of evolutionary psychology is that the discipline allows discovery of how human ancestors felt about various aspects of their environments; the discipline allows discovery of our emotional roots”. A beautiful idea indeed, and one which I also found to be extremely moving (Tomlin, 2003, pp. 1,3).

The idea of recycling emotion, whether from the designer, the object user, or from the object itself, leads to another way designers can look at design energy. The recycling from the car to the chair is also about reusing the emotion, and the reinterpretation is part of the design process . The emotional and anthropomorphic connections of the human with the car and sex and violence are a little bit of what Jean Baudrillard talks about in his book *Simulacra and Simulation*. Baudrillard, from the chapter “Crash,” writes of technology, more specifically the car, as an extension of the human body. He imagines the interchangeability of car chrome with human mucous. Just like:

> sex and violence being covered by the same technological super design controlled by pleasure which has always been mediated by the manipulations of objects; Here, pleasure is only orgasm, that is to say, confused on the same wavelength with the violence of the technical apparatus, and homogenized by the only technique, one summed up by a single object: the automobile (Baudrillard, 1995, pp. 111,116).

The reaction could be different from the designers’ intentions, but there is no question that emotion is part of design. Just imagine if someone created a device to measure mixed emotions influenced directly by product design. This was done and studied by Pieter M.A. Desmet, Paul Hekkert , and Jan J. Jacobs, who explain the effectiveness of emotion on and by product design in the article, “When a car makes you smile: Development and application of an instrument to measure product emotions.” Desmet and company used positive emotion descriptors such as enthusiastic, inspired, and desiring, and negative ones such as disgusted, indignant, and contempt, and they assigned them to cartoons so participants could use them to describe automobile design (Desmet, Hekkert, & Jacobs, 2000, p. 3). This is intriguing research; potentials customers were given a chance to rate design with the use of emotion, possibly explaining the emotion behind the car design itself and the emotion of the consumers. Desmet goes on to say that:

> Consumer behavior studies have found emotions to be an important component of customer response, one significant aspect of the consumption-related emotions has been left ignored: the nature of emotions elicited by product appearance. Emotions elicited by products can enhance the pleasure of buying, owning and using them and can be strongly influenced by the appearance of the product. Since products are nowadays often similar in technical characteristics, quality, and price, the importance of product design as an opportunity to make a product unique is increasing. Therefore, from a marketing point of view, emotions elicited by product appearance, are important objects of study (Desmet et al., 2000, p. 1).

Information from this research for designers and marketers is relevant; actually knowing how a car is designed shows less boredom and actually attracts the potential user. While analyzing the car's appraisal resulted in boredom, which helped find the subjects' concerns with the appraisal and was found only if the emotion was known (Desmet et al., 2000, p. 10). When comparing and analyzing humans faces and their relationship with each other, explaining human-like shapes and expression, Sonja Windhager and company were able to do this by "applying geometric morphometrics; showing distinct features in the car fronts correspond to different trait attributions." She explains, "Humans possibly interpret even inanimate structures in biological terms, which could have implications for driving and pedestrian behavior" (Windhager et al., 2008, p. 344). Certainly product design can be reinterpreted or reused, but can the emotion behind the making?

Design Reuse, Reinterpret, and Refabricate

In a world full of over consumption and ridiculous waste, it is absolutely important to find a way not only to reduce the waste stream but to design to prevent and reuse, not throw away. I am proposing a possible solution by reusing and reinterpreting both the automobile's design energy as well as its leftovers. Dematerialization, getting more product using less material, has been a big part of design in the automotive industry for the last couple of decades, but this method needs to be evaluated further to prevent life-cycle from being shifted; an example would include shifting from steel to aluminum, since aluminum costs more time and energy to recycle (Graedel & Allenby, 1998, p. 82).

A toilet, stump, rock, ottoman, tailgate, and chair all have something in common: you can sit on them. Is furniture art, or can art be functional? "Construction" is concerned in the sense of industrial design, so replacing the handicrafts, and removing the aesthetic gives validity to the industrial artifacts and "colour and ornament" is needed by the user for connection to form; while with machine-produced objects the only good repeated ornament is geometrical, implying a suppression (Kinross, 1988, p. 39).

In 1937 Sydney Jones defined Functional Art by claiming that:

> The totality of the human being includes an aesthetic impulse as well as various practical impulses; a concern for the form as well as for the efficiency of the instruments of production… He later whittled this theory down to "'Functionalism': If an object is made of appropriate materials to an appropriate design and perfectly fulfils its function, then we need not worry any more about its aesthetic value: it is automatically a work of art (Kinross, 1988, p. 44).

Galen Cranz says historically a chair is furniture with typically four legs and a back for someone to sit on (Cranz, 1998, p. 31). Lain Mott and Marc Raszewski, were able to combine the user to the *Talking Chair* with surrounding 3D sound, producing a theatrical type experience, which combined the wavelengths of music with the material world, expressing physical poetry requiring the creative input of the user to apply meaning, which gave cause, effect and response (Mott & Malina, 1995, p. 69). Ron Arad was ultimately put on the designer's world map with his *Rover Chair* in 1981. This piece, in a clever way, reused a found *Land Rover* driver's seat combined with a fixed tubular structure that reinterpreted the lounge chair. Andy Gregg is a furniture designer who reinterprets the bicycle by reusing its parts to make furniture; his Tour de France Lounge Chair was featured in the Eco-Friendly section of the May 31, 2008 issue of *Interior Design Magazine*. More examples of reuse and reinterpreted design can be seen at http://www.superuse.org/. People have copied art and/or design throughout time, it is part of reuse and recycling, but can design energy be copied? "Copying is no longer seen as being derivation or unimaginative. In the postmodern culture it has become a key element in the creative process" (DeWitt, 2002, p. 137).

The term refabricating has become part of the design and architecture vernacular mostly due to Stephen Kieran and James Timberlake. In their book *refabricating Architecture: How Manufacturing Methodologies Are Poised to Transform Building Construction*, they speak directly to how architecture would benefit from looking at the automobile, ship building, commercial product, and aircraft industries to show and influence main line design, which make architecture more customizable. Companies such as Nike and Dell Computers and the automobile and apparel industries are extremely organized meeting the demand for choice, low cost, and high quality needs (Kieran & Timberlake, 2004, p. 133). Kieran and Timberlake developed mass-producible architectural products that prove in their experience the relevance to streamlining design and construction. Two designs that stand out are the *Modular Vanity* and the *Cornell Bathroom.* The first is a water wall, sinks, mirrors, isolated plumbing, lighting, wiring, and final finishes all in one easy-to-ship and then be install in place. The second takes the first vanity design to the next level; the idea was a whole bathroom with everything in the prior description as well as the addition of four walls, a door, floor and ceiling. This ability to make building components and even whole buildings in a controlled factory environment, then ship and install in place like large *Lego* blocks, is not crazy—it is real—and Kieran and Timberlake are developing arguments and designs to streamline these tasks further.

"Let us imagine ourselves forward in time, it is autumn 2013, we are driving our new hydrogen-powered Cad-Wire *Cadillac,* when we pull up to the gate of a massive facility, no one around, it is a converted unused building owned by *Boeing*, but there is no airplanes around", are those buildings inside those buildings (Kieran & Timberlake, 2004, p. 157)? When Le Corbusier said "Architecture or revolution. Revolution can be avoided," he did not realize the potential of a *Boeing* constructing assembly line architecture. Who would have, really? "To create a machine to live in you need to build it as you would a machine" (Kieran & Timberlake, 2004, p. 172). Should we really be living in machines or are we already? Take the machine apart and reassemble it as furniture, then the machine is no longer what it was designed to be. It has been reinterpreted.

Reinterpretation of art, design and architecture has and continues to be done from simple reuse of space and/or products to redesigning meaning of one object to another. To rematerialize is to displace the machine with the hand tool, bringing quality into action and linking oneself to making and remaking; which provides an alternate travel through the world we live in, whether physically, emotionally, aesthetically, or functionally (Fry, 2009, p. 219). Automobiles can become furniture through more than just recycling; think of the reinterpretation as rematerializing. If one could rematerialize the car into a simpler form of transportation like the bicycle, then what if the new form had a different purpose, sitting not moving? What can the designer/user find, remake, or reinterpret, to displace a more complex technology with one that has a lower impact (Fry, 2009, p. 77)?

CHAPTER III

METHODOLOGY

I used both qualitative and creative methodologies to form a comprehensive documentation and analysis of my generative design process, using primarily the morphing software Morpheus and, as required, software to edit animation. My generative process, similar to the methodology to study it, is cyclical, not linear, and therefore neither travels a straight path. "Methodology should not be a fixed track to a fixed destination, but a conversation about everything that could be made to happen. The language of the conversation must bridge the logical gap between past and future, but in doing so it should not limit the variety of possible futures that are discussed nor should it force the choice of a future that is unfree" (Jones, 1992, p. 73). I reviewed and studied three main aesthetic approaches to aid in the categorization of my methodologies, which are: empathic-logical, aesthetic, and artistic (Buchanan & Bryman, 2009, p. 233). I found that some of my sub categories overlapped, as demonstrated later in this section.

Qualitative research

Qualitative research can be simply put as "social or behavioral science research without the numbers" and has become more complex with the use of more "increasingly sophisticated analytic methods" with the use of the computer (Salkind, 2009, p. 208).

I started by performing a critical analysis of the literature regarding generative processes, then I created a method for documenting my design process. I consulted Nigel

Cross's descriptions of the design process, a pattern of "work-relaxation-work," in order to determine the components my process and the ways in which I would document the steps in my own project. My study of the design process is primarily qualitative research, since my data is in the form of Lit Review Analysis, snapshots, digital imagery, morphing animation, and tween data. Most qualitative research shares two similar elements, one being concentration on the real world and the second the complete in-depth study of natural and real phenomenon (Leedy & Ormrod, 2010, p. 135). The empathic-logical approach seems to apply to qualitative research directly.

Empathic-logical Approach

The empathic-logical approach "highlights the organizational control exercised at the level of aesthetics, beginning with the pathos of the organizational artifacts constituting the symbolic landscape of the tangible organization" (Buchanan & Bryman, 2009, p. 233). This approach has been used to study objects such as furniture, office equipment, marketing materials, and other products, making it an ideal approach for the analysis of my prototype (Buchanan & Bryman, 2009, p. 233). From fall of 2009, through the review and gathering of my process snapshots and later through the creation of their morphing tweens, I studied the images' aesthetic value and determined which were most promising for further idea development. I was able to use the approach of studying existing seating height options in an office setting while developing a design idea for my summer 2010 project for the Center for Design Innovation, which led to the production of my second prototype in fall of 2010. The process snapshot, tween creation, and analysis of the second prototype from fall 2010 led to the design and creation of a third prototype in fall 2010. Looking back on the information from my fall 2010 process, I continued with but evolved the design further to create a fourth prototype in the spring of 2011.

Creative Methodology

Spalter mention if creative methodology is stressed properly, then design is considered the most important element to solving design problems, which then allows to the focus on the idea which is innovation (Spalter, 1999, p. 115). My design methods were focused on design idea generation coming from the study of my own process. Cross says that “design methods are any procedures, techniques, aids or ‘tools’ for designing. They represent a number of distinct kinds of activities that the designer might use and combine into an overall design process” (Cross, 1989, p. 33). I studied my design process and compared it to examples mentioned by Cross. My design methods started with generating drawings and 3D models, both by hand and using the computer. I followed this by looking back on my making of objects, as well as how I manipulated them physically and digitally.

In the beginning, I looked into how design energy can be transferred from one object, a car, to another, a chair. This soon evolved when it became clear that the question of what design energy was, or its transferability, was about looking at the whole of the design process itself. My comparative method originated with these five categories from Lewin’s automobile design process: Concept Generation - (ideas on paper, sketches), Themes Selection – (sketches are evaluated in search of theme and which look more interesting), 3D and Computer Model Development- (scale models are built, and measurements and drawings are put into the computer to be further manipulated), Design Evaluation – (full-sized model is evaluated, appearance and ergonomics are reviewed, and a customer clinic can be given to get potential user reactions), and Prototype Development – (a hand built prototype is constructed and then tested) (Lewin, 2003, pp. 108-109). These steps were then developed, manipulated, and analyzed to comprise the whole of what design energy could be. The aesthetic and artistic approaches, although examples of qualitative methods fit nicely under the creative methodology and were used to organize the review of my generative process

Aesthetic Approach

The aesthetic approach "shows how the aesthetics from which the organization acquires its form are negotiated. It emphasizes the quotidian construction, reconstruction and destruction of the aesthetics specific to the organizational context studied" (Buchanan & Bryman, 2009, p. 234). For me, the tween data is a way of deconstructing and reconstructing the design process already, so it is logical to use this approach to further study the morphing output. Although the tweens were only used to generate designs ideas from the second prototype to the third, it became clear that this was worth using again to generate more ideas, so I used this method to analyze my last prototype creation.

For all of my projects, I generated ideas by sketching, drawing, sketch- and scale-model making, 3D digital model creation, and the production of full-scale prototypes. The process was generative and recurrent, creating various ideas that I evaluated and then honed to isolate one idea from various iterations. Not only comes into play during idea generation but, as I describe Cross's pattern in detail later, helped me to organize and break down Lewin's five steps throughout the whole design process.

This gave me direct insight into the culture of the material used, how to tweak the design, and what to consider for the design of future objects. This information also made me question the use of the chair depending on which setting it was in, bringing to mind Jules David Prown. "Material culture is based upon objects that are made or modified by man [which] reflect, consciously or unconsciously, directly or indirectly, the beliefs of individuals who made, commissioned, purchased, or used them, and by extension the beliefs of the larger society" (Prown, 1982, p. 1). The variety of seating in different cultures led me to allow the variety of body sizes to justify the evolution of my seating design. You can see the evolution from the first prototype to the last as I took more consideration of scale when designing to be more ergonomic.

Artistic Approach

Buchanan & Bryman describe the artistic approach as follows:

> [It] critically focuses on the experience of art in organizing, [and it] comprises the sensible aesthetic experience of the empathic-logical and aesthetics approaches, [but] like the archaeological approach and unlike the empathic-logical one, [it] envisages the hybridization of artistic creative energy and ratiocinative capacity in the performative conduct of both research and organization (Buchanan & Bryman, 2009, p. 236).

This method, or the artistic hybrid, best describes how my process of designing and making from the first prototype to the last evolved. As I got away from the concerns of design energy and began to concentrate on the importance of revisiting my own generative process, the "hybridization of artistic creative energy and ratiocinative capacity" became more apparent in the evolution of my work (Buchanan & Bryman, 2009, p. 236).

Creative Thinking Pattern / Work-Relaxation-Work

To further evaluate my process as derived from Lewin's categories, I analyzed my design development from beginning to end. I first studied my creative process in an attempt to make sense of the spontaneousness of the idea's creation, or the "ah-ha" moment. I had several of these moments throughout the five categories, which allowed me to analyze them. These moments and steps of my process became more honed as my works evolved from fall 2009 to spring 2011. Looking back but still moving forward, my Lewin steps evolved so I started to put the phases of my process into Cross's creative thinking pattern of "work-relaxation-work," which is as follows:

1. *Recognition* is the first realization or acknowledgement that a "problem" exists.
2. *Preparation* is the application of deliberate effort to understand the problem.
3. *Incubation* is a period of leaving it to "mull over" in the mind, allowing one's subconscious to go to work.
4. *Illumination* is the (often quite sudden) perception or formulation of the key idea.
5. *Verification* is the hard work of developing and testing the idea.
(Cross, 1989, p. 41).

I concluded that Cross's sequence of steps directly line up with and are related to Lewin's five steps, so I decided to use this sequence to organize and analyze the design and production of my four prototypes. The connections are as follows: recognition with concept generation, preparation with themes selection, incubation with 3d and computer model development, illumination with design evaluation, and verification with prototype development.

Recognition

During my first project, in the fall 2009, the recognition of the problem first came to me after investigating the Consumer Assistance to Recycle and Save Act (or C.A.R.S., a.k.a Cash for Clunkers), and how it added nearly 700,000 vehicles to the ever growing junk pile (Consumer Assistance to Recycle and Save Act & U.S. Department of Transportation, n d). After I started to mimic Lewin's process, my recognition changed and the new problem became about the study and revisiting of my own design process through combining five of Lewin's design steps instead of the study of design energy from the car's design process to the chair's.

After reviewing my first prototype design and production from fall 2009, my approach to recognizing my design evolved. From spring 2010 to spring 2011, the review of my design processes as described by Cross and revisiting my own processes through evaluation, selection, and morphing, is where not only the design question was discovered but the answer as well.

Concept Generation

The generation of the concept was in the form of ideas on paper, written and drawn. "In developing a new product concept, it is imperative to elicit design knowledge for product conceptualization using a simple yet effective knowledge acquisition technique”(Yan, Chen, & Shieh, 2006, p. 275). Chen shows the complexities of product conceptualization as “a complicated process that involves multidisciplinary knowledge sources, possibly overlapping or conflicting with one another” [and design knowledge as] “a complex inherence with fuzzy, uncertain, stochastic, imperfect and incomplete nature”(Yan et al., 2006, p. 275). This blend of complicated process and fuzzy uncertainty directly relates to my generative process, which was clarified further through the selection of snapshots and then morphing. This gave me a chance to look back on the designing and making of my studio project and find ways I could change or improve. This morphing creates secondary output in the form of tweens that could still inspire new design.

Preparation

Through my review of literature I was able to find several examples of design processes and use them for inspiration, as well as start to mimic them. This allowed for the my discovery of Lewin’s process and its use in my design development. Cross’s description of processes was the filter through which I was able to modify my design process. I was inspired by Lewin’s and Cross’s descriptions of the design process.

Themes Selection

First, I evaluated early sketches in search of themes, and then a couple were isolated and taken further. In fall of 2009 only, my process of outlining car shapes and doodling car parts lacked direction. In order to provide a framework for myself, I chose to analyze the car shapes for inspiration to become design ideas and analyze them to create a mechanism for generating form. This changed for my projects after fall of 2009 because I started to get my early theme selections from the evaluation, selection, and morphing of the process snapshots. This theme selection method allowed my production of various iterations to become faster and more abundant, both by hand and in the computer.

Incubation

A delay in my design process was consistent with the period of mulling over as describes earlier by Cross. This period, although consistent throughout the designing of my prototypes, was shortened and became more exacting. The first example, in the fall of 2009, during the 3d and computer model development phase, I found myself a bit scattered, seeking a final direction. After developing a first half-scale model, I needed time to breathe and mull over what I had learned from the first half of the semester. This time turned out to be helpful; although it was short, I came back from the mid-term evaluation with a clarification of what the design was to become. My subconscious, full of shapes and movements, directly fueled a series of graphite and crayon drawings that ultimately opened the rusty door of ideation. In later design and production processes, the time from idea generation to this incubation phase came faster with each succession of prototype completion. This was because, similar to an artist's series of work, one fed into the other, shorting the time and need for my subconscious to kick in.

3d and Computer Model Development

My first phase went from the concept or idea to the theme, which led to me creating a series of output in the form of sketches to sketch models and 2D digital drawings to 3D digital models. After this, I took what I had learned from the first phase of my process and from the mid-term evaluation and went back to drawing. The mulling over phase, or time to incubate my thoughts, came between phase one and two. Phase Two started with drawings that were purposefully loose and free flowing to give me a different perspective on what the design at the time could become. I analyzed the drawings and selected one to give me further inspiration in developing the design. Then, like in the first phase, I created a series of 3D digital models and then manipulated them until I chose one to convert into a half-scale model. This half scale model was evaluated by my professor, fellow classmates, and myself. This led to more development of the digital model until I chose a final one to be developed into a life-size prototype. This continues throughout each prototype design and production from spring 2010 to spring 2011. After the completion of my prototype from fall 2009 the time between incubation and the 2D to 3D development was shorten. I feel that since I was looking back at my own process that the idea generation happened very quickly due to the fact my inspiration came directly from my previous process so in turn I got to mull over multiple 3D iterations earlier in the process. This led to me making digital and physical models, and later the production of a prototype, more quickly.

Illumination

My "ah-ha" moment came during the design evaluation phase throughout all my projects during my two-year stint. I noticed that my design evaluation came to me sooner after I produced my first prototype. This was because was I decided that my processes would be part of a series of work. Once I started revisiting my processes to gather snapshots, I noticed that the early steps of my design development were stretched out and had too many directions, making it harder to meet a consensus on the design idea. By looking at the snapshot data and analyzing it further with the morphing and tween creation, I realized the perception or formulation of the key idea could be reached faster. This decrease in time led me to a moment of illumination and was probably due to the sheer numbers of images that were visually feeding my subconscious, both from just looking at my process images and looking at the tween images. This blend of factors, from re-visiting my process by evaluation of the design steps, the selection of snapshots, and the creation of tweens, led to my series of work becoming more efficiently connected.

Design Evaluation

My evaluation of all of the prototype designs went from the early analysis of both physical and digital models to the final 3D design model and production of my final object. Through my process evolution, I questioned potential materials, connections and construction, considering cost, environmental factors, and durability, all of which I discussed with my thesis committee, chair Robert Charest, sculptor Billy Lee, and furniture designer Stoel Burroews. My final computer models were also created and rendered, which created images to show potential color, texture, scale, and even lighting analysis. This allowed me to predict issues of variety without the added expense and time constraints of constructing multiple prototypes. My four full-sized prototypes were built after earlier evaluation by me and my peers, which allowed the final pieces to be used and be evaluated even further by me and my committee.

Verification

The second part of my verification process was to document and analyze the components that comprise the whole of design energy from beginning to end. *Morpheus Photo Morpher* became my main method to take snapshots and create the tween output. I used it for morphing two unalike photos together, showing similarities in the form of a third created image and animation. This method I used to analyze the process from fall 2009, summer and fall of 2010, and the last process from spring of 2011. The differences were that the tween data created from the fall 2009 and spring 2011 were analyzed, but the idea generated was not used to inspire a new prototype; only the data from summer and first part of fall 2010 was used to create a new prototype in the last half of the fall 2010 semester. I picked an early phase sketch, digital image, photos or drawing, then put it into the first frame, and then put the next in the sequence of creation into the tenth frame (See figure 11, page 62). I also experimented with more frames, deciding ultimately on 20 frames depending on the complexity of the image. More complicated images, such as an actual photo of me in the process of making, would need more frames than a simple image such as a scan of a sketch. This software lends itself successfully to morphing two images taken chronologically from my generative process, showing how the phases of prototype production come together. Within the forming of the animation in-between images, tweens are created, which were analyzed and could be used to inspire future design (See figure 12, page 62). The software only allows two fixed-sized images at a time to be morphed. This prompted me to used Adobe Photoshop to make all images fit the same layout and have the same dpi. After the images were morphed and animated, I had to edit them in order of creation by splicing them together using Microsoft's Live Movie Maker. Morpheus allowed me to create multiple color coded alignment points, which allowed for image synching and morph adjustment. This software also was able to export as more various animation file types, as compared to *Flash*. This creates a new method of studying my design process itself but also a method for me or maybe another designer to use by just putting the required data into Morpheus and then creating the animation. Then the series of images can be separated by me or another designer to create a new and different layout of creation. These images could also be viewed as a continuous animation, from the beginning of the design process to the end, from one product design to the next. Imagine an ongoing running of morphing design steps that shows the progression from early work to later work. The snapshot and tween data from all the design processes can be seen under Appendix A.

Prototype Development

The first part of verification came in the form of four completed prototypes. From the completion of the final three-dimensional digital models to the life sized prototypes, I verified my design for each phase because once the first was completed the series of work could start. Verification came from each prototype's production but each step evolved, further verifying the output. Verification came also through re-visiting the process from snapshot to tweens and from one product prototype to the other. One could argue that I used design energy from one prototype to another but not with 100% certainty. This was because the reinterpretation and verification is too hard to nail down since the nature of my generative process, similar to the methodology, is cyclical.

CHAPTER IV

RESULTS

Since I concluded earlier that Cross's sequence of steps directly line up with and are related to Lewin's five steps, and I decided to use this sequence to organize and analyze my processes, I wanted to actually use the descriptors—recognition with concept generation, preparation with themes selection, incubation with 3d and computer model development, illumination with design evaluation, and verification with prototype development— to divide up the results section for clarity and consistency.

Prototype 1, fall 2009

Recognition / Concept Generation

In the beginning, with my fall 2009 project, the recognition of the design problem came from the CARS act dilemma, which took working cars off the road, creating added waste. This was not a design problem, though, so I wondered if the inspiration or energy behind a failed design could be reused to create a successful design. After the midterm was over, it became clearer that my concept and problem were to be found by mimicking the steps in which a car is designed. I chose to start the concept with Lewin's design steps, and then studied my process to seek future idea generation and manipulation. Lewin's process is a slightly more complicated the descriptive model that Cross describes, but closely fits into French's model as shown earlier. This matters for how I proceeded, because it supplied the early framework for my attempt to transfer design energy from cars to furniture.

My idea generation came from first thinking about design energy: what is was, exactly, and how it could be transferred. After reading about the automobile's history from early invention to how cars are designed and manufactured today, I realized that ideas could start with the aesthetics—the final shape of—the car. I decided to take inspiration from one of the most popular vehicles that were traded in through the CARS act. The early ideas for shapes for my first design were too literal and were later simplified, losing any resemblance to any particular car. I started with informal and formal critiques and peer-focus groups, with my thesis committee, and my fellow grad students. I worked on turning broad, abstract concepts into simpler categories, such as "Innovation" and "Creativity." I wrote down my thoughts and then developed them into early sketches, (See figure 4, page 52).

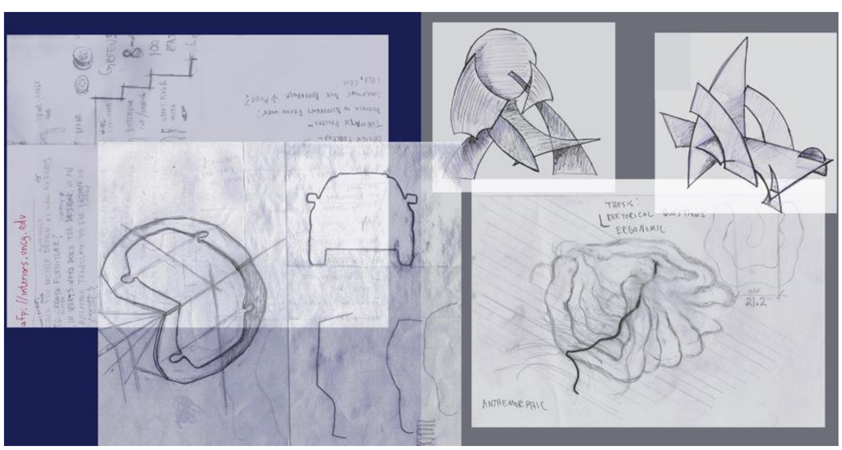


Figure 4. Early and later sketches

Preparation / Themes Selection

My selection of the theme started with car size, shape, and aesthetic analysis, and then developed into a final object to be later manipulated. I started with the vehicle most Americans traded in under the CARS act, then with the car that was bought by most, and a third, yet-to-be-developed car to represent a future “what if” option. These automobiles were the Ford Explorer, Toyota Camry, and MDI’s CityFlowAIR 2. I tried to find inspiration by mimicking Le Corbusier’s methods of using the golden ratio to break down the automobiles’ shapes, but only ended up creating colorful images (See figure 5, page 53).

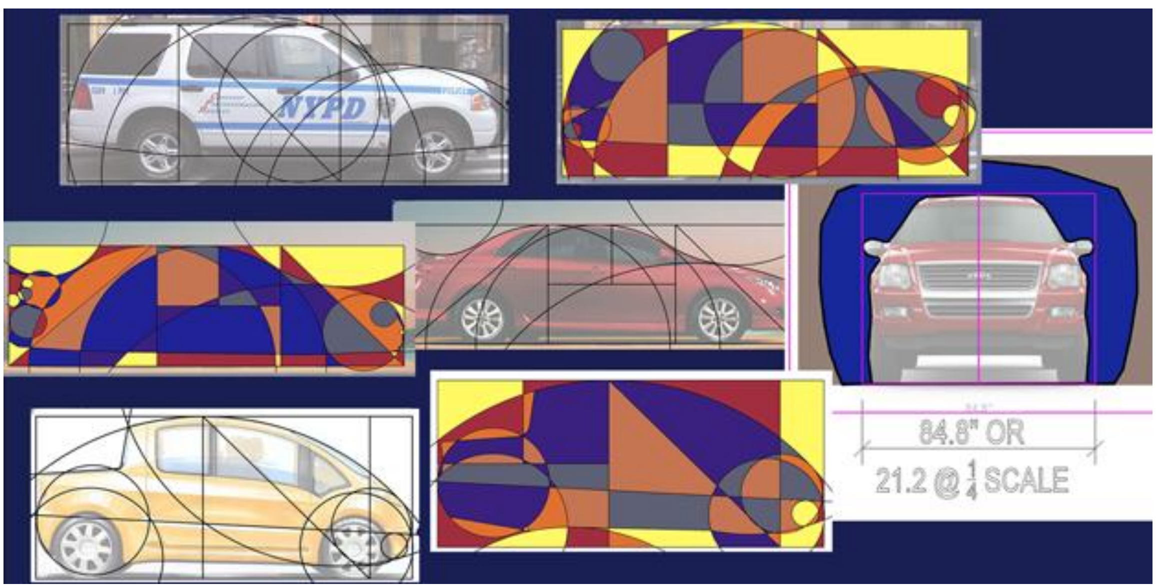


Figure 5. Early break down of automobiles’ shapes

I created more sketches, which I evaluated further in search of a specific theme; I veered more away from a literal translation of the shape of a car and into something more conceptual. The middle range of vehicles that I studied, from four-door sedans to SUVS, tended to be the human scale times four. That is width to width; further research comparing a person's height and depth to a car's length and height would need to be done as well to find more scale comparisons. The evaluation led to a shape that developed from the outline of the front of the Ford Explorer (See figure 6, page 54). Both the Ford shape and the car shape studies led to objects progressing into the 3D form.

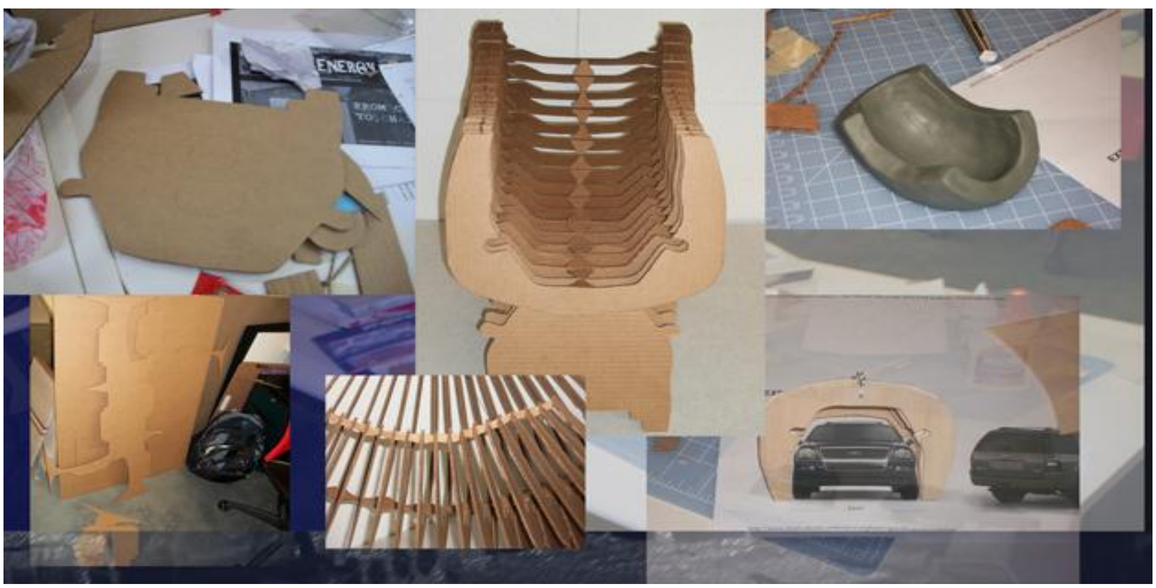


Figure 6. Early 3D form development

Incubation / 3D and Computer Model Development

Once shapes that represented the theme were selected, I further developed them into sketch models, digital models, and scaled models. This came in two phases, each ending with the completion of a half scale model. Once the first few models were quickly drawn in 3D in AutoCAD, it became clear that the shape derived from the Ford outline had the most potential. This came from a combination of my own opinion and that of my studio professor, mostly due to the visual effect that occurred after the shape I came up with was repeated. The other preliminary options had too many pieces, but the repetition of this one shape led to smarter and more appealing shapes. I further developed this model into a series of similar alterations. I then made into a half-scale model, which I presented at mid-term to professors and students in the department, (See figure 7, page 55).

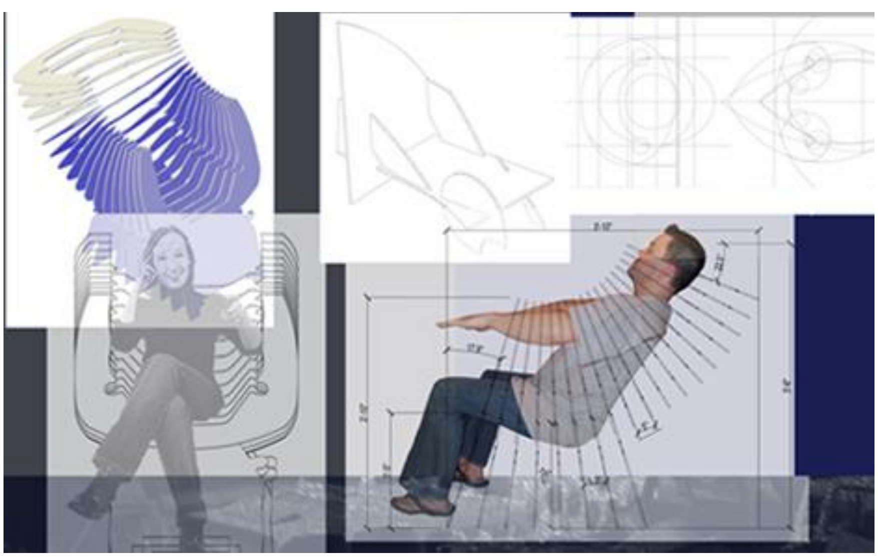


Figure 7. Early digital 3D model development

Illumination / Design Evaluation

During the design process of fall of 2009, my “ah ha” moment came after I completed some Conte crayon drawings after the return from mid-term. My sketches led to the formulation of the design’s key idea and also how to potentially construct it. The design further was clarified after completing a half scale model (See figure 8, page 56). I just had to prove it to myself and my studio professor. This led to the creation of the second scale model and a more developed and accurate digital model. The final computer model was rendered to show potential final color, shape, light and shadow, scale. All I had to do was build it to prove and test the idea, (See figure 9, page 57).

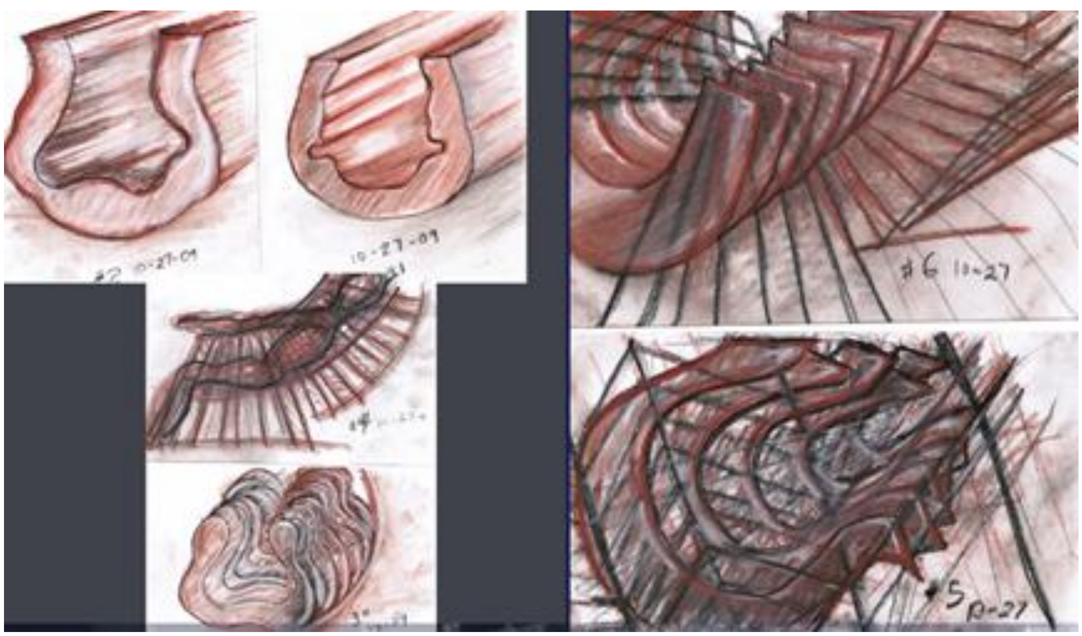


Figure 8. Conte incubation drawings

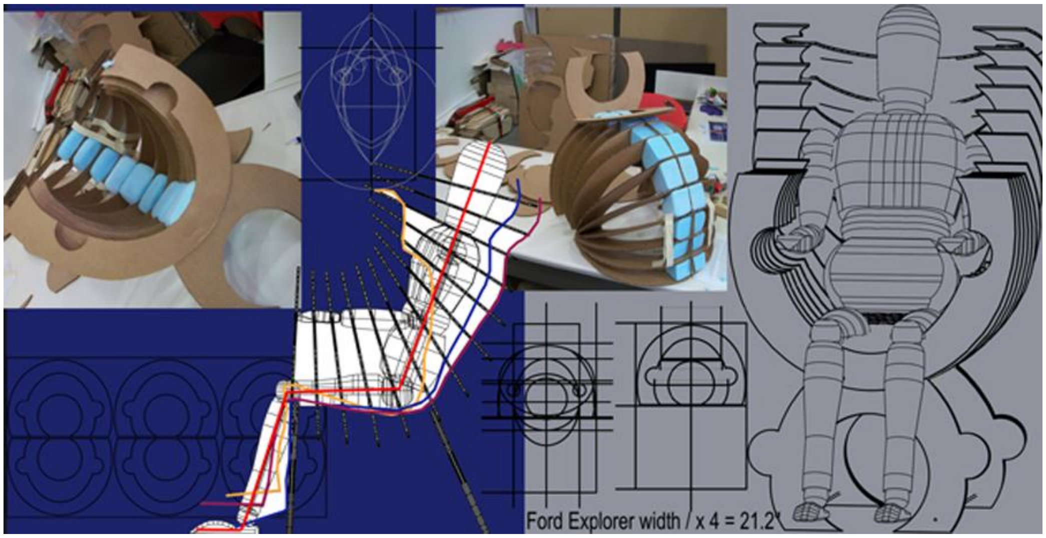


Figure 9. Digital model studies

A detailed digital mockup of the final design became important because the digital template would aid in final construction. I then repeated the shape I decided on to form an accurate model of the final chair design (See figure 10, page 58). Potential materials, connections, and construction were discussed by me with my thesis committee, chair Robert Charest, sculptor Billy Lee, and furniture designer Stoel Burroews. The final computer model was also rendered in 3ds Max to create images to show color and light analysis (See figure 11, page 58). This allowed for a potential user to see future options and/or finishes without the expense and time constraints of constructing multiple prototypes. I built my full-sized prototype after I evaluated the final digital model for appearance and ergonomics.

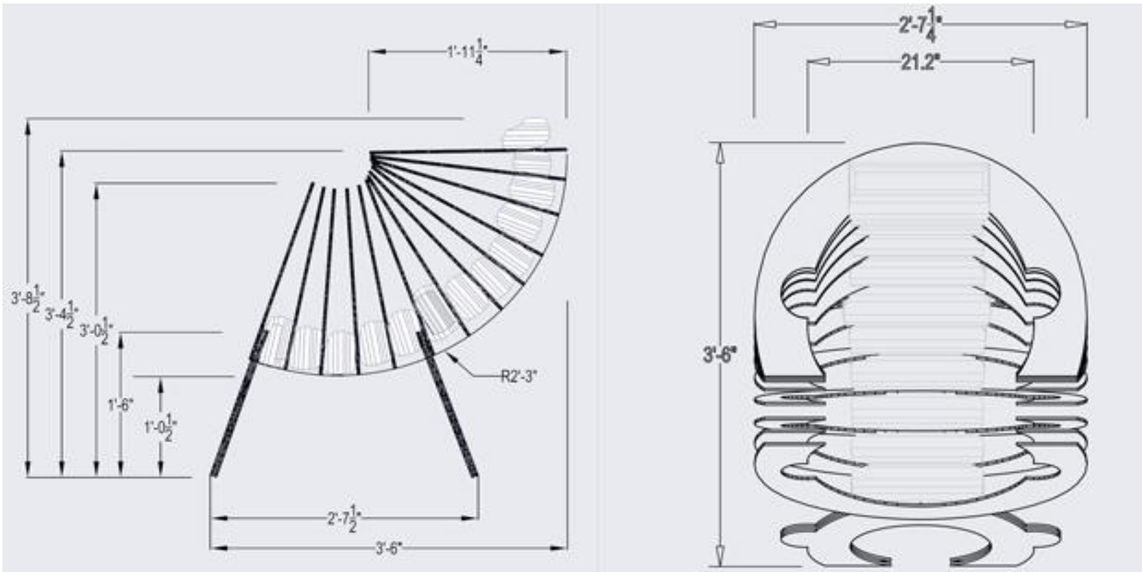


Figure 10. Final CAD model

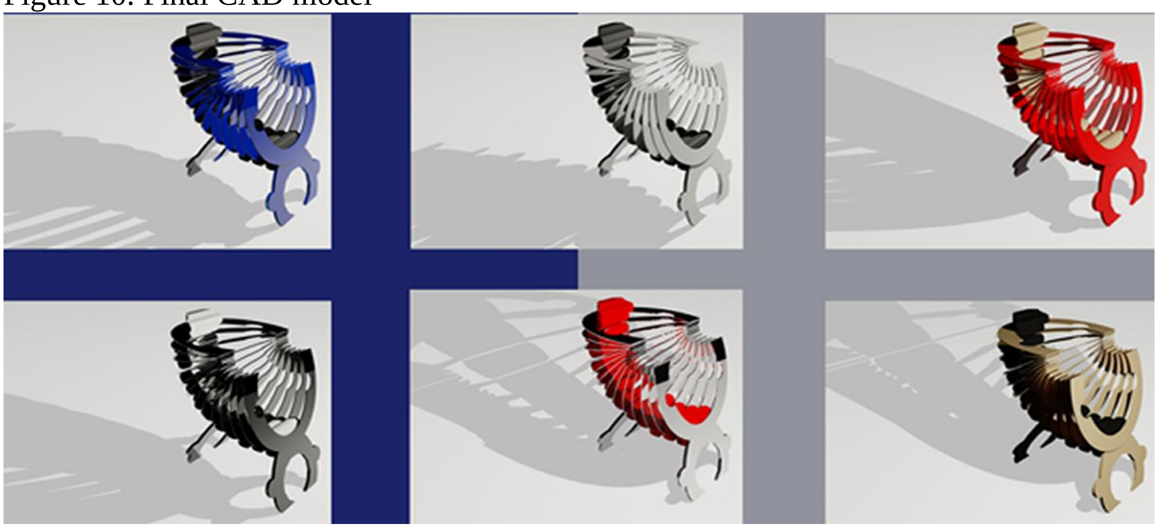


Figure 11. Digital model lighting studies

Verification / Prototype Development

The construction and development of my first prototype, during fall of 2009, was completed after the final models and my final design were evaluated. It became clear, after discussions with Robert, that I wanted to use connection hardware that was designed for the automobile and reuse a found Ford back seat. This allowed me to successfully reuse and reinterpret loosely the energy behind the engineered automotive. I was able to reuse the foam from the SUV seat to provide cushion for sitting and supply rigidity between the pieces (See figure 12, page 59).. After researching fast and accurate methods of cutting extremely accurate shapes, I concluded that laser cutting was the best option and found a local company able to help me. I wanted the pieces of the chair to be made out of a relatively lightweight, affordable, easy to find, sustainable, and environmentally friendly material. I chose two, .220 thick and formaldehyde free, MDF boards, which were $25.00 per 4'x8' sheet and readily available. I also considered plywood, but the thickness and finish were an issue and it was more expensive. Some of the MDF was combined with the seat foam to create additional support. The final outlines of the MDF pieces were laid out two-dimensionally on a 4'x8' template representing the full size MDF board, in AutoCAD (See figure 13, page 60). This CAD drawing was broken into lines and arcs at the suggestion of the laser operator; it was then converted to a dxf file format and was emailed to the laser cutter. I went to the cutter and supervised the process and was there to answer questions if any last minute corrections had to be made. None were—the file worked, and the setup and cutting took approximately thirty minutes.

Figure 12: Foam reuse and reinterpreted

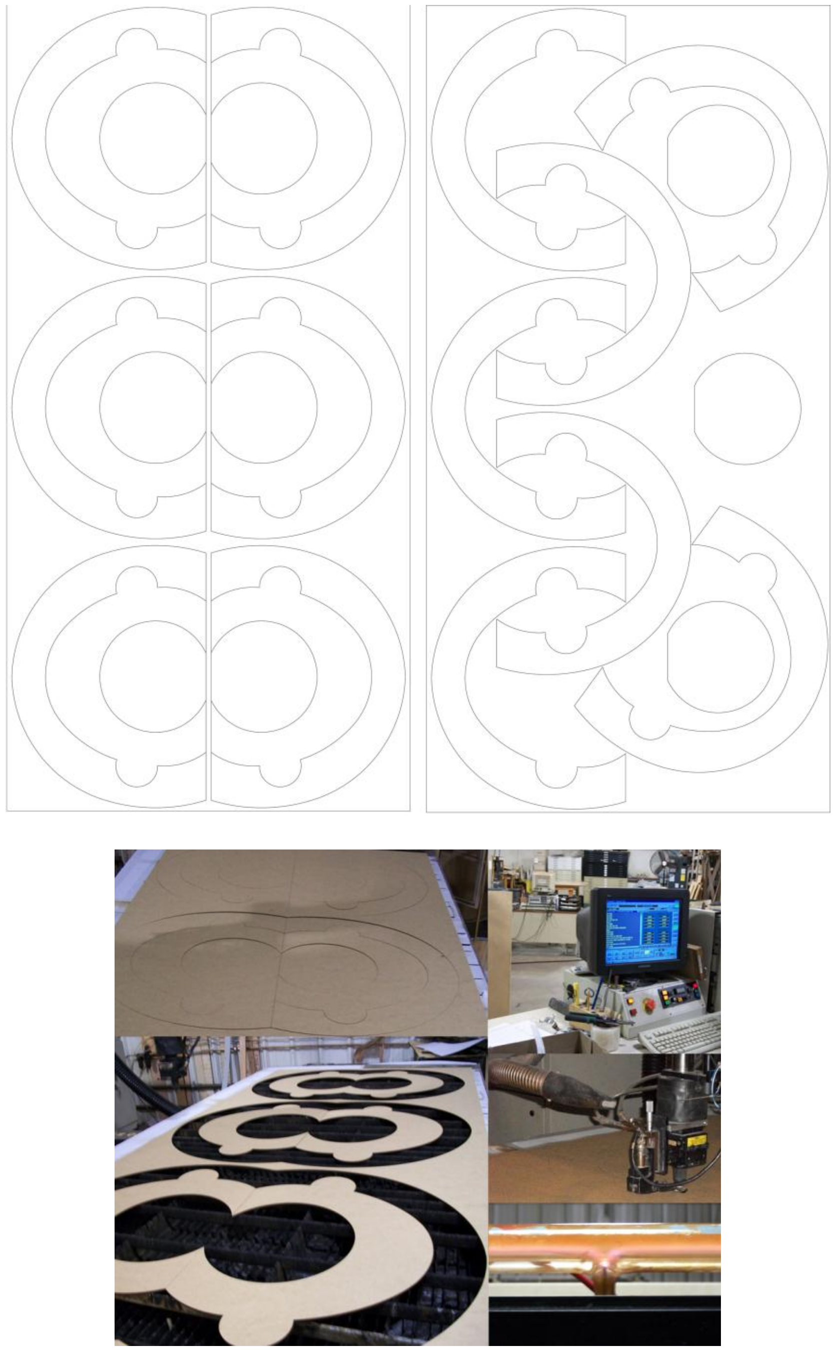


Figure 13. Laser cutting templates and cutting process

Since it was important to me early in my design process to connect the car through reuse and reinterpretation, I purchased parts from a store in Greensboro NC: Automotive Fasteners, who specialize in parts designed for cars. Zinc coated ¼" in diameter fine threaded nuts and bolts were used to make the hard connections, both 3 ½" and 6" in length. In addition to the bolts, I used 6" zinc coated springs that I stretched and then cut in half to cover the connections and to add tension between the chair pieces. I used zinc-coated threaded rods to add support to the base of the chair and to tighten or shore up the MDF pieces (See figure 14, page 62). This chair was constructed primarily in the IARC'S woodshop and partially in the graduate studio space. I placed the final chair in different settings and environments both inside and out to show and study potential use location (See figure 15, page 63). It was evaluated by my peers and professors during a final presentation at the end of the fall 2009 semester. They interacted with the chair, touching it and sitting in it, commenting on scale, shape, comfort, construction quality, and aesthetics.

Figure 14. Production and complete final prototype

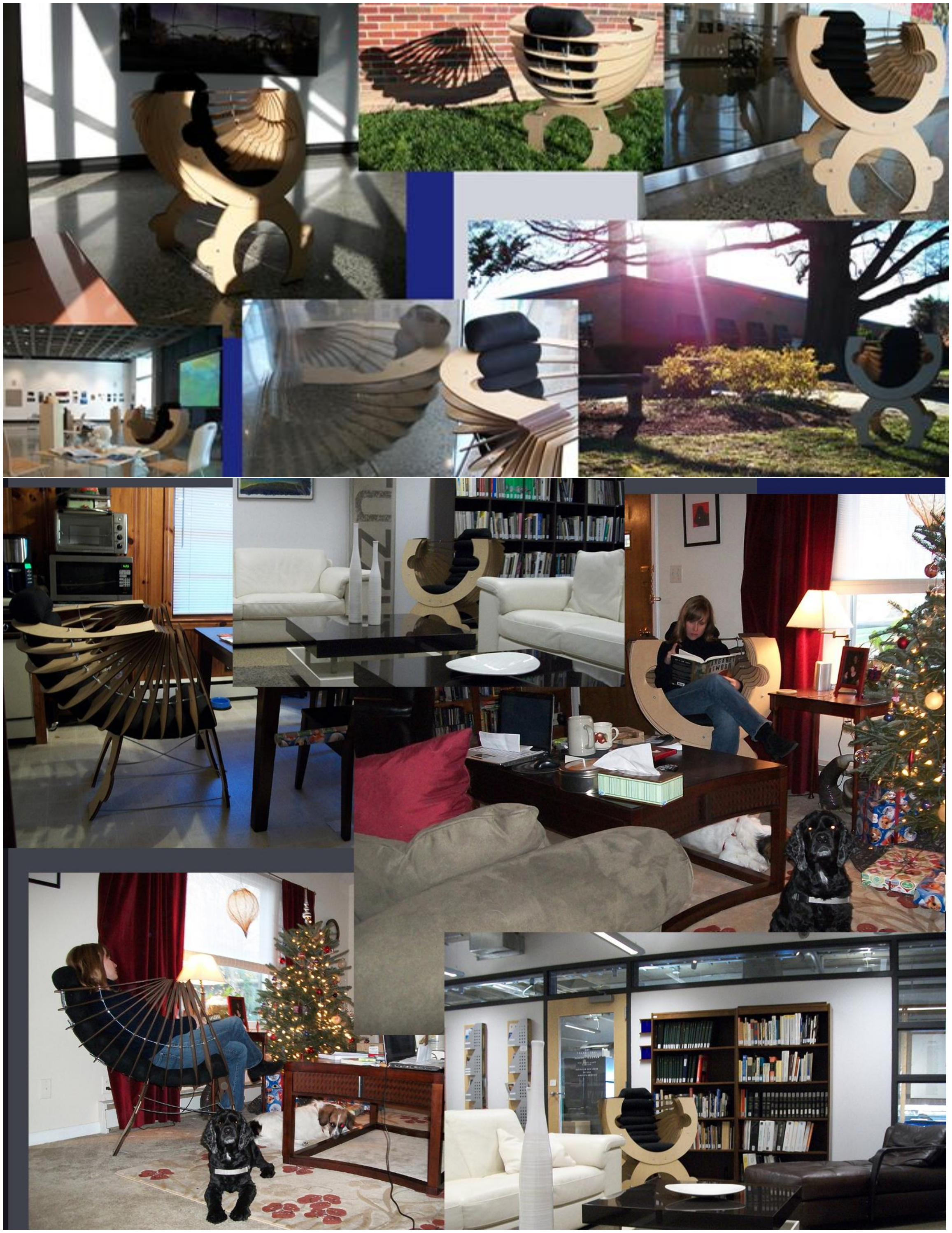


Figure 15. Prototype in multiple settings

Prototype 2, summer into fall 2010

Recognition / Concept Generation

My process quickly evolved from Lewin's car design process after I compared it to the processes I described previously by Cross. I revisited my previous process, evaluating my steps and searching for snapshots to create tween data. The process study and tween development was started during my advanced CAD class during spring 2010, (See figure 16, page 64). Since this was fresh in my mind, I decided to use the information for my summer professional experience with the Center for Design Innovation (CDI) in Winston Salem, NC. The recognition of the problem came from the need to have multifunction seating at CDI.

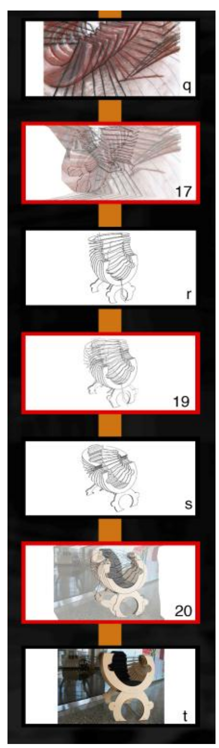


Figure 16. Sample process tween study

Idea generation came from first meeting with supervisor Nickolay Hristov, in which furniture precedents were given by Nickolay and early sketches were created by me to start generating ideas. Concept generation started with informal conversations with my fellow summer grad student interns. My work quickly went from abstract concepts and early sketches to existing seat height studies and early fast digital 3D iterations (See figure 17, page 65).

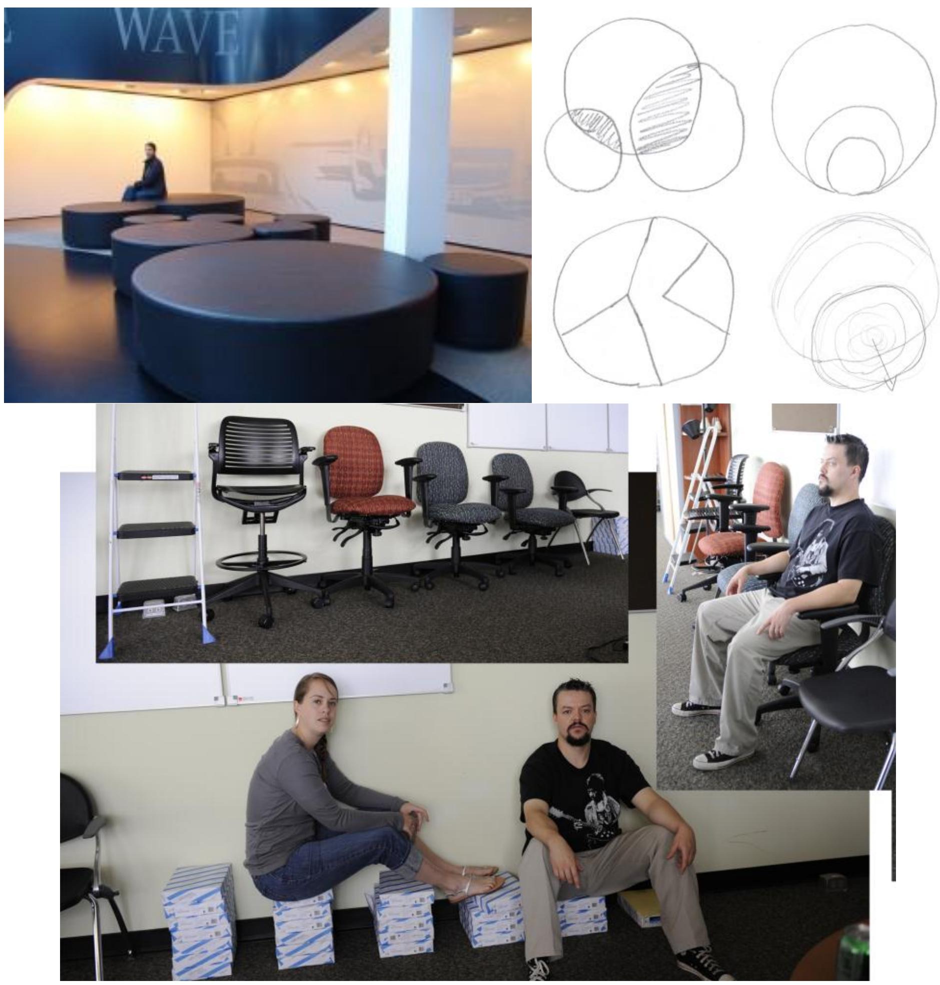


Figure 17. Precedent, sketches, and seat height study

Preparation / Themes Selection

I selected the design theme after the early concept generation was worked out with me and my fellow interns in the existing break out space. To isolate a theme, early on I was inspired by circles from the furniture precedent I was shown by Nickolay, and the discussion of organic shapes after walking around Winston Salem. I soon created profiles from circles and the incorporation of fixed seating heights. (See figure 18, page 67). These profiles were soon developed three dimensionally from lofting one profile to the other in AutoCAD, which created a fluidly shaped object. After working with my fellow interns on documenting the existing space, I quickly increased the creation of multiple fluid iterations. I was trying to keep in mind the evolution from the repeated circle as well as factors such as multiple seating heights. Soon I had several digital 3D models that incorporated repeated circles, organic flow, and seating transitions (See figure 19, page 66).

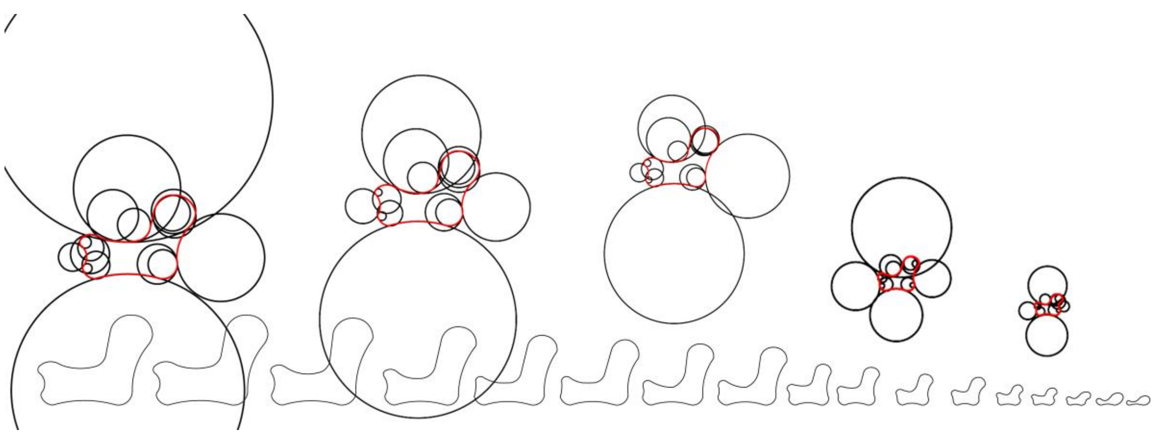


Figure 18. Circles to profiles design

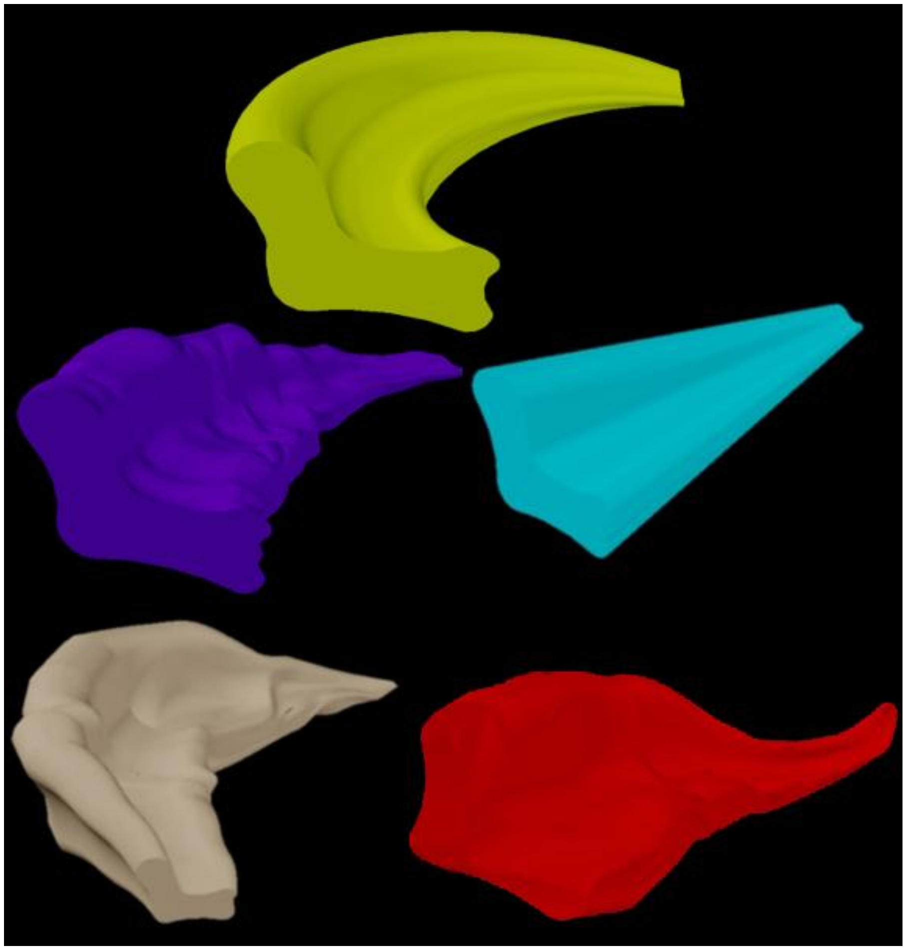


Figure 19. Early iterations

Incubation / 3d and Computer Model Development

The time of incubation came to me after I headed to Sewanee, TN and took time away from the creation of the iterations. After the brief pause, while away, I evaluated the latest design further by adjusting the scale and color for various seating possibilities. Developing the model further, I showed the object in a 3D digital mockup of the space in multiple orientations to show possible seating arrangements as well as possible materials and colors. The design was shown to my colleagues and supervisor, and after I explained the form and discussed possible changes, I final form started to make since (See figure 20, page 68).

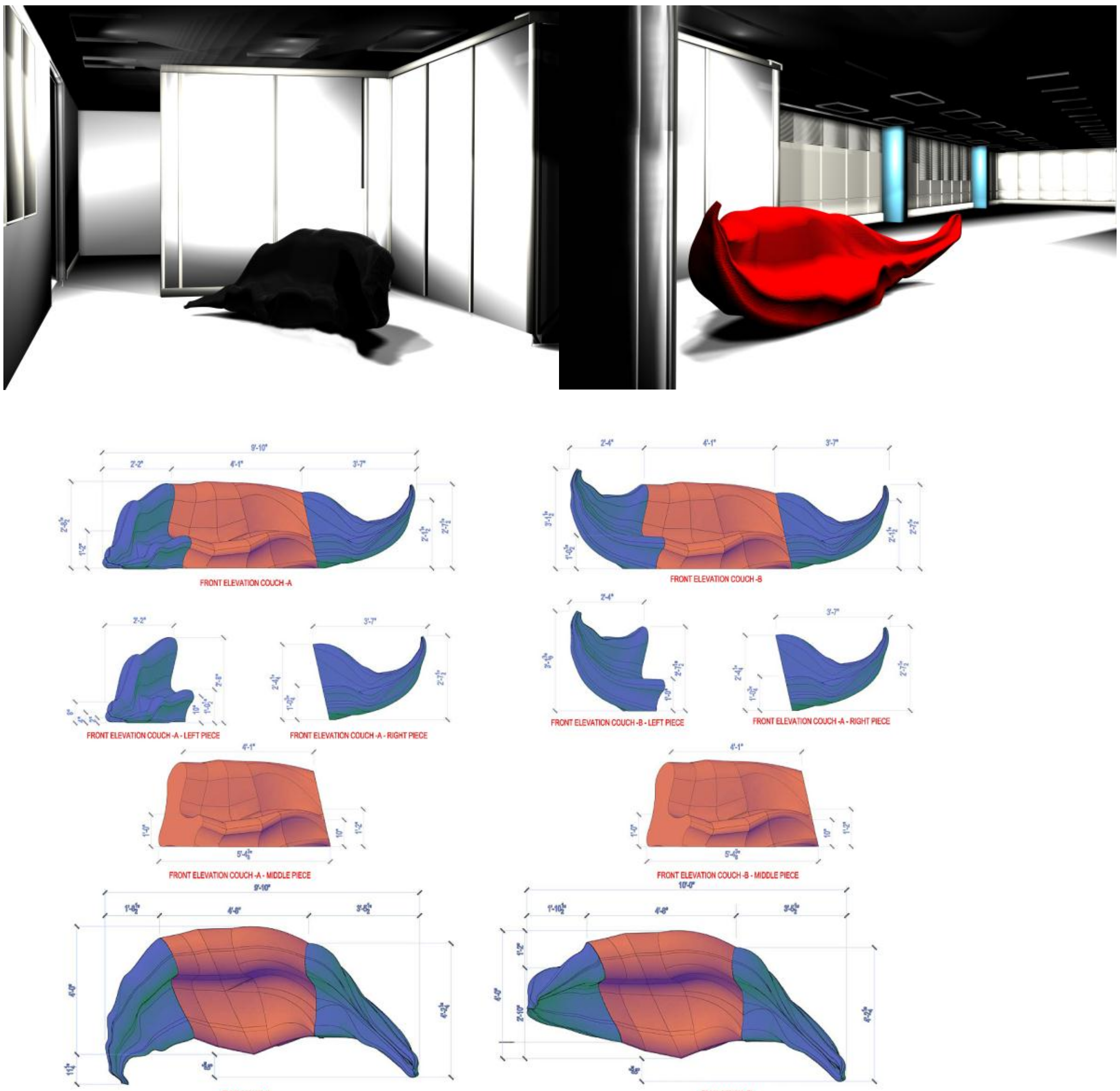


Figure 20. Later iteration further studies

Illumination / Design Evaluation

My second prototype design “ah ha” moment came after I reviewed the iterations and decided to further explore the last and most evolved iteration. I decided to create a last digital 3D model that covered some of the concerns of the space by curving more around and adding side support and an arm rest. The computer model was important because a dimensioned model would aid in final construction. The model was shown in a variety of locations within the breakout space with a fellow intern to show scale and optional seating possibilities. Potential materials and construction were rendered in 3ds Max to create simulated accuracy (See figure 21, page 70, 71). This allowed me to finalize the form without constructing multiple prototypes. A 1”=1’ scale prototype was created from a 3D printer out of solid acrylonitrile butadiene styrene (abs) plastic resin (See figure 22, page 69).

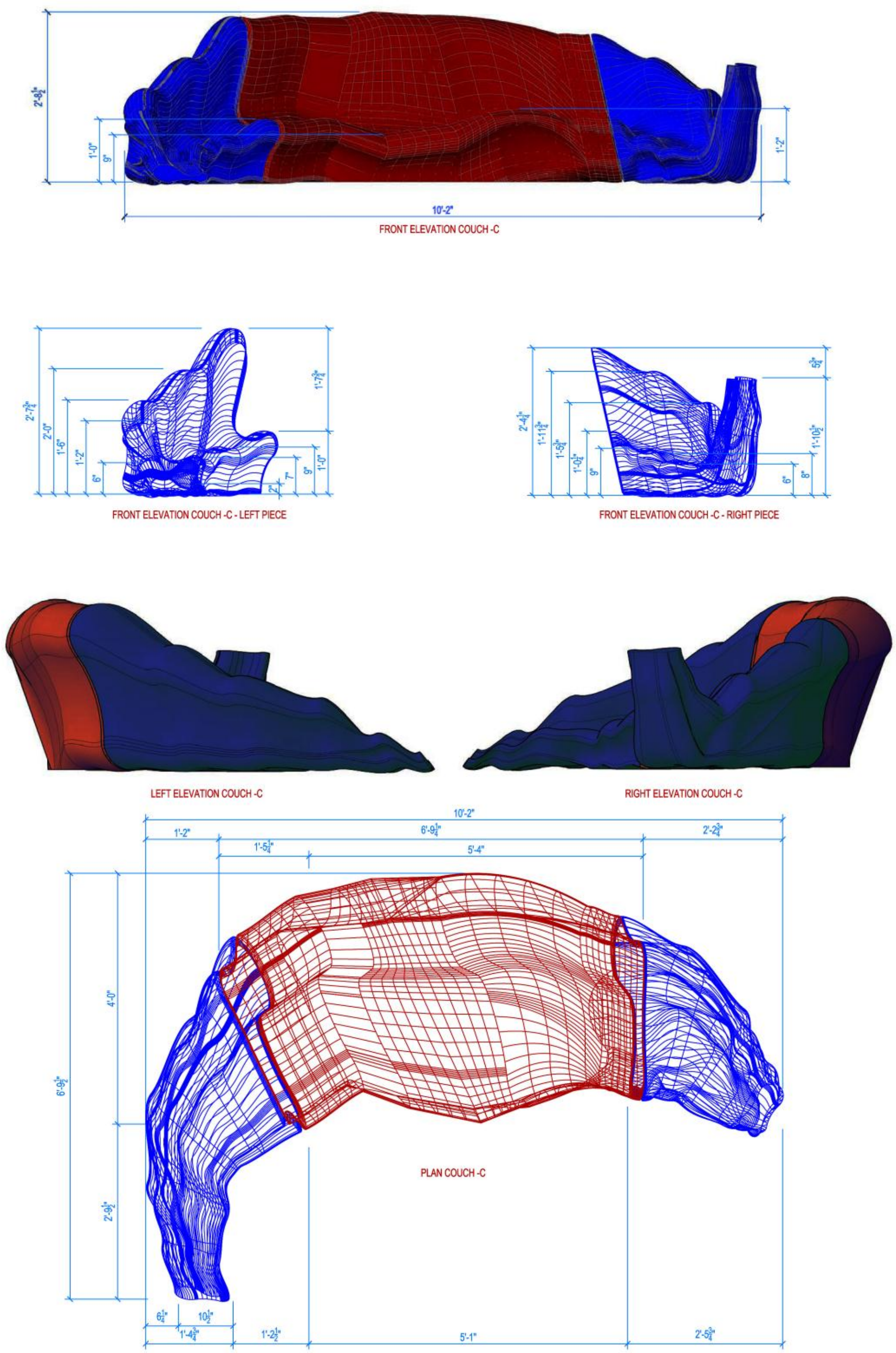


Figure 21. Final, summer 2010, object design analysis

Figure 22. Final, summer 2010, 1”=1’ ABS model

Verification / Prototype Development

The construction and development of my second prototype was begun and then completed during the first part the fall semester of 2010. It became clear, after discussions with my graduate committee and studio professor, that carving from a solid piece of foam would be the best technique to achieve the accuracy of the organic shape of the seating design. I chose to use closed-cell extruded polystyrene foam because it is 100% recyclable, light weight, easily carved, easily sanded, and paintable. I cut the large block down into smaller blocks with a chainsaw, then carved and sanded the smaller blocks using hand rasps, small hand saws, and an orbital sanded (See figure 23, page 72).

Figure 23. Cutting, carving, and sanding the foam into the design

I finished carving the block into the final form, referring to the CAD drawing that that was open on my computer as I worked. Using my own creative license, after discussing the form with my studio professor, I changed details of connection, size, and shape but I did not change the original digital model. Initially I planned on wrapping the extruded polystyrene with softer medium density upholstery foam and then fabric, so the overall scale was decreased slightly by 10%. I made final adjustments after seating trials were done, marking the places for recline and/or seat placement (See figure 24, page 73).

Figure 24. Final adjustments from seating tests, and final painted model

After several attempts to apply foam and then fabric, I decided to paint it with a rubber paint which was flat black, but I later decided to change it to a flat white low voc paint after the advice of my studio professor and part of my committee. I decided to show different color options digitally using Photoshop (See figure 25, page 74).

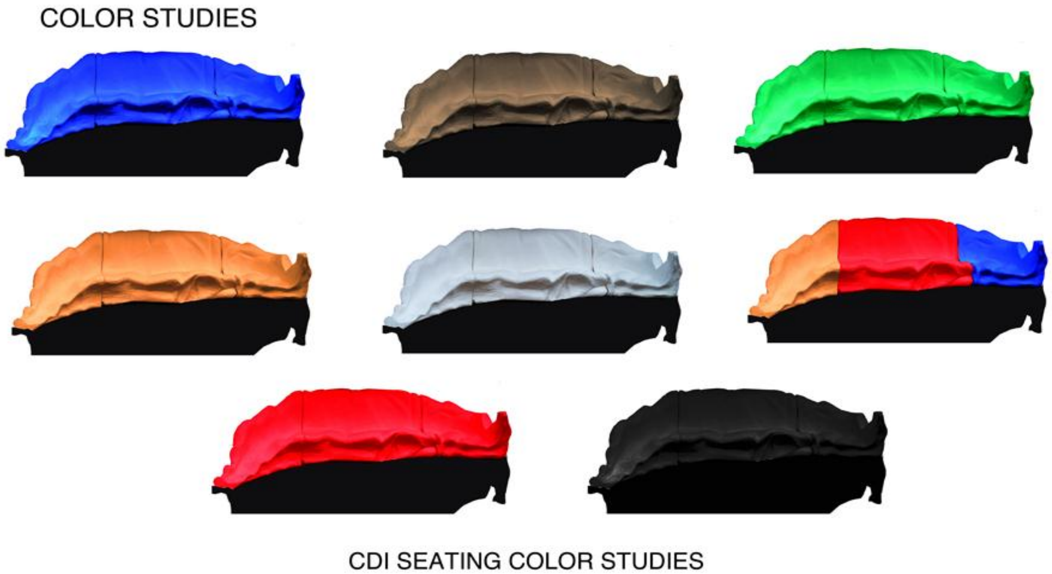


Figure 25. Color studies

I collected final snapshots of my design process to be used for tween creation to inspire design ideas for a new prototype. Below are just the my chosen snapshots, the tweens were used as part of the concept generation for the third prototype (See figure 26, page 75).

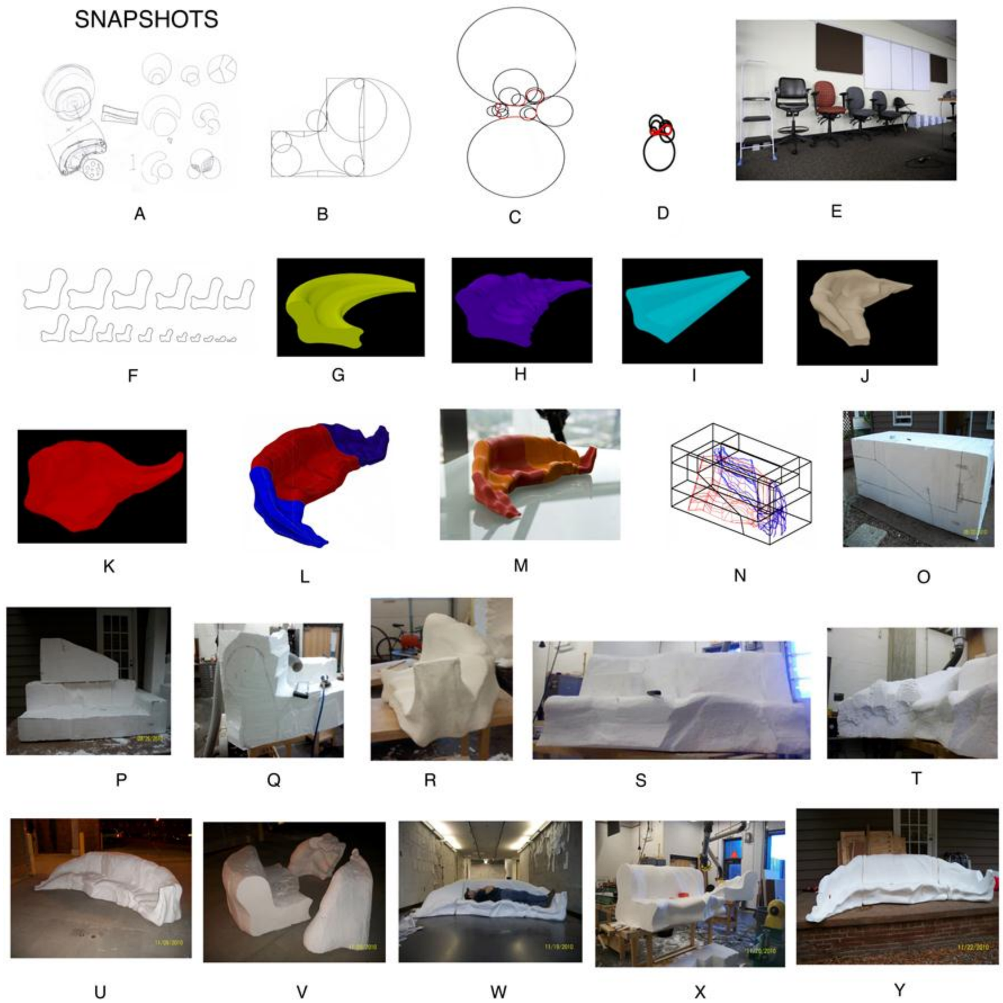


Figure 26. Design process snapshots from summer and early fall 2010

Prototype 3, later into fall 2010

Recognition / Concept Generation

My design problem recognition for my third prototype was from the question of, which if any of the created tweens from the morphed snapshots would or could generate design ideas? I had chosen twenty-five snapshots, shown earlier, from the design and creation of the second prototype and the morphed, using Morpheus, into twenty-three tweens which are shown below (See figure 27, page 76).

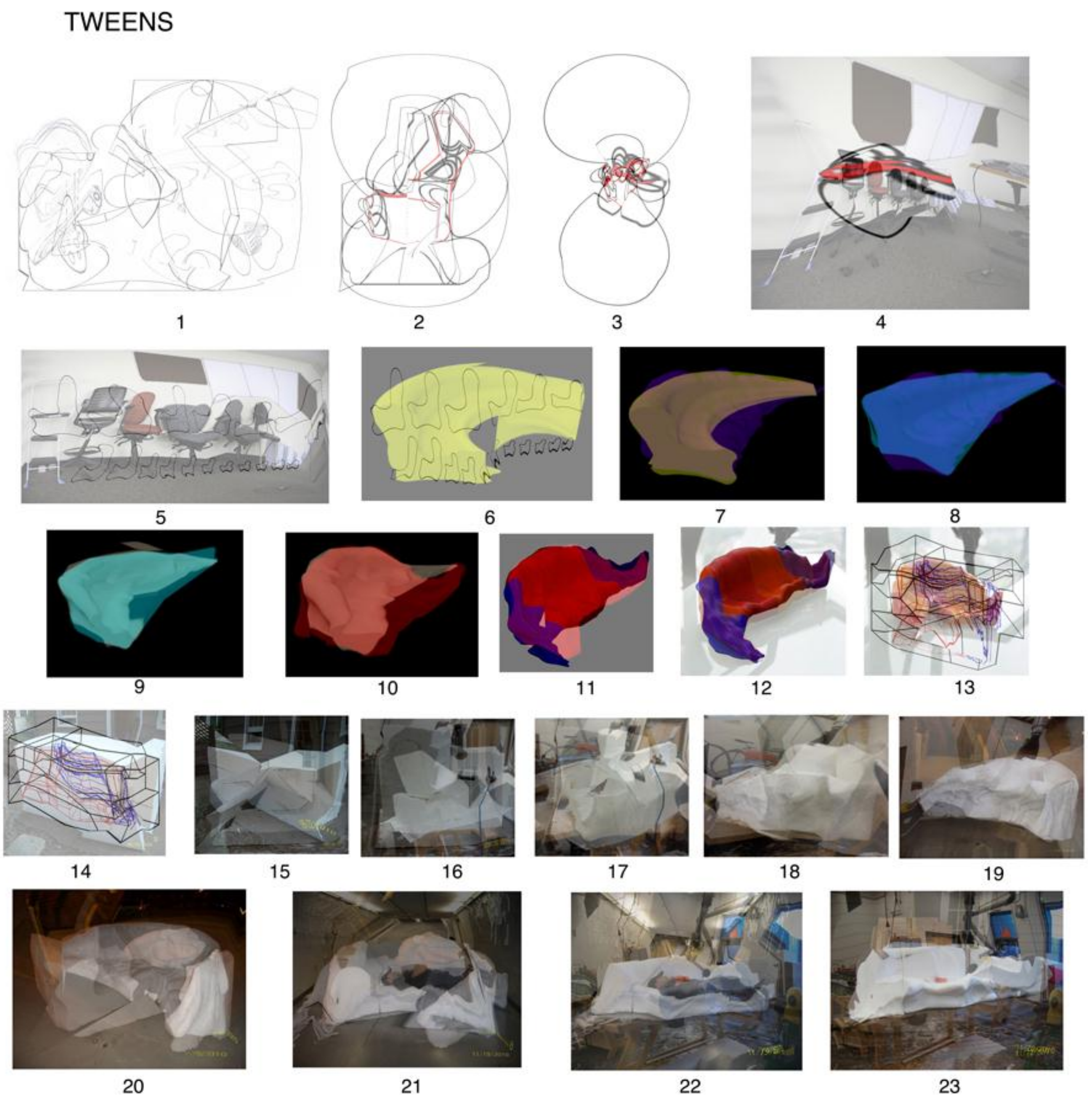


Figure 27. Design process tweens from later fall 2010

My idea generation was inspired from the tweens, but not all of them and not directly. The inspiration came after I chose a few to analyze further. It was important to figure out a selection process, so I started by separating a few tweens from the twenty-three using some basic guidelines that I created, which are explained in the next section. The tween manipulation started as 2D color studies to isolate shapes that could potentially become 3D forms, and later were manipulated three-dimensionally.

Preparation / Themes Selection

The selection of the theme was completed after the tweens I analyzed and manipulated them further. This led to the main design element becoming three-dimensional. I started the tween study going from 2D to 3D manipulation. They were isolated using the following criteria: visual uniqueness of morphed tween, contrast between lines and shapes, color or shades of gray, evolution of shapes and or forms, feasibility of potential form, and potential functionality. This came from early versions of tween creation, but as my process grew, I chose more snapshots, to which newer and more tweens were created for study in a digital three-dimensional space (See figure 28, page 78)

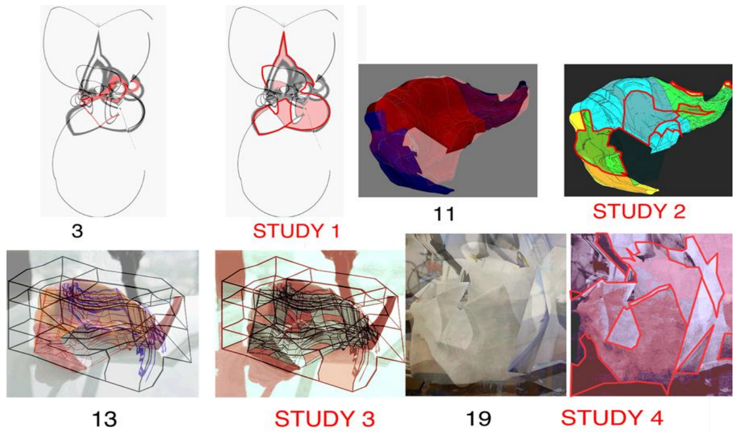


Figure 28. Early tween 2D analysis

The final tweens that I finally chose encompassed more of the process, which created a larger variety of new distinct images. I chose tween 3 and 16 t, shown below, bringing them into 3ds Max to manipulate further (See figure 29, page 79).

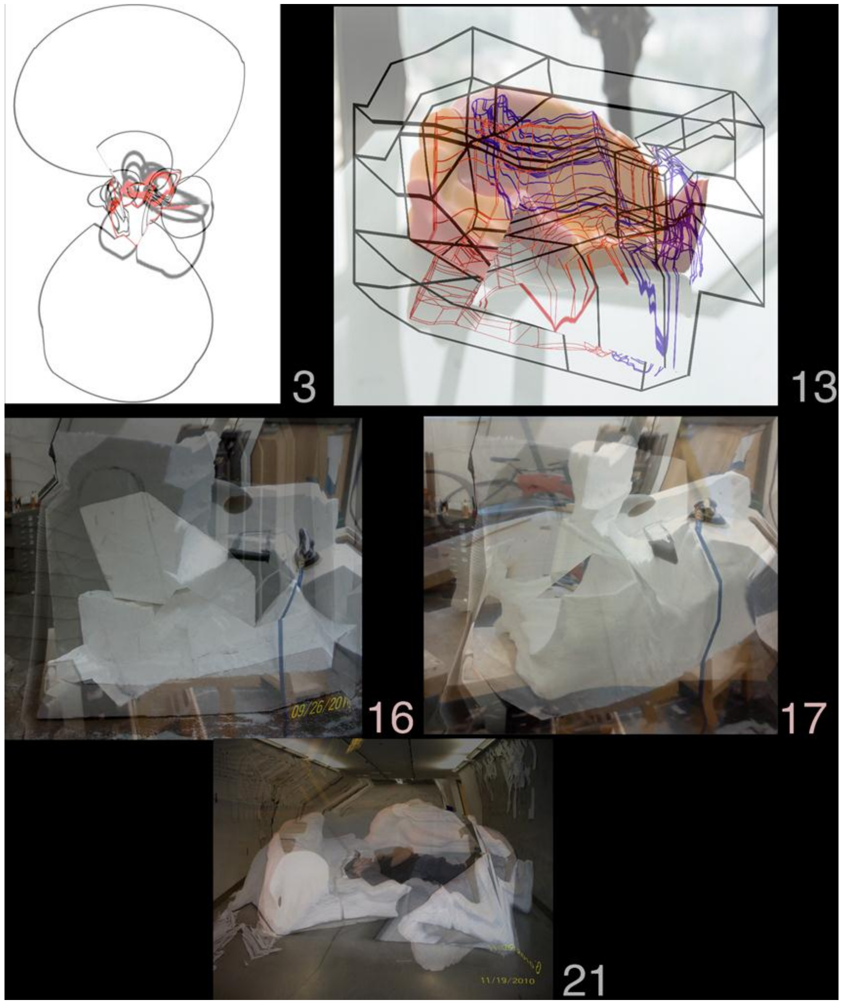


Figure 29. Later Chosen tweens

Incubation / 3d and Computer Model Development

With this design process, I had a little time of incubation to mull over the Legitimacy of the 3D tween forms and whether or not they could be carried further into the production phase of a prototype. After choosing two to carry ahead, using the same criteria as earlier, I decided to manipulate the images further. I decided to place the 2D tween studies into 3ds Max by attaching the image to a cv surface that was converted to an editable mesh with 150 plus movable vertices. I created a template, from the previous profile from CDI, that I placed in 3ds Max to control scale, seating height and recline to meet typical chair size and ergonomic factors (See figure 30, page 80).

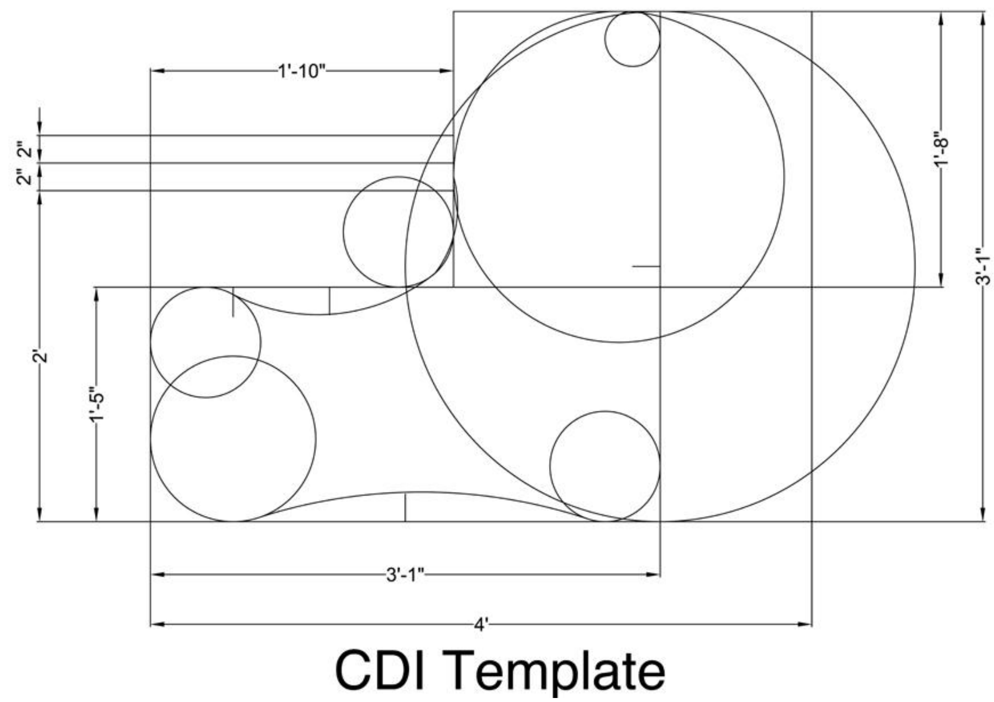


Figure 30. Two chosen 3D tween manipulation

This process created a way for the tweens to become 3D forms more related, at least in size and reclines, to something that could be further manipulated into final digital 3D furniture (See figure 31, page 81).

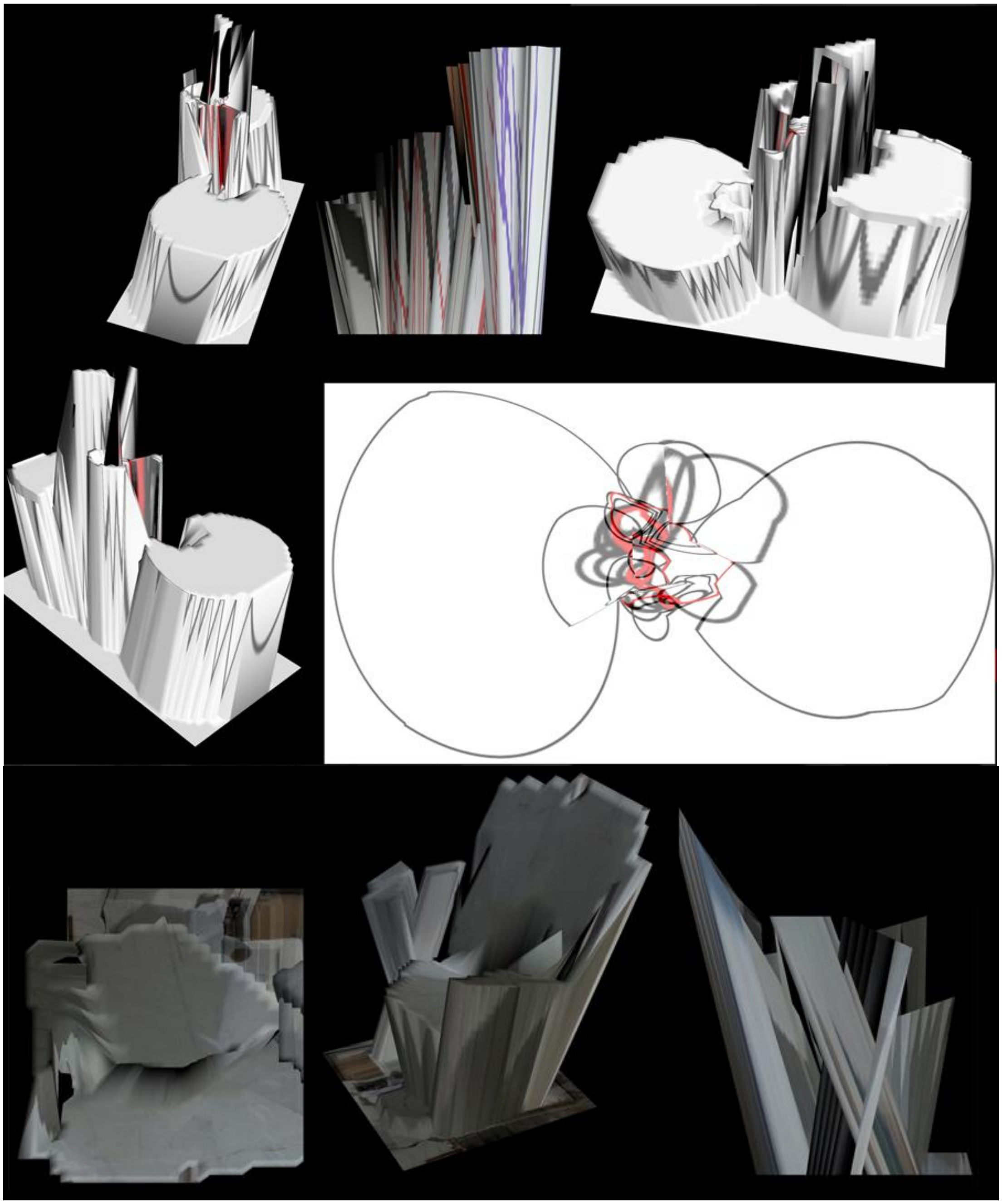
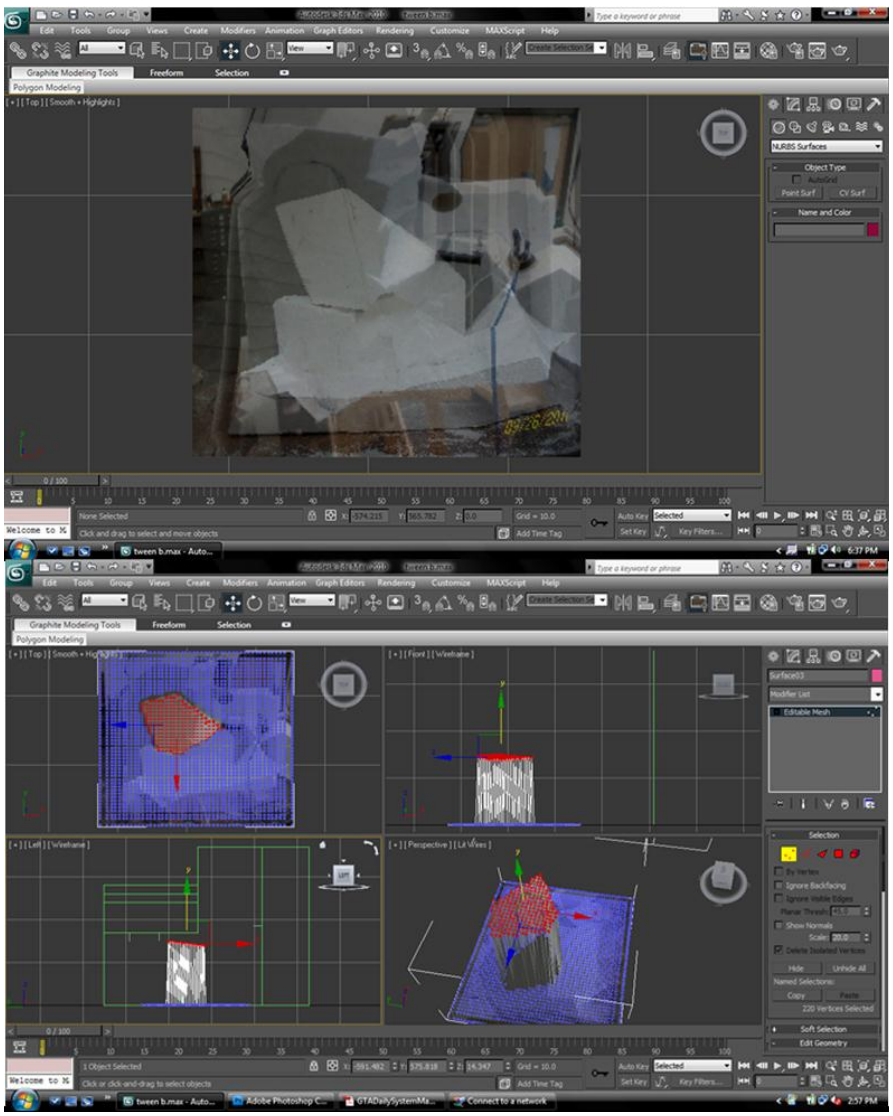


Figure 31. Two chosen tweens

Illumination / Design Evaluation

The “ah ha” moment came after I realized that the manipulated tweens were made of triangles. When the vertices were stretched into a 3D form creating a skin of triangles, I decided to create a prototype that not only mimicked the form but shared the triangle skin. I choice to take distorted tween #16’s mesh and develop it into a potential chair (See figure 32, page 83).



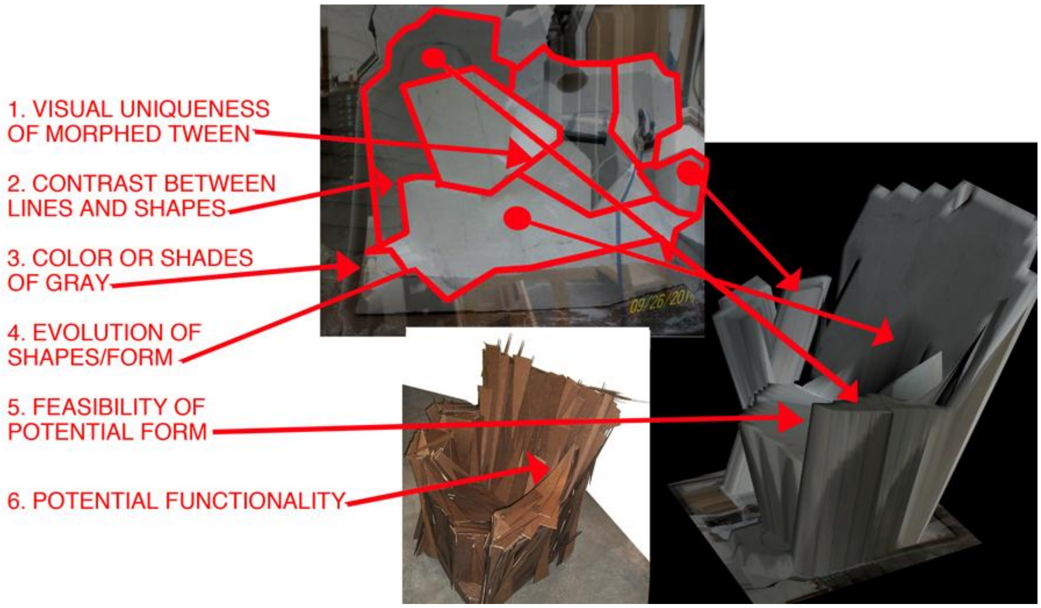


Figure 32. 3D tween manipulation to prototype form

I continued by creating a template to use with a laser cutter to create the triangles. I also further evaluated the final 3d model from the previous template adjustment that was made in 3ds Max. When I brought the model into AutoCAD, I made more adjustments to fine tune the chair's recline, scale, and final seating height, all of which translated to the final prototype and final drawings that aided in construction (See figure 33, page 84).

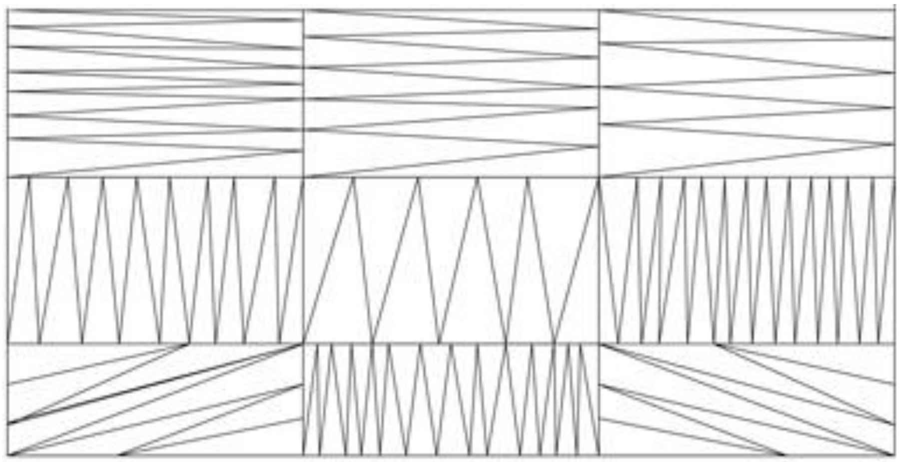


Figure 33. Laser cutting template

Verification / Prototype Development

After I completed the construction and development of my third prototype my final models and designs were evaluated. I decided to use a 100% recycle material called hard board, or HDF, which is made up of reused wood fibers glued and pressed into flat sheets. After I dimensioned the final computer model in AutoCAD I used the information for guidance in building the prototype. Once I started creating the final object, I made decisions to change aspects of the design as I realized that the triangles would not create the mesh look shown in the computer. Although the scale, seating height, and recline angle matched the computer mockup, the skin defining the final shape and form changed as I overlapped a series of triangles to create a more textured surface. You can clearly see how the form evolved from the digital model to the prototype in the templates below (See figure 33, page 85).

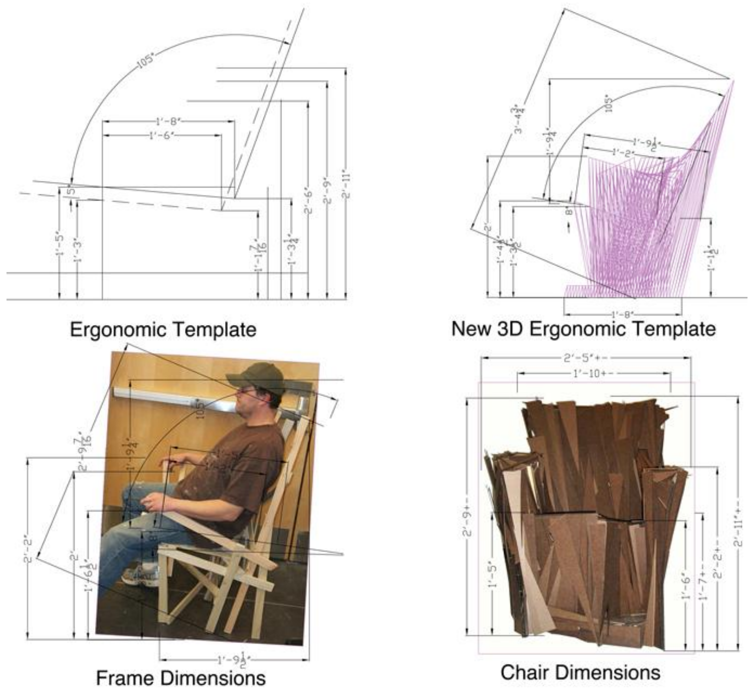


Figure 34. Digital and prototype templates

The final full-sized prototype verified that the tween study led to design idea generation. The path was not straight, but the form that was built mimicked the final digital model closely, which came directly from the tween analysis. I feel that during the actual construction of my prototypes up till now, changes were allowed to happen during the making. This is, I believe, should be fine and encouraged, because these final last-minute touches make the prototype more unique and frees the form away from the computer. I used pin nails in an air finish nailer to attach the triangles because they grabbed the hard board better and because they left less of a mark than the typical finish nails that I tested (See figure 35, page 86).

Figure 35. Prototype construction

Prototype 4, spring 2011

Recognition / Concept Generation

The last prototype started with a suggestion by my committee members to go back and look at both the design and the construction of the final form of the second prototype. My recognition of the design problem was how to evolve from the second prototype but keep with the idea of an organic sweeping seating object. I decided to go back and look at the profiles that I used to make the digital 3d model in AutoCAD originally. After looking at the profiles, I decided to simplify the previous polyline CAD profiles by converting them to splines in AutoCAD. By using the default settings in AutoCAD, I was able to generate more simple organic forms (See figure 36, page 88).

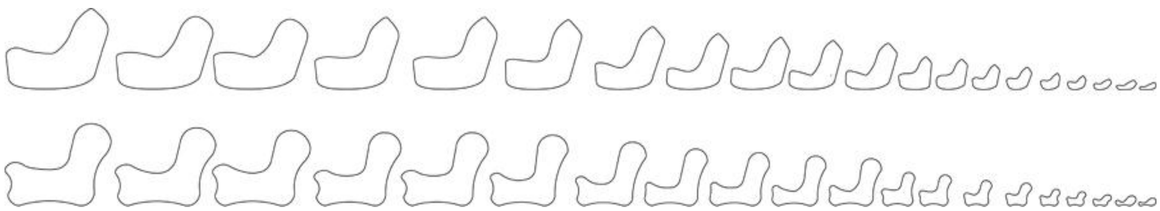


Figure 36. Outline transformation from second to fourth prototype

So after revisiting the process that led to the creation of the second prototype, I generated a concept that was consistent with my previous processes but basically skipping the early sketching and idea generation. I was able to go from the one process to the other because the previous finalized form was to be the inspiration, which meant I could start creating multiple 3d models in CAD, closing the gap from preparation / themes selection to incubation / 3d and computer model development.

Preparation / Themes Selection

My theme came after my 3d cad iteration were started. I started by preparing all the profiles for lofting in AutoCAD and then I started moving and rotating them to create various early forms. This was the same technique that I used to generate early forms for the second prototype. In the beginning, I chose the profiles starting on the left and moving right, picking every other one to create somewhat of a free reaction to the previous design. This time I had the previous prototype design to start with, which gave early precedent for scale and shape. I was able to prepare the forms further by comparing them to two solids that represented two basic couch scales ranging from 38”x40”x82” to 34”x36”x78” (See figure 37, page 88).

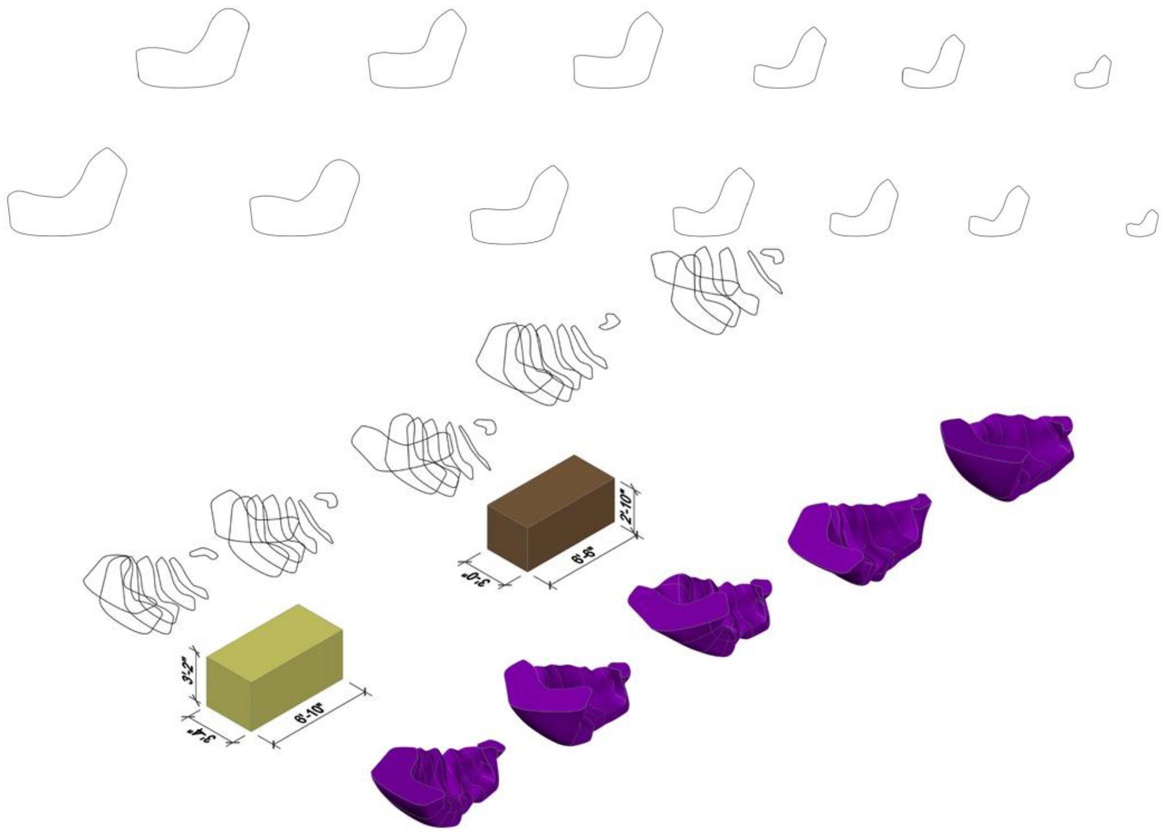


Figure 37. Early CAD iterations

Incubation / 3d and Computer Model Development

The time for incubation came halfway through the creation of the iterations. The iterations were evolving but I knew I had to control the creation of the form more precisely. I realized my creation was lacking in a clear direction, so after speaking to my committee members, it dawned on me the ergonomic and human scale information was unclear and could provide a way to control the form. I decided to look at some ergonomic information provide online for free by *Herman Miller and Egrotron. Herman Miller* did an angle of recline study, stating, “A work chair’s movement should mirror the user’s movement. Tilt is to a chair what suspension is to a car” (Caruso, Dowell,, & Gscheidle, 2005, pp. 1, 3). Referencing their study article *Supporting the Biomechanics of Movement: The Science and Research Behind the Harmonic™ Tilt,* I used the recline angles and contour shape from the charts they developed (See figure 38, page 89).

Figure 38. *Herman Miller* reclines and body contour form

I tried adjusting the forms by subtracting a solid created from the lofted contour shapes but did not get the desired affects I imagined, so I had to rethink how to use the ergonomic information forms using *Egrotron’s* interactive seating and workstation heights, where one can use “The values displayed [to] help you place your equipment for optimum ergonomic comfort” (“Ergonomic Workspace Planner, Workstation Installation Tool,” n d). I started with my height at the middle and move back to 5’2” and move forward to 6”-4” to encompasses a larger range of human scale, and I also decided to add a fourth more reclined angle to the *Herman Miller* angles. (See figure 39, page 90) (“Ergonomic Workspace Planner, Workstation Installation Tool,” n d).

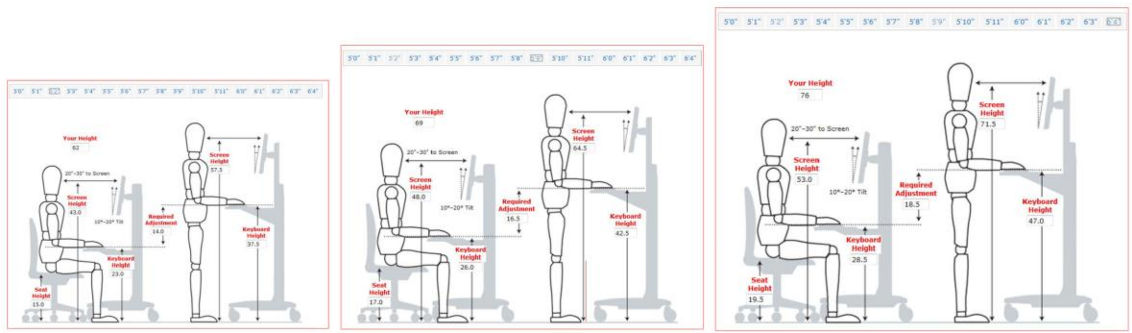


Figure 39. Ergonomic recline, seating, and work surface information, *Egrotron*

Illumination / Design Evaluation

During the design process of my last prototype, the “ah ha” moment came after I realized that I could incorporate the ergonomic information from both *Herman Miller* and *Egrotron* into the profiles themselves. This created a method to create and control the form by scale, angle of recline, and shape (See figure 40, page 90).

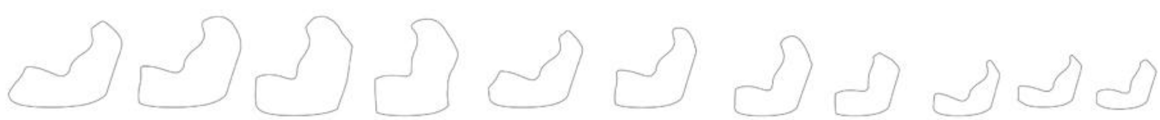


Figure 40. Ergonomic embedded profiles

I was able to create more iterations, but this time the scale and recline were embedded directly into the profiles so in turn became embedded into the 3D forms (See figure 41, page 91).

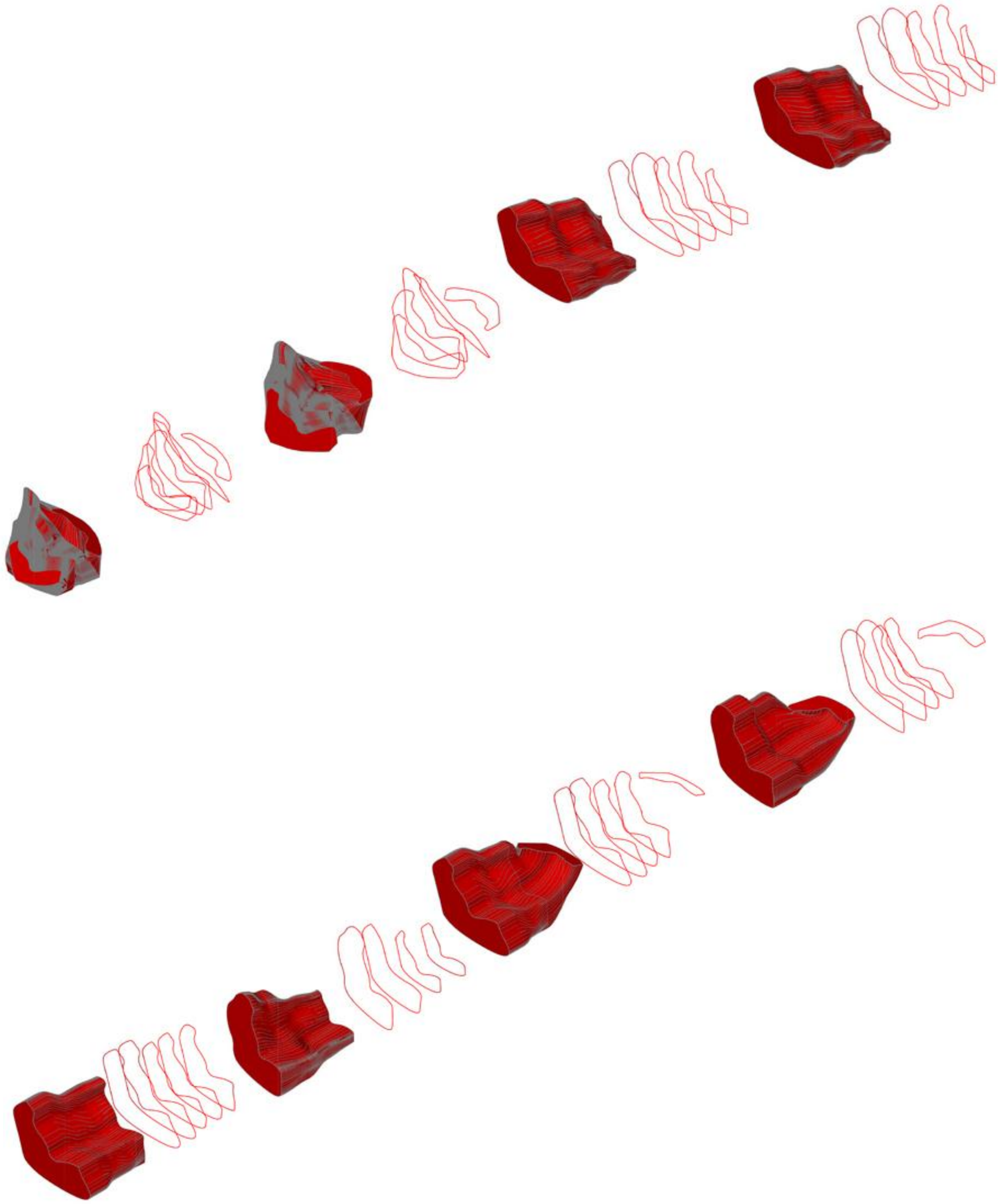


Figure 41. Ergonomic embedded 3d iterations

I further evaluated the design by isolating three forms to use to create templates to aid in future construction. I chose three different forms to created three a 1”=1’ scale models. I made templates that I later cut out on a laser cutter. I later decided to only make only two (See figure 42, page 92).

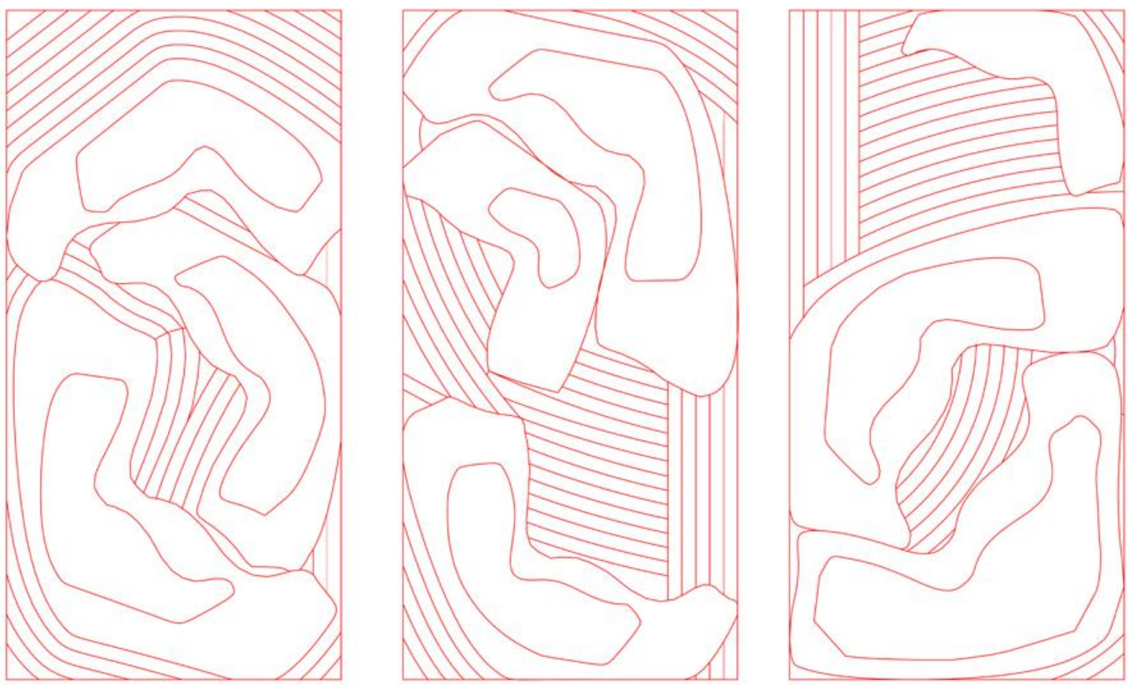
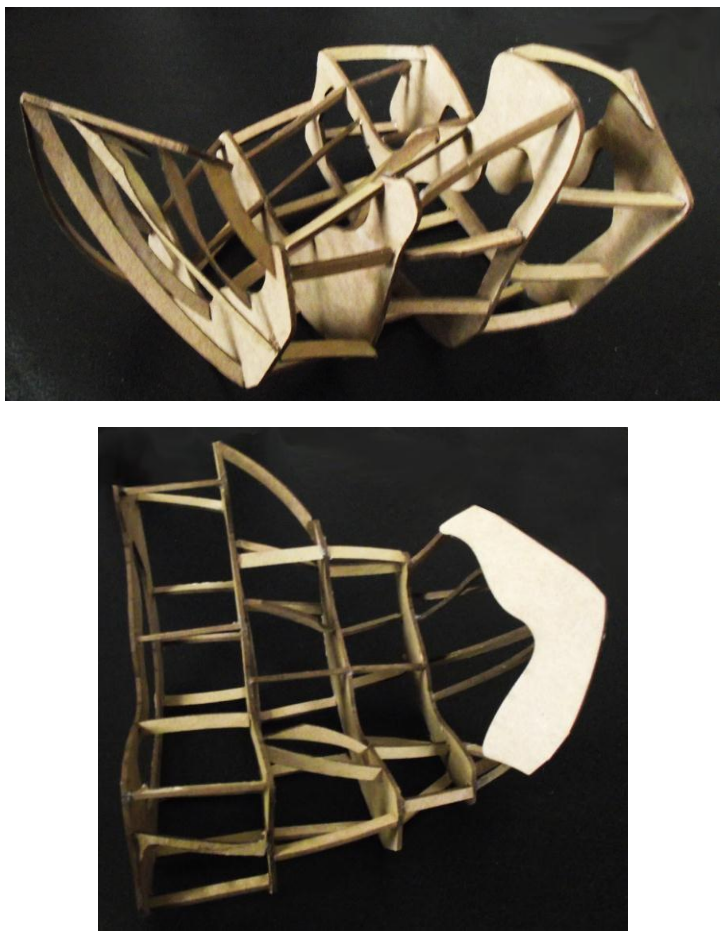


Figure 42. Laser cut templates for scaled models

I stopped at two scale chipboard models because after I made the second one I decided that I liked the first one better. When I showed the chipboard model to each member of my committee, they agreed the form was worth carrying further into prototype development (See figure 43, page 94).

A

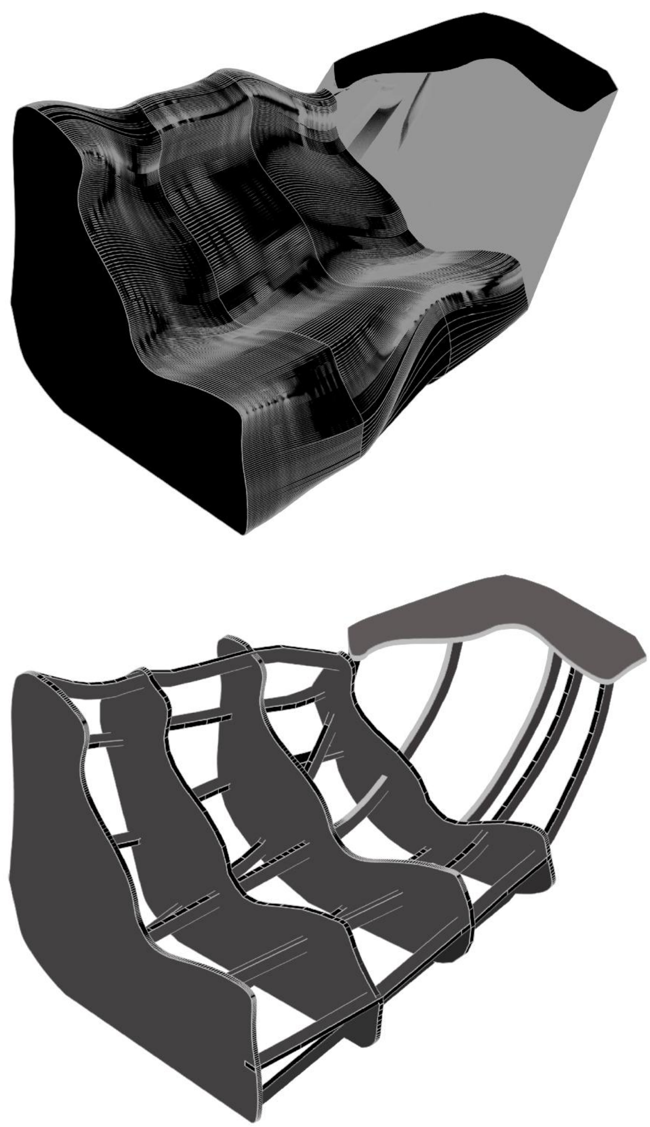


B

C

Figure 43. A: 1”=1’ template, B: first model, and C: second model

After I decided to move further with the committee preferred scale model, I chose to simplify the form in AutoCAD by creating a 3D digital mockup of a potential structural frame. I quickly figure that a since existing cabinet grade solid wood precut pieces were too expensive and limited in length that using cabinet grade sheet goods would make more since on creating a full scale prototype. So when I was designing the frame in the computer I chose to make my frame pieces two inches wide by ¾” thick since it was slightly bigger and would be as strong as the solid wood precut pieces that generally come as 1 ½” wide and 1/2” thick (See figure 44, page 96).



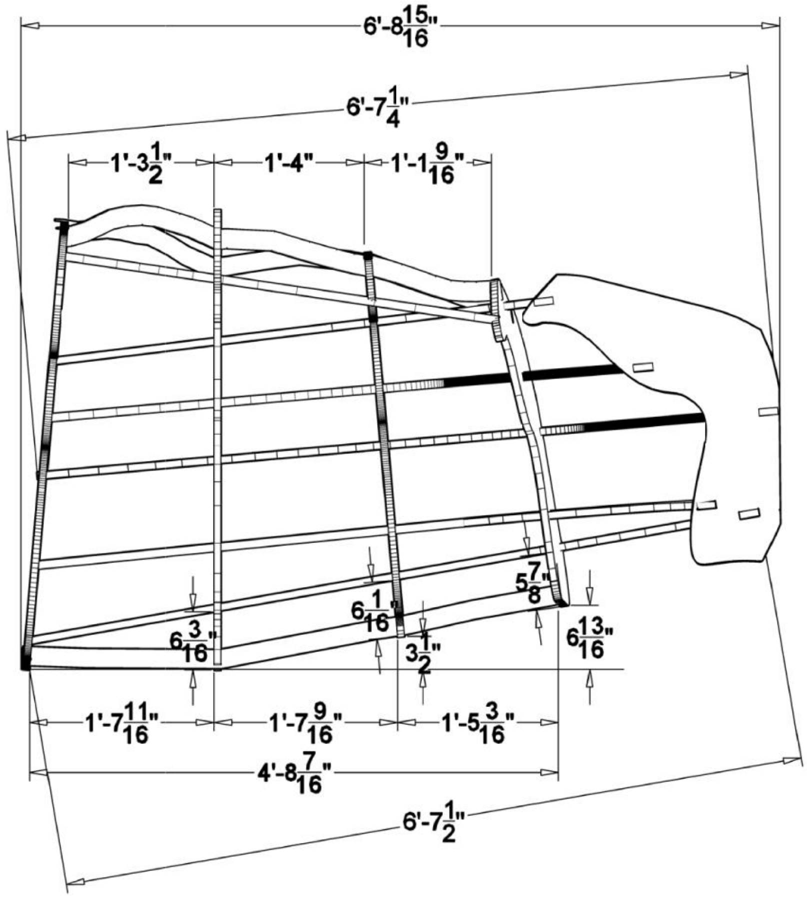


Figure 44. 3D digital mockup of a potential structural frame

Verification / Prototype Development

The construction and development of my last prototype was completed after the final 3D computer designs were evaluated by me and my committee. It became clear, after discussions with my committee that I needed to figure out what sheet good to make it out of. Since I have managed to design and make three full-scale prototypes that have all dealt with aspects of sustainability, I wanted to continue by making the final object out of all green materials. After exploring bamboo plywood as an option, I ultimately chose to go with formaldehyde free and forest stewardship council (FSC) certified plywood. This was due to its availability and its much lower cost as compared to the bamboo product (See figure 45, page 97).

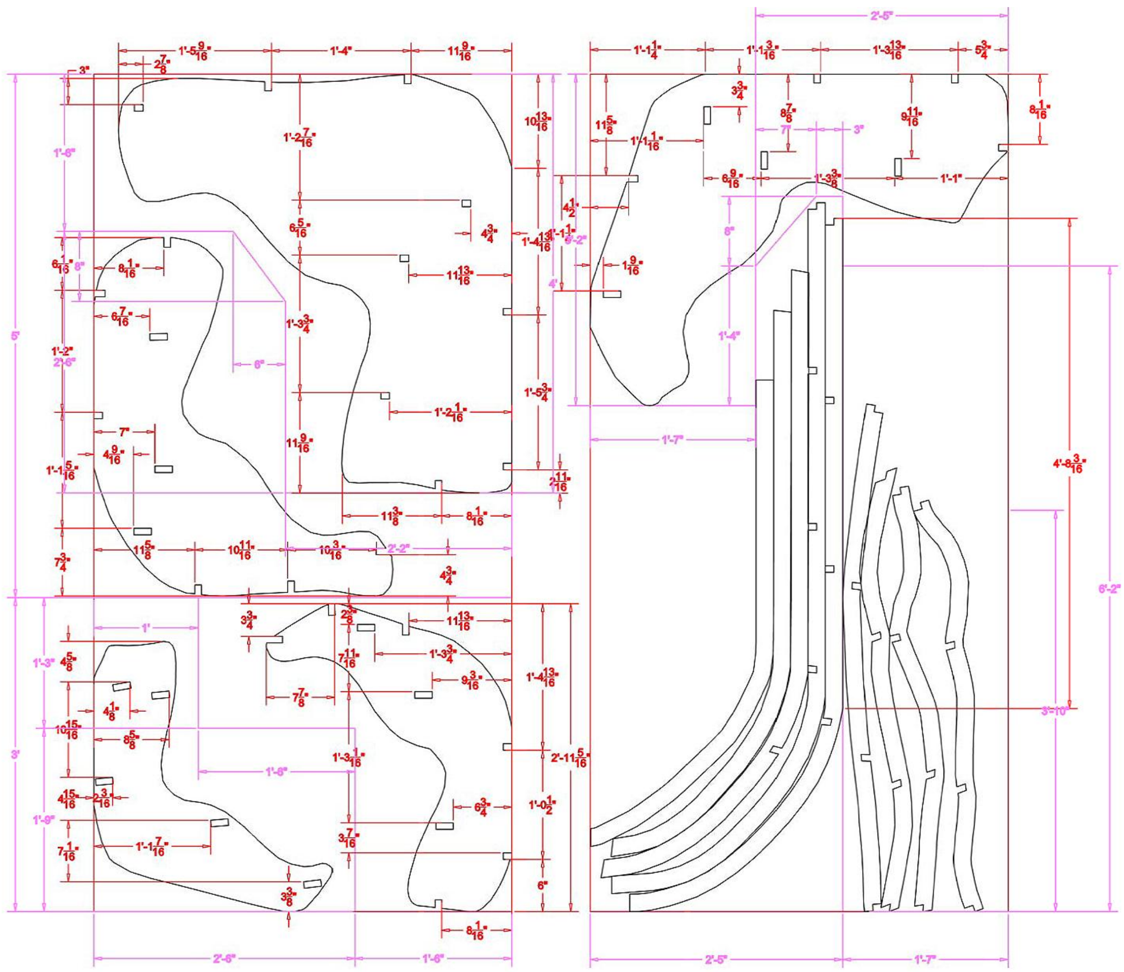


Figure 45. AutoCAD templates

I created templates to use for a CNC router, but later I had to dimension them in AutoCAD to aid in hand drawing the profiles onto the sheets of plywood. This was due to losing access to the router after the plans were already were set in motion. I was able to draw the profiles on the sheets and cut them out using a table saw, band saw, drill, and jig saw (See figure 46, page 99).

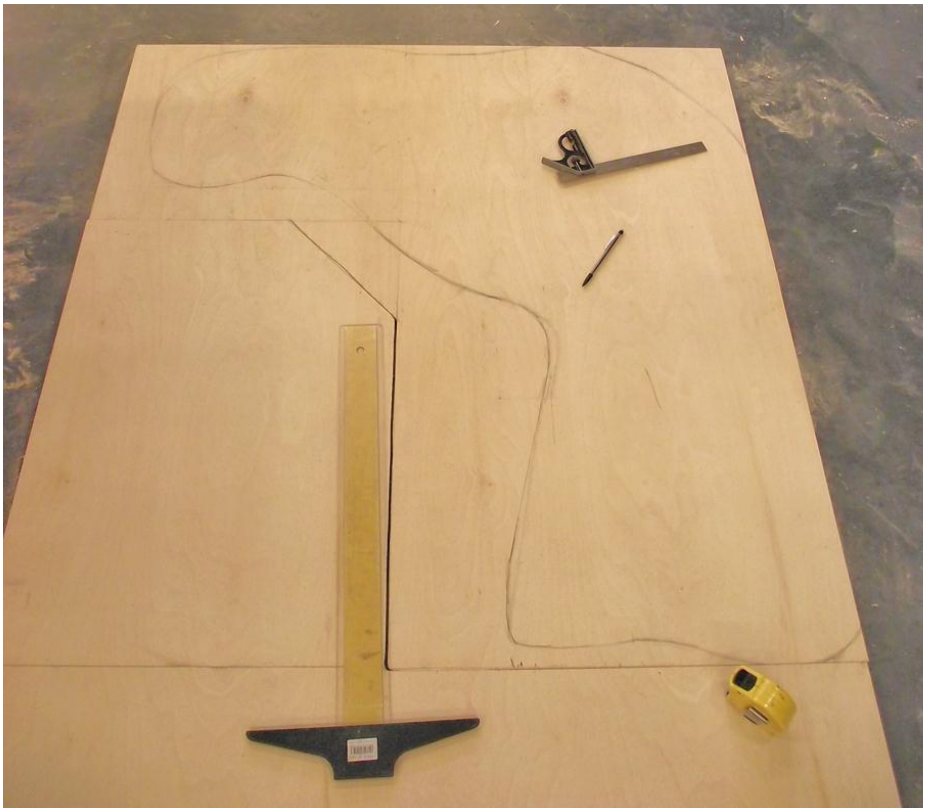


Figure 46. Plywood templates and cut pieces

I had to adjust each connection after the initial cuts were made due to the complexity of the organic form and the multiple angled connections. I chose to only design the frame in the computer, leaving free creative license in how I would solve the seating area including size location and appearance (See figure 47, page 100).

Figure 47. Plywood frame construction

Waiting to complete the final design was also due the nature of the complexity of form so I waited until the frame was completed before I truly was able to understand the shape in full scale.

After I completed the frame my committee and I set around the project and we discussed possible cover material options and installation techniques. Before the meeting I experimented with different combinations of soy blend medium density upholstery foam with rubber sheets or inner tubes and chipboard. I decided to show my committee foam with rubber inner tubes and one ply cardboard with a thinker layer of paper on one side (See figure 48, page 101).

Figure 48. Seat cover and cushion tests

After I met with my committee it was clear that I should go with just the rubber inner tubes for the cover and cushion. This was due to a number of factors, by using just the tubes I was able to emphasize the form more by not covering it up as much. By retrieving recyclable rubber from the waste stream of bicycle shops, I added to the sustainability of the piece at the same time minimizing the cost since the inner tubes were free. I also determined that the cushion from foam, added to the top edges under cut open inner tubes where the seating would occur, combined with the stretch and spring of the tubes was enough without adding more foam. Although more foam would add more cushion I thought, after getting the consensus from my committee, that the aesthetics of the form were stronger with just the stretched tubes and no added foam or cardboard. I also tried connecting the rubber tubes differently at first, with screws and washers, pulling thru holes of different sizes then tying knots and/or using staples. I decided the best affect, both visually and structurally, was to pull the tubes through and over ¾" diameter holes and then stapling them in place with 5/8" crown staples shot from an air gun. I used a triangle cut from a scrap piece of wood to locate the holes on one side so they would be staggered and spaced a ½" a part. One can see this trial and error part of my process with some clarity below (See figure 49, page 103).

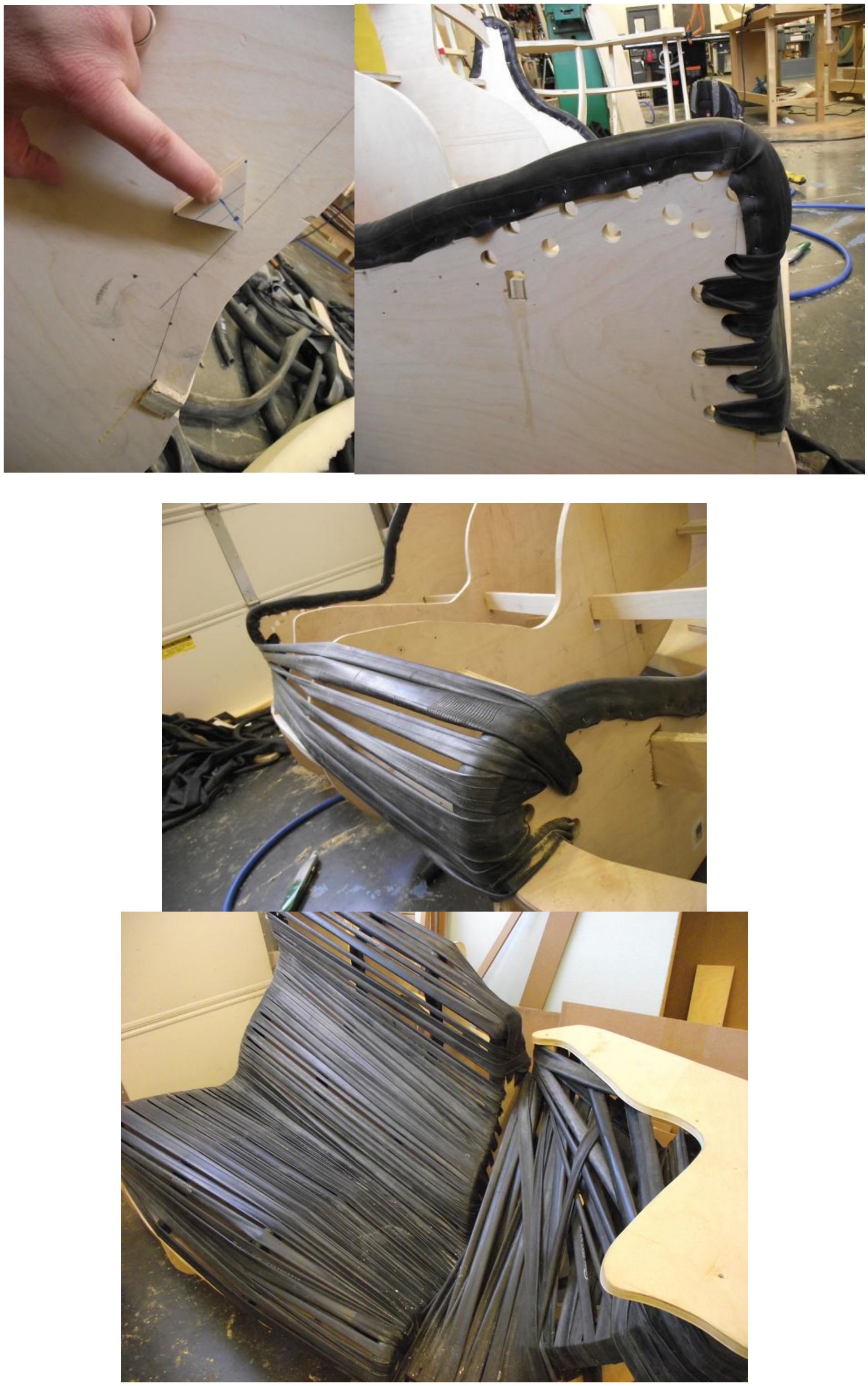


Figure 49. Rubber bike inner tube installation

I wanted to show different people interacting with and using my prototype that fit in the range of my template sizes which were from 5’2” to 6”-4” as shown earlier. I took pictures of three people approximately ranging in height from 5’4”, to 5’9 ½”, to 6’3”. This was to show scale relationships between the prototype and person as well as show how the people physically related to the piece (See figure 49, page 106).

A

B

C

Figure 50. A: 5’-4” tall person, B: 5’-9 ½” tall person, C: 6’-3” tall person

I placed the final prototype in different settings to show and study potential use location and I also decided to show different color options digitally using Photoshop (See figure 51, page 107).

Figure 51. Setting and color studies

CHAPTER V

CONCLUSION

After focusing on the creation of a method for documenting all my design processes, I arrived at several conclusions. First, through the incorporation of scans and images and other process data from AutoCAD, 3ds Max, Photoshop, Morpheus, and various animation creating software, I was able to look at output from all my processes to gain more of control and create an exactly point of view. This re-visiting of the generative nature of my processes, by searching for and selecting, or by morphing the chosen images and/or by comparing to and mimicking other design processes, allowed me to filter out repetitiveness and distraction, honing the path to production. I cannot say I officially ever found one product’s design energy or whether or not if it could be captured and reinterpreted for the design of a new product. I did, however, find that by looking back to be able to move forward, I was able to reuse, reinterpret, and even reimagine steps and whole parts of my design process throughout, from the generating of ideas to the production of prototypes. I also was able to determine that the collection of process images and the morphed tweens that were created from them did directly inspire new design ideas. In one case, the tween development actually led to the design and production of a new prototype.

In the end, because of the highly subjective nature of the overall process of revisiting through the selection, evaluation, and morphing methods, I could not really say if my method worked 100% of time to generate new design ideas. Ideas were generated, but to say how relevant they are or whether or not they could lead to production of more prototypes is yet to be determined. I am ready to say that by combining this technique of looking back with the artist's technique of creating a series of work, I was able to generate work that was able to evolve and explore the story of organic forms that not only find the body but are found by the body.

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APPENDIX A

TWEENS AND SNAPSHOTS

Prototype 1 Snapshots, fall 2009

The snapshots of my design process from fall of 2009 are shown below (See figure 52, page 116).

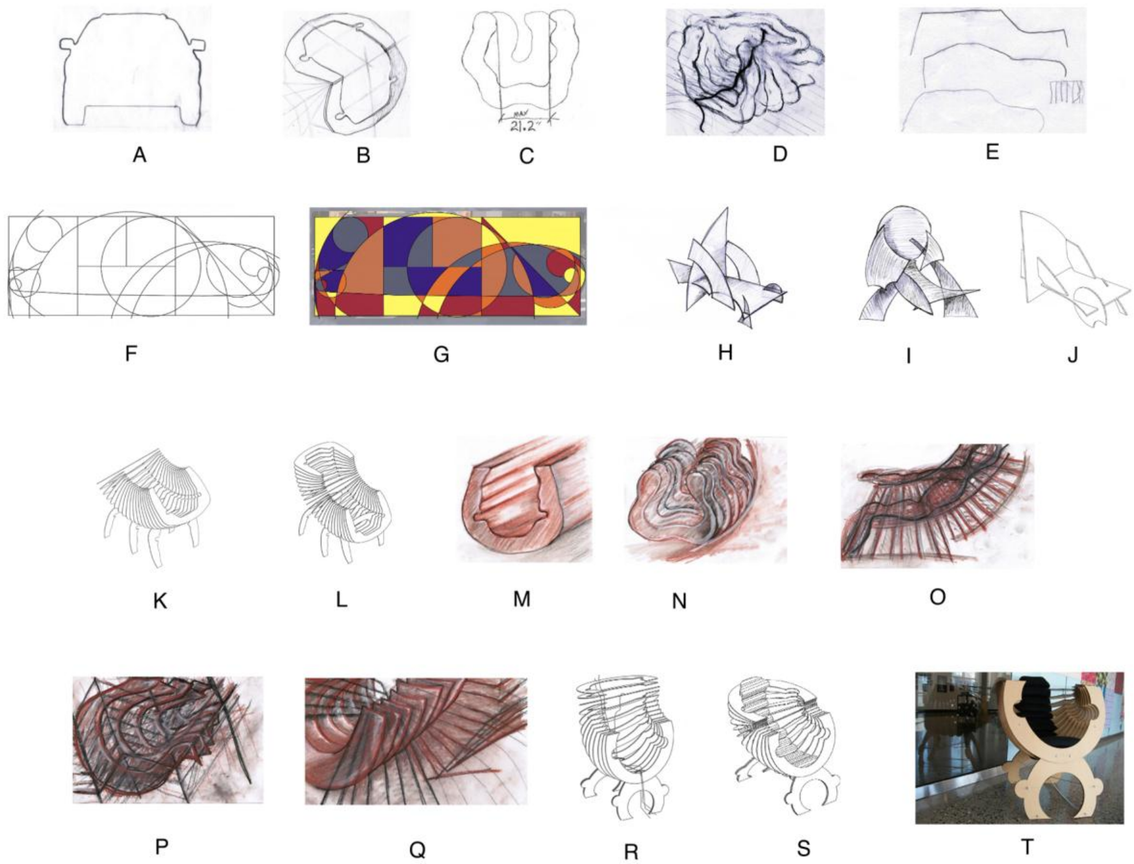

Figure 52. 2009 fall design process snapshots

Prototype 1 Tweens, fall 2009

The tweens of my design process from fall of 2009 are shown below (See figure 53, page 117).

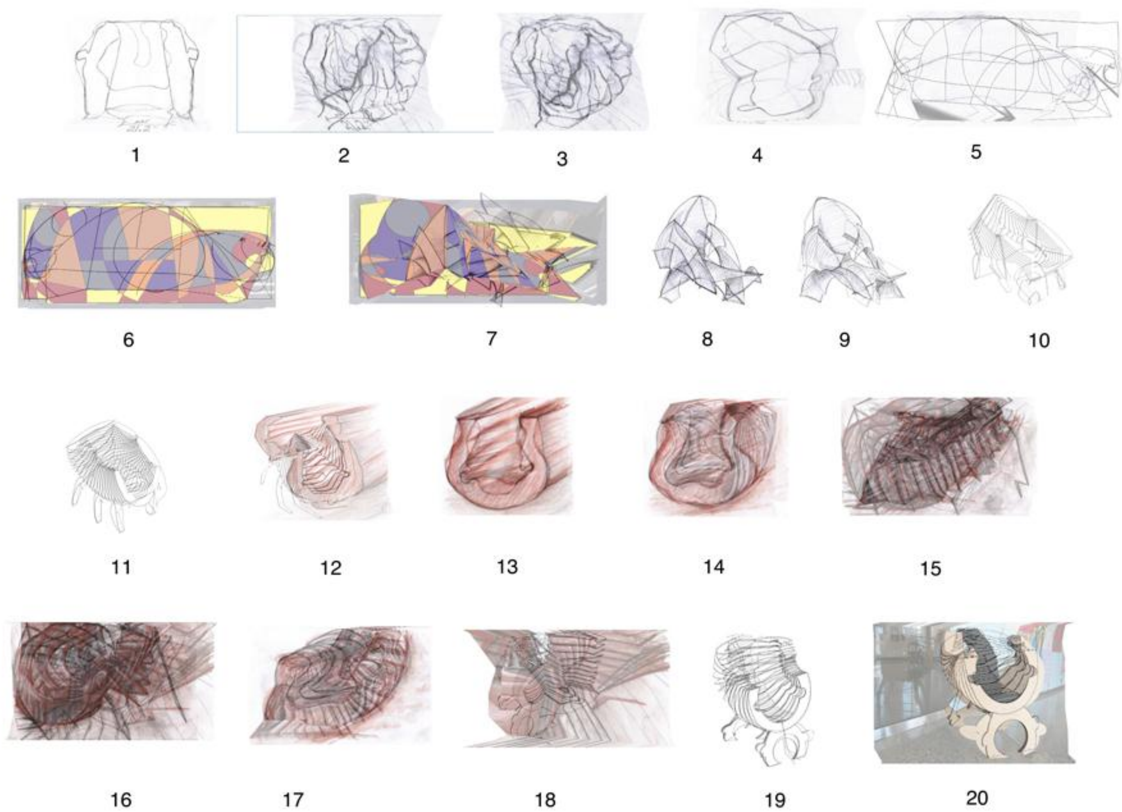

Figure 53. 2009 fall design process tweens

Prototype 2 Snapshots, summer to early fall 2010

The snapshots of my design process from summer to early fall 2010 are shown below (See figure 54, page 118).

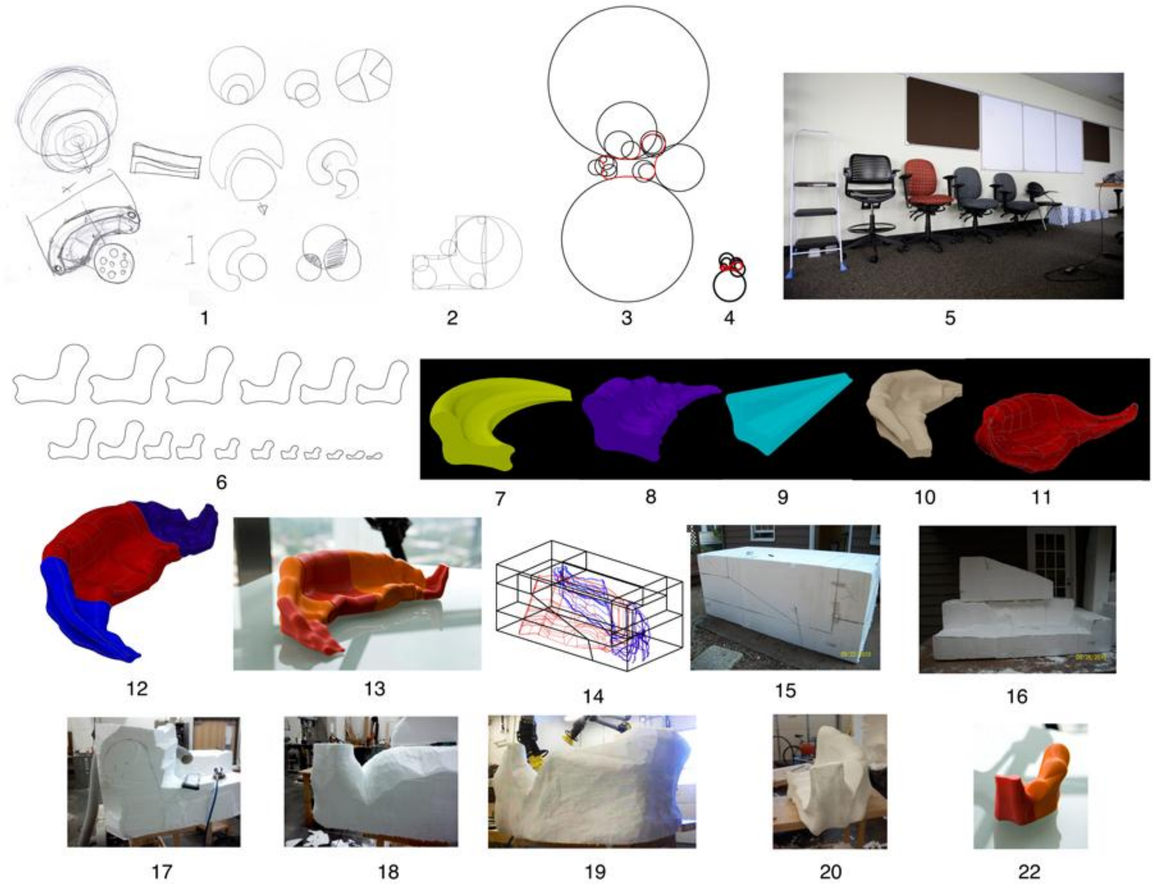

Figure 54. 2010 Summer to early fall design process snapshots

Prototype 2 Tweens, summer to early fall 2010

The tweens of my design process from fall of 2009 are shown below (See figure 55, page 119).

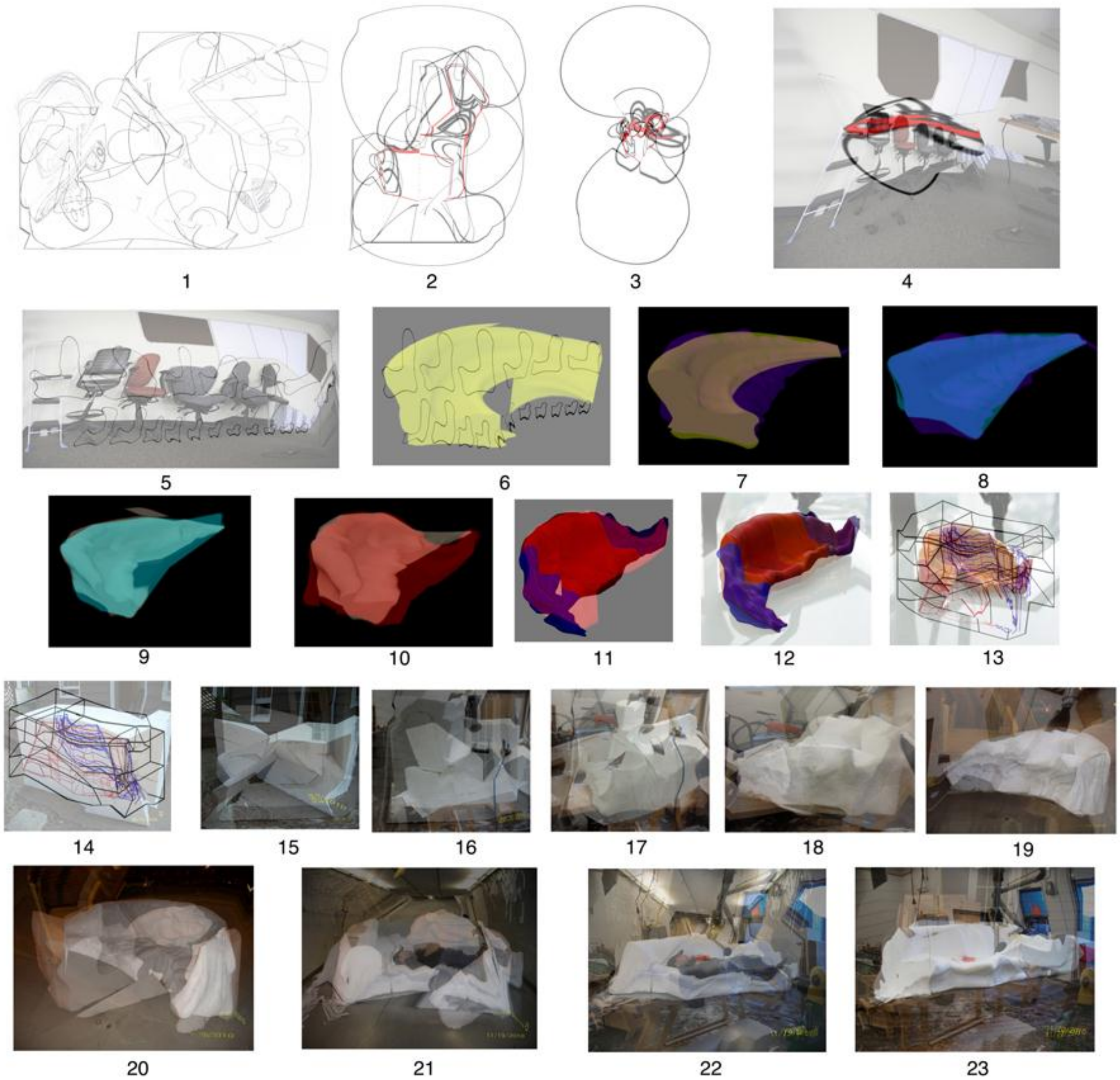

Figure 55. 2010 summer to early fall design process tweens

Prototype 3 Snapshots, late fall 2010

The snapshots of my design process from late fall of 2010 are shown below (See figure 56, page 120).

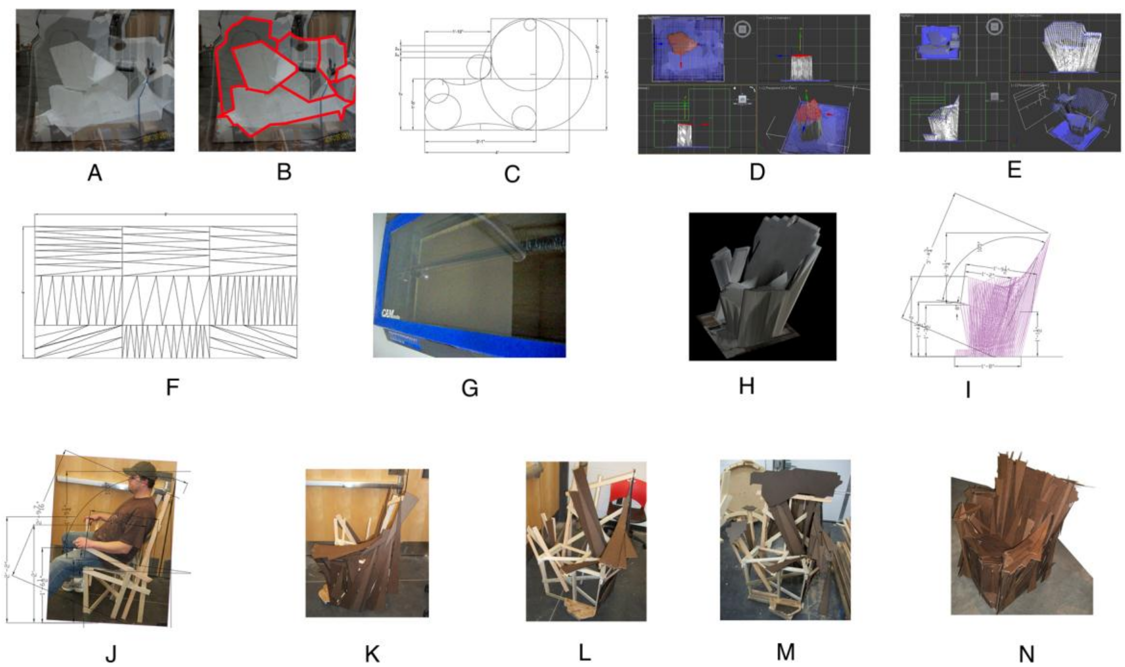

Figure 56. 2010 late fall design process snapshots

Prototype 3 Tweens, late fall 2010

The tweens of my design process from fall of 2009 are shown below (See figure 57, page 121).

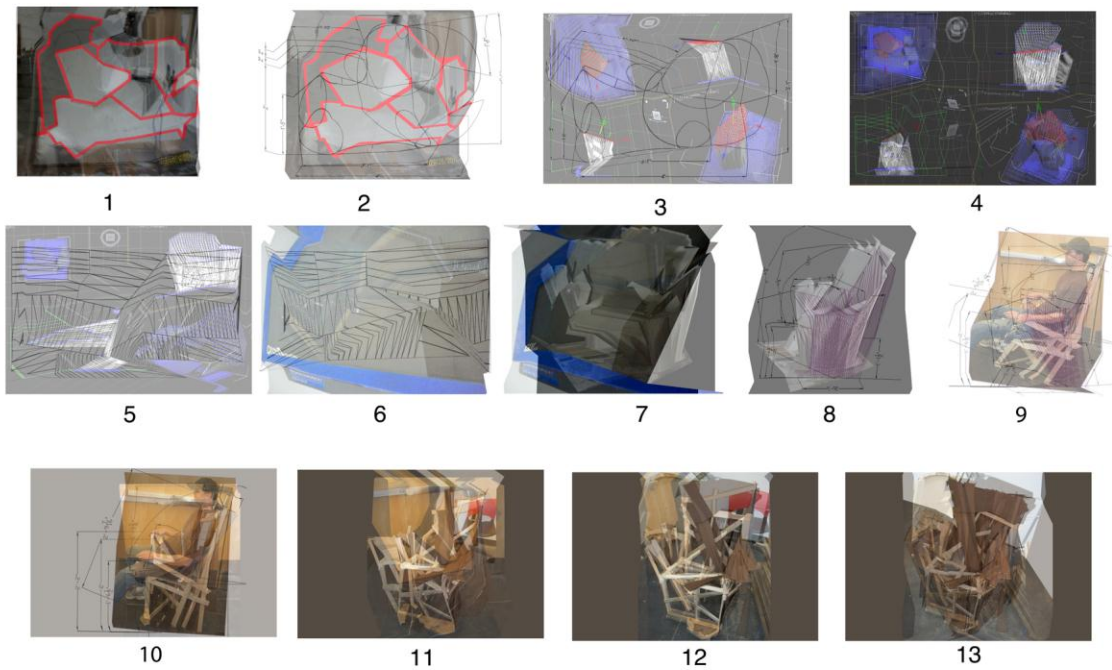

Figure 57. 2010 late fall design process tweens

Prototype 4 Snapshots, spring 2011

The snapshots of my design process from late fall of 2010 are shown below (See figure 58, page 122).

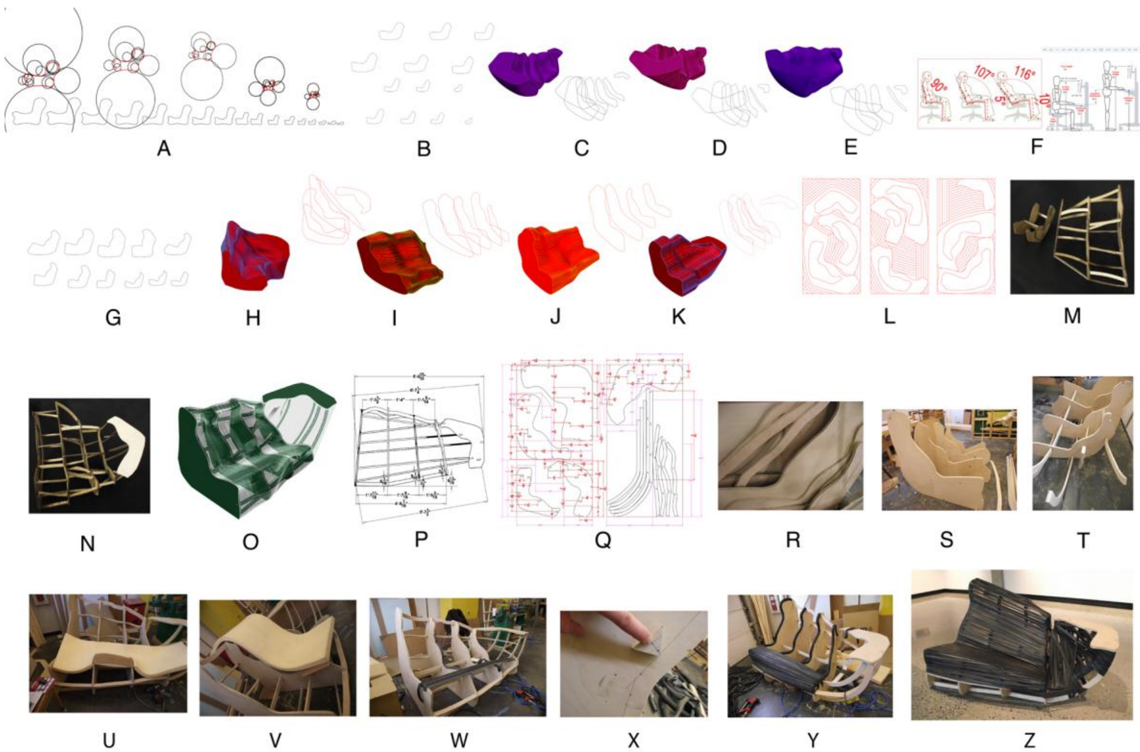

Figure 58. 2011 spring design process snapshots

Prototype 4 Tweens, spring 2011

The snapshots of my design process from fall of 2009 are shown below (See figure 59, page 123).

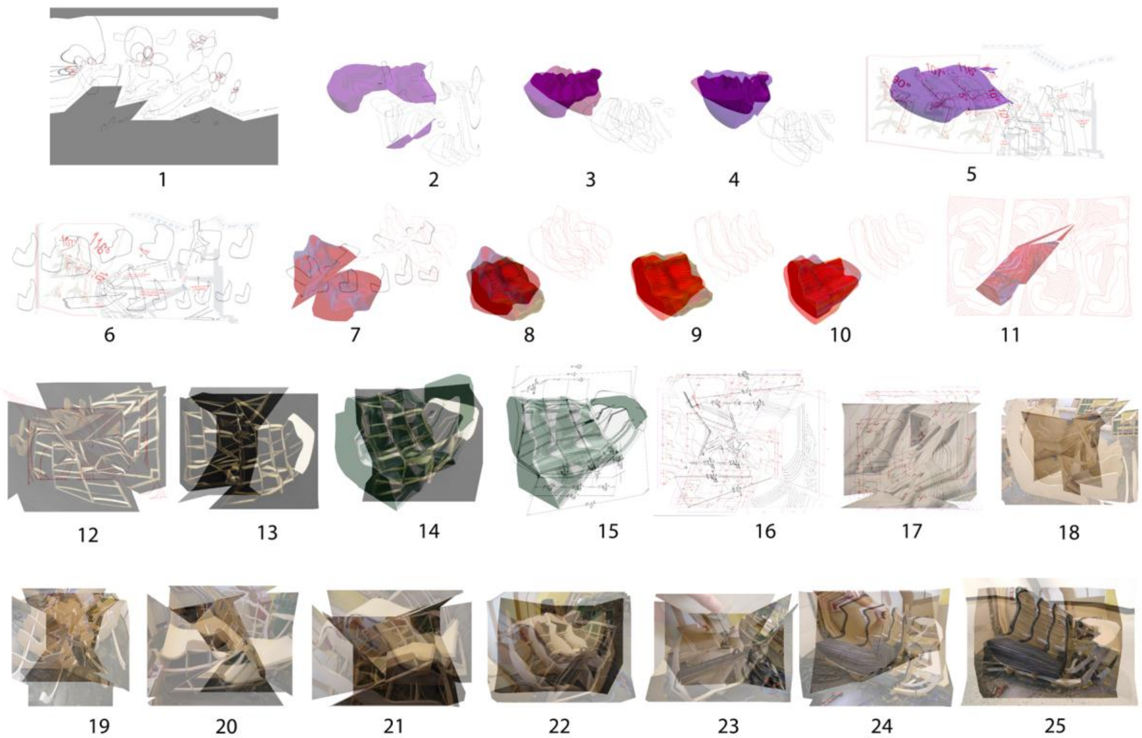

Figure 59. 2011 spring design process tweens

APPENDIX B

MY DESIGN PROCESS EVOLUTION AND COMPARISON

Prototype 1 Design Process Comparison, fall 2009

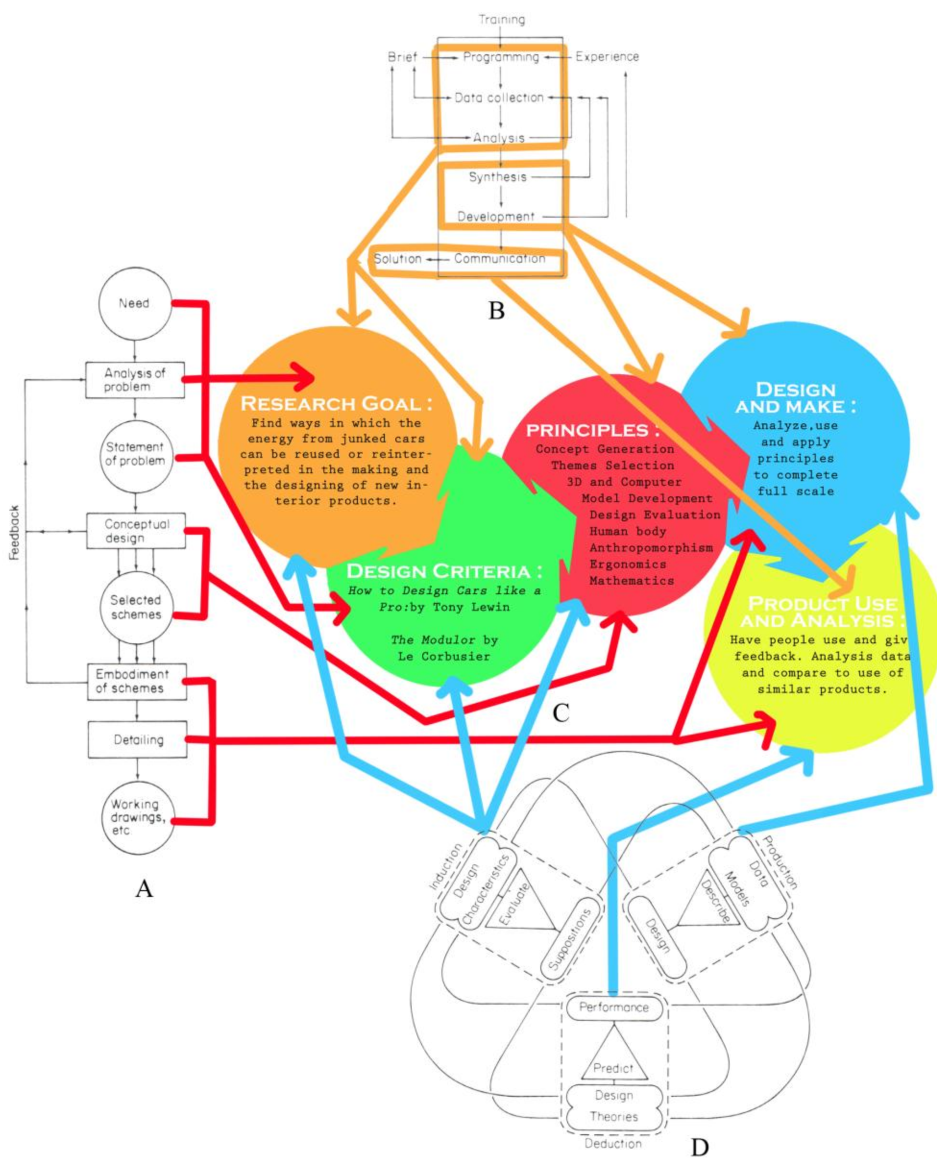

Figure 60. Process Cross's studies; A,B,D (Cross, 1989, pp. 19,20,24,29,30)

Prototype 1 Cross, Lewin, and Fiskel steps, fall 2009

I have highlighted the aspects that relate or fulfill *Cross, Lewin, and Fiskel steps.* The image below shows my first prototype (See figure 61, page 125).

Cross's creative thinking pattern of "work-relaxation-work,"

- Recognition – early inspiration from Ford Explorer, reuse failed design energy
- Preparation – abstract design from ford shape and scale
- Incubation – after mid-term shape and form evolved away from car shape
- Illumination – ah ha moment came after realization of repeat profile became a new form to analyze further in scale models
- Verification – prototype was built that embraced new form (Cross, 1989, p. 41).

Five of Lewin's automobile design process

- Concept Generation – ideas were generated from car shapes
- Themes Selection – one shape was taken further
- 3D and Computer Model Development – digital shape became new form when repeated in two axis's
- Design Evaluation – final models were evaluated to decide on construction
- Prototype Development – prototype was built and tested (Lewin, 2003, pp. 108-109).

Fiksel's Design For Environment (DFE)

- design for dematerialization - MDF and fabric will biodegrade
- detoxification - MDF is formaldehyde free and fabric is cotton based
- revalorization - not clear to how renewable the final prototype is
- capital protection and renewal – not applicable (Fiksel, 2009, pp. 371-373).

Figure 61. My first full scale prototype from fall 2009

Prototype 2 Design Process Comparison, summer / early fall 2010

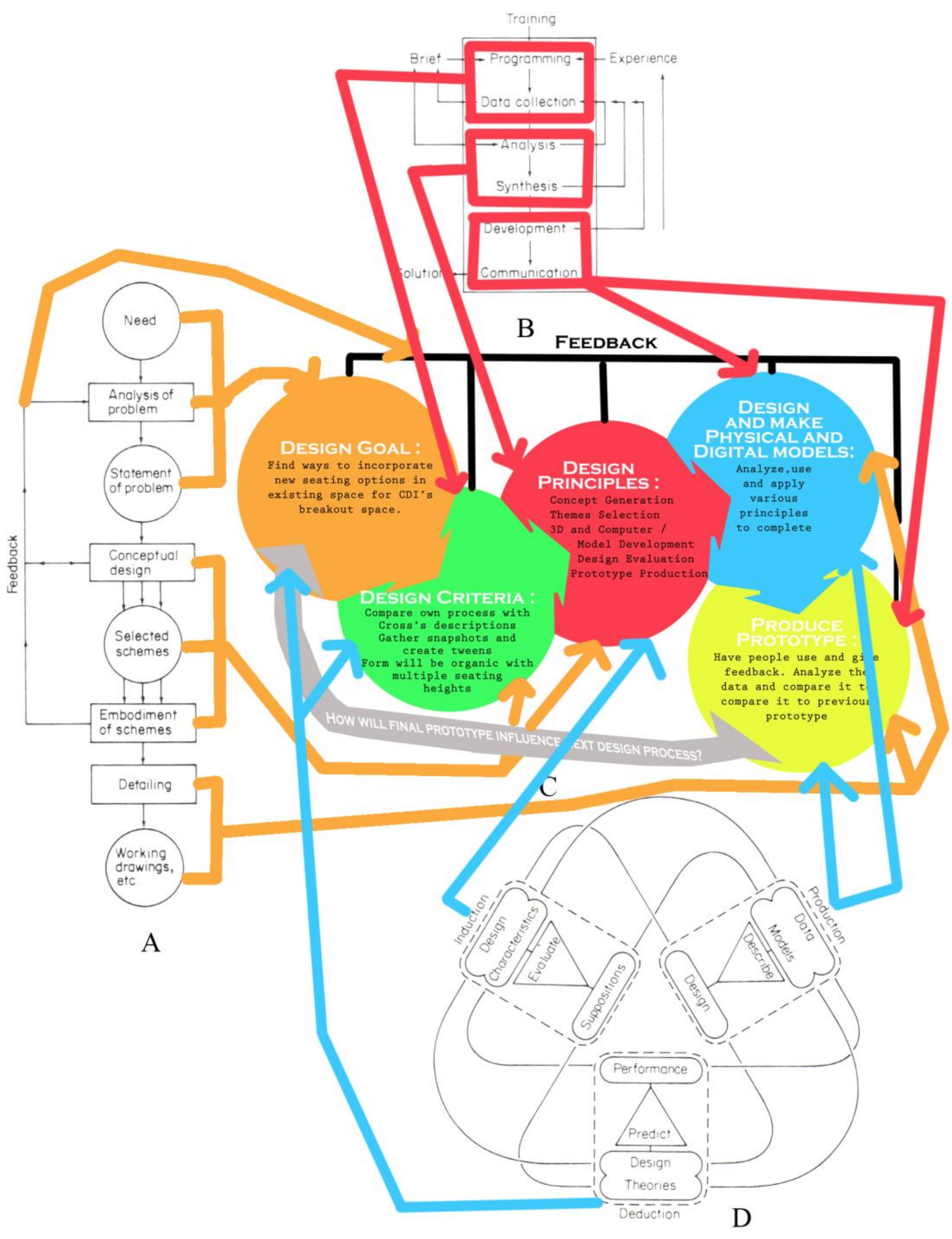

Figure 62. Process Cross's studies; A,B,D (Cross, 1989, pp. 19,20,24,29,30)

Prototype 2 Cross, Lewin, and Fiskel points, summer / early fall 2010

I have highlighted the aspects that relate or fulfill *Cross, Lewin, and Fiskel points.* The image below shows my fourth prototype (See figure 63, page 127).

Cross's creative thinking pattern of "work-relaxation-work,"

- Recognition – seating for existing breakout space at CDI in Winston-Salem NC
- Preparation – examine space look at precedents
- Incubation – take time away from space review early 3d digital iterations
- Illumination – repeated profiles become morphed tween information
- Verification – prototype was built from foam (Cross, 1989, p. 41).

Five of Lewin's automobile design process

- Concept Generation – generate new seating ideas
- Themes Selection – circle were early theme selection
- 3D and Computer Model Development – multiple 3d digital iteration were created
- Design Evaluation – iterations were evaluated and one was chosen to evolve
- Prototype Development – final evolution was built (Lewin, 2003, pp. 108-109).

Fiksel's Design For Environment (DFE)

- design for dematerialization – breaks down but does not biodegrade
- detoxification – coated with low VOC primer, recyclable foam is non-toxic
- revalorization - renewable due to 100% recyclability
- capital protection and renewal – not applicable (Fiksel, 2009, pp. 371-373).

Figure 63. My second full scale prototype from summer / early fall 2010

Prototype 3 Design Process Comparison, summer / early fall 2010

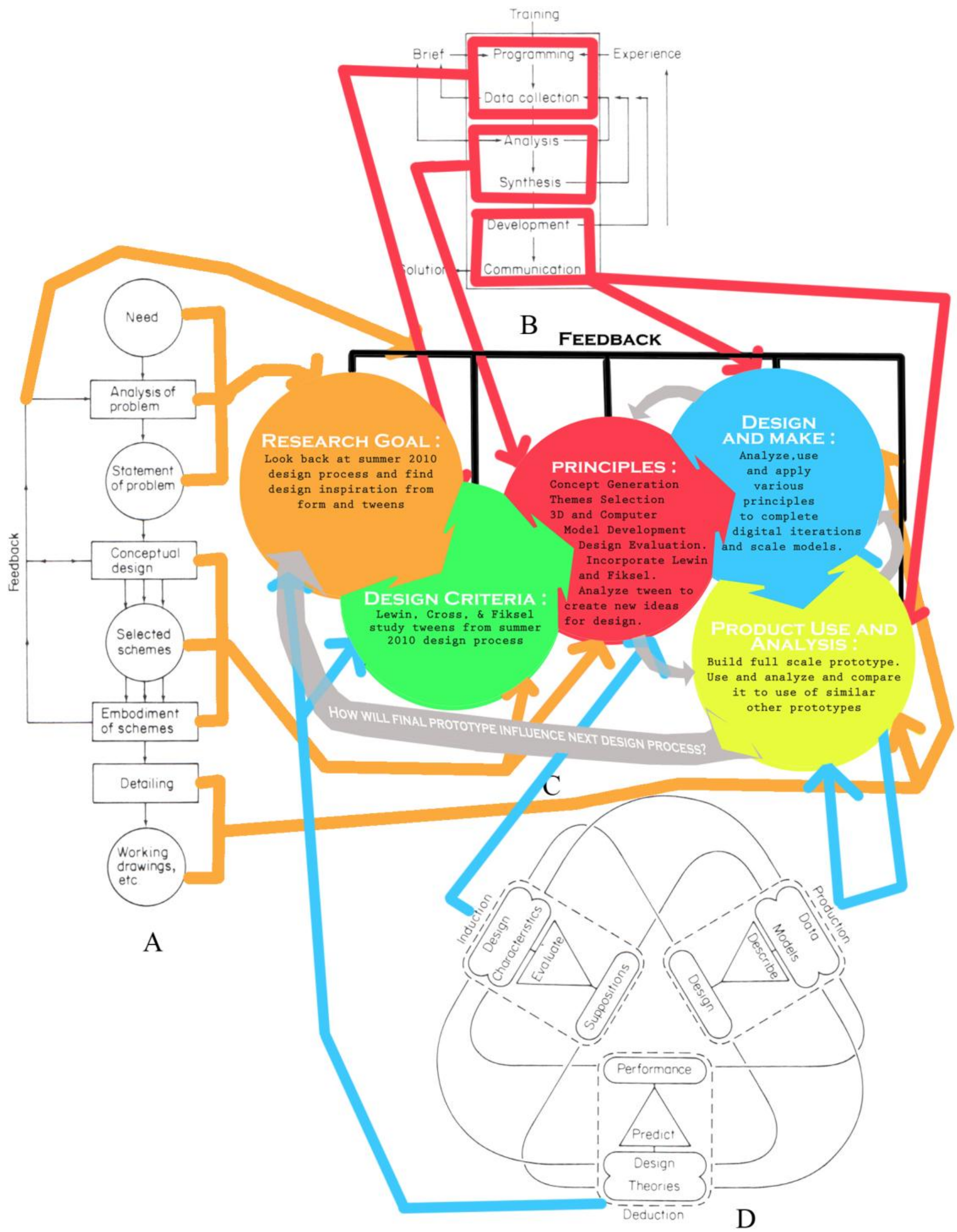

Figure 64. Process Cross's studies; A,B,D (Cross, 1989, pp. 19,20,24,29,30)

Prototype 3 Cross, Lewin, and Fiskel points, late fall 2010

I have highlighted the aspects that relate or fulfill *Cross, Lewin, and Fiskel points.* The image below shows my fourth prototype (See figure 65, page 129).

Cross's creative thinking pattern of "work-relaxation-work,"

- Recognition – how will tween create new form
- Preparation – review tween data from summer 2010 prototype
- Incubation – step away from computer review digital forms
- Illumination – ah ha moment was when conversion of mesh into triangles was realized
- Verification – mesh model became full scale prototype (Cross, 1989, p. 41).

Five of Lewin's automobile design process

- Concept Generation – tween generated new form
- Themes Selection – forms became new iterations
- 3D and Computer Model Development – digital iterations were narrowed down
- Design Evaluation – digital models and scale models were carried further
- Prototype Development – prototype was produced (Lewin, 2003, pp. 108-109).

Fiksel's Design For Environment (DFE)

- design for dematerialization – hard board or HDF will biodegrade
- detoxification – raw wood frame is non-toxic, HDF has some formaldehyde
- revalorization – most of frame is reclaimed wood and hard board is renewable due to made of 100% recyclable wood fibers
- capital protection and renewal – HDF is cheap, scrap wood is free (Fiksel, 2009, pp. 371-373).

Figure 65. My third full scale prototype from late fall 2010

Prototype 4 Design Process Comparison, spring 2011

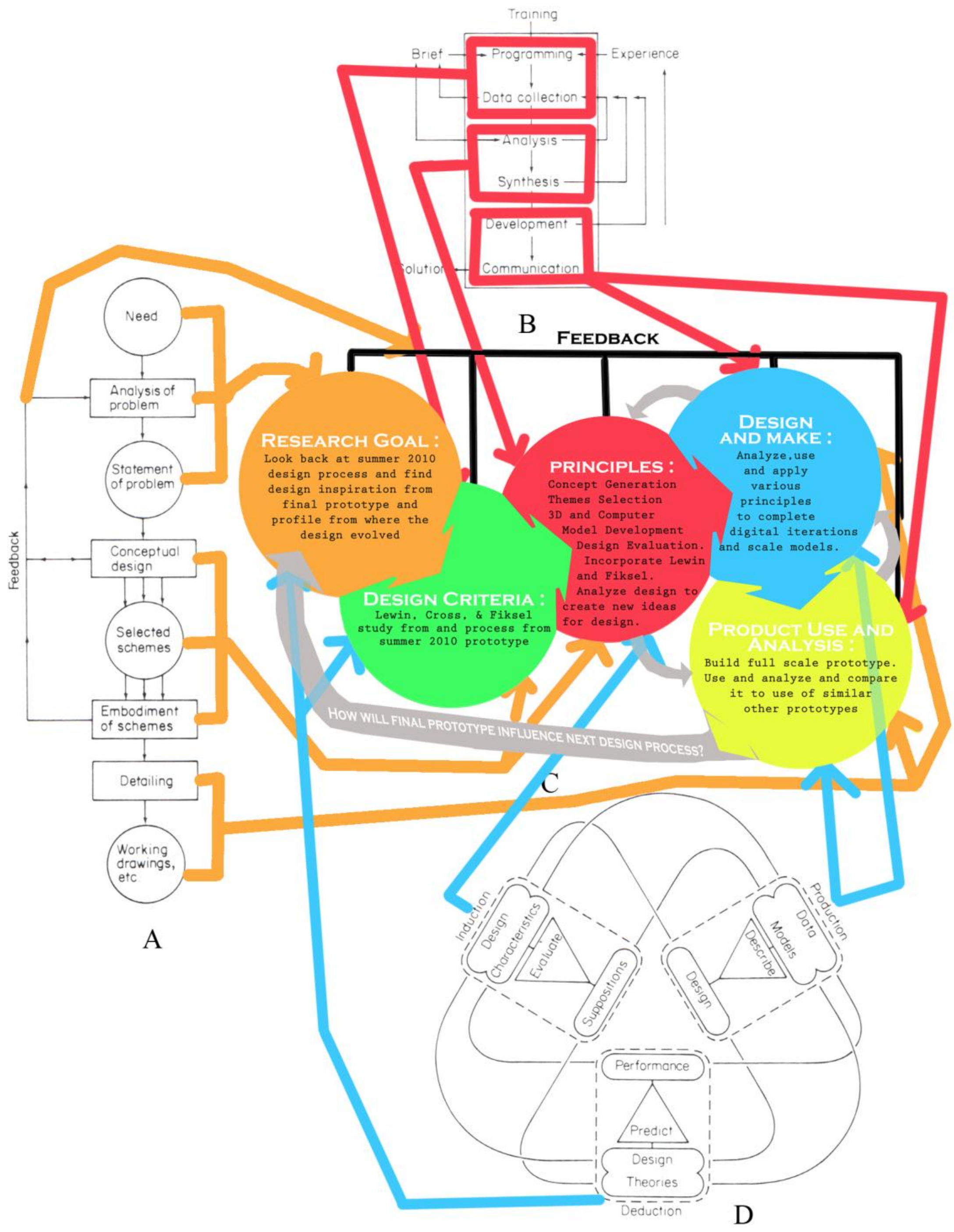

Figure 66. Process Cross's studies; A,B,D (Cross, 1989, pp. 19,20,24,29,30)

Prototype 4 Cross, Lewin, and Fiskel points, spring 2011

I have highlighted the aspects that relate or fulfill *Cross, Lewin, and Fiskel points.* The image below shows my fourth prototype (See figure 67, page 131).

Cross's creative thinking pattern of "work-relaxation-work,"

- Recognition – revisit second prototype, evolve form from 2D profiles.
- Preparation – create new iterations prepared from new profiles.
- Incubation – step back from computer make scale models.
- Illumination – ah ha moment, was I decided to stop simulation of design and started making.
- Verification – full scale prototype was completed (Cross, 1989, p. 41).

Five of Lewin's automobile design process

- Concept Generation – second proto type form generated new idea
- Themes Selection – multiple digital iterations were done before selecting theme
- 3D and Computer Model Development – iteration was analyzed further both digitally and in form of scale model
- Design Evaluation – after scale was evaluated final digital plan were completed
- Prototype Development – digital information further evolved after final prototype was completed (Lewin, 2003, pp. 108-109).

Fiksel's Design For Environment (DFE)

- design for dematerialization – birch plywood and rubber biodegrade
- detoxification - plywood is formaldehyde free and rubber is recyclable
- revalorization - plywood biodegrades and rubber is renewable due to recyclability
- capital protection and renewal – rubber was free, ply wood cost approximately $90.00 (Fiksel, 2009, pp. 371-373).

Figure 67. My fourth full scale prototype from spring 2011