CUSTOM HALF-SCALE DRESS FORM AS A PATTERNING TOOL

A Thesis

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In Partial Fulfillment of the Requirements for the Degree of

Master of Arts

by

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ABSTRACT

Half scale forms have been used in education for years, but these forms have not been adopted by the fashion industry or the entertainment industry. Both of these industries have specific body figures that they work with: in fashion it is a fit model (intended to represent a range of bodies) and in theatre and film costuming it is an actor (therefore, a design intended for a specific, individual body). Creating custom half scale forms has not been possible due to the limitations in technology for capturing the 3D image of the individual. We now have the ability, with a hand-held scanner, to capture a 3D image of anyone, anywhere. In this study, I worked with several professional experienced cutter/drapers to create patterns with the custom half scale forms and in one case, with a standard full-scale form at the same time. By documenting the process for each method through journals, photos and observation, a comparison was made between the time and material spent on each. A mixed methods approach was used to analyze the data collected from the study participants. At the end of the study, we found a slight timesaving when using the custom half scale forms, and we started to collect data on material use. The fit results from the final fitting muslins made from the patterns were mixed, and it became clear that the participants did not trust the custom half scale forms enough to create patterns that fit closely to the form. Based on results from the pilot test, in which inexperienced students fitted their patterns much more closely, we believe that with experience the use of these

innovative forms will be able to, in many cases, eliminate the muslin fitting stage from the development of theatrical costumes entirely.

BIOGRAPHICAL SKETCH

Kimberly Ann Phoenix started working at Cornell University in January of 1997 in the Department of Theatre, Film, and Dance. She was fortunate to have a supervisor who encouraged everyone to take classes at Cornell. In 2004, she walked across campus to take TXA 114 with Professor Racine, this was the beginning of a mentoring relationship that has impacted her life to this day. In 2012, she graduated from Fiber Science Apparel Design with a BS in Apparel Design Management. After a short adventure in Winston Salem, North Carolina at Wake Forest University, she returned to Cornell University to a job in the Department of Fiber Science Apparel Design. With the encouragement of the Prof Ashdown and Prof Racine, she once again decided to go back to school and receive her Masters. With the completion of this latest goal, many new adventures wait.

This is dedicated to my children Kelly, Mitch, and Jenni.

ACKNOWLEDGMENTS

There are many who helped me reach this point in my academic journey. I would like to first acknowledge and thank my committee Professor Susan Ashdown and Professor Val Warke. Your time and guidance throughout this program has been invaluable. I would also like to thank the Department of Fiber Science Apparel Design, I could not have done this without your support. I would also like to acknowledge the Cornell Employee Degree program, this program is the reason I was able to reach my life goal. To my fellow graduate students in the apparel design program your support and acceptance was amazing, every time we got together I learned something more. Thank you!

To my family and friends thank you for believing in me when I doubted myself. Your support was the reason I was able to do this. Thank you for all the little and big things you did to help me reach my goal.

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CHAPTER 1

Introduction

1.0 Pattern Development for Apparel

Clothing is made from two-dimensional fabric and must fit around the three-dimensional body. In order to create a pattern of the complex 3D body shape, a patternmaker uses one of several methods, subject to the results desired and production methods employed. Clothing production is linked to the final goals of the process.

We think of clothing in terms of the mass production of ready-to-wear, but there are also clothing production processes that make use of custom manufacture. Theatrical costume making is one example of a custom production process. Each show in theatre brings a new set of actors into the costume shop; after casting the actors come to the shop for a complete set of measurements. While each costume shop has their own measurement form, many of the measurements are common to all shops. (See Appendix A) The measurements are then used by the cutter/draper to guide the creation of custom patterns for the costumes (rendered or sketched by the Costume designer) through flat patterning or draping. (Ingham 2003) The cutter/drapers often create the patterns by draping on standard dress forms either with or without padding. The padding is added to the form to more closely reproduce the body measurements of a specific actor. To pad a form, these professionals use batting, shoulder pads or padded bras to modify the form dimensions; once this is done the form is then coved with a knit fabric to

achieve a smooth surface on which to work. From this point, the cutter/draper drapes and pins muslin pieces together to create a pattern for the costume that is then used to make a fitting muslin to try on the actor at the first fitting.

With continuing cuts to budgets in the arts (Boehm 2011) many theatre costume shops are under increasing pressure to create shows with smaller budgets and fewer shop personnel. Here at Cornell in 2010 the costume shop (in the then Department of Theatre, Film, and Dance) was reduced from four cutter/drapers to one. The budgets that were generous by many standards were severely cut. Budget cuts are not unusual; both academic and professional costume shops are facing financial stresses. Therefore, shops are looking for ways to create quality costumes using more efficient methods.

1.1 Purpose of the Study

With the advances in 3D body scanning there is now affordable technology to go to remote locations to capture a scanned image of individual actors. Using this mobile scanning technology, we can now capture an image that can be used to create custom half scale dress forms using the model image here at Cornell. Once the scan is captured, the image is processed by creating numbered half inch horizontal slices of the scan with registration holes and prepared for cutting on a laser cutting machine. Once the slices are cut from the half-inch foam they are stacked, glued and covered to produce a custom half-scale dress form.

By documenting the patternmaking processes, collecting data from both traditional and custom half scale patternmaking methods, I will determine which method is more time and cost effective. I will examine whether the custom forms are a reliable tool for efficiently providing a good fit, with minimal changes from the initial pattern.

1.2 Research Questions

Do custom half scale forms save time through faster pattern development, compared to traditional patternmaking processes?

Do custom half scale forms save money by using less material in the initial draping and patterning process compared to traditional patternmaking processes?

Does the use of half scale forms result in fewer fitting alterations to the initial fitting muslin, and fewer iterations of fitting muslins?

1.3 Term Definitions

Costume Designer - Costume designers create the look of each character by designing clothes and accessories the actors will wear in performance. Depending on their style and complexity, costumes may be made, bought, revamped out of existing stock or rented.

Cutter/Draper - The primary responsibility of the Cutter/Draper (generally a full time, hourly position) is the creation of costumes; the interpretation of original design work and custom patterning based on the design, and all facets

of the construction process for the costumes as well as alterations, fittings, and maintenance of pulled (from stock) or rented clothing items. The Cutter instructs the First Hands and Stitchers, as appropriate to the assigned project.

Draping - Draping is the art of manipulating fabric directly on the dress form in three dimensions to create patterns. It is the most direct way for a designer or patternmaker to turn design ideas into reality.

Dress form - a form generally made of paper- mâché or foam and covered with cloth that is a representation of a human figure, generally from shoulder to thighs, but minus arms, that is mounted on a stand and used for draping and fitting garments

First hand – the artist who assists with the pattern creation and construction of costumes, they work under the supervision of the draper.

Fitting muslins – Sometimes called a toile, a muslin refers to a test garment sewn from inexpensive fabric, in order to check the fit of the garment. The muslin is used to identify fit issues and mark alterations that will be made to perfect the final product.

Flat patterning – The creation of foundation patterns by drafting on paper or fabric, using the dimensions of the body to create a series of two-dimensional pieces with straight and curved edges. When these edges are connected and later sewn together in a fabric, they will create a three-dimensional garment that is tailored to the body. To put it plainly, a series of points are plotted (guided by the body measurements), and these points are connected to create a flat pattern.

Half scale dress form – modern half scale dress forms are specifically made to design patterns that can be scaled to full size. All of the measurements are exactly half of the represented full-size form.

Sloper - A sloper pattern (home sewing) or block pattern (industrial production) is a custom-fitted, basic pattern from which patterns for many different sizes and styles can be developed, using a slash and spread or slash and overlap methods. The process of changing the size of a finished pattern is called grading.

Stitcher- The artisan who assist in the sewing of costume, either by hand or machine under the supervision of the first hand or draper.

1.4 Significance of the Study

Both economic and environmental pressures are increasing in many areas of clothing production, as well as in academic settings. Through this study, I will explore a more effective, timesaving, and resource efficient way to produce patterns. As we struggle with the production waste from the creative process studios are also looking for ways to reduce the environmental impact of patternmaking. Timesaving and resource saving methods can both help increase the efficiency of patternmaking processes and allow time for more creative work.

CHAPTER 2

Review of Related Literature

2.0 History of Dress Forms

Dress forms are one of the most helpful tools a patternmaker, draper, or dressmaker can use. In the industry, the form is a representation of the fit model for the brand. The patternmaker works with this form to create the patterns to be shared with the manufacturing facility. Within the theatre costume shop, the form characterizes the actor for whom the patternmaker is creating a costume. For the dressmaker, it represents the client. In each of these cases, it is a vital tool for developing pattern shapes and checking fit as the patterning process is undertaken.

The conventional dress forms of today evolved from the display mannequins of the past. While there is some research into the history of the display mannequin the history of the dress form as a tool for patternmaking has not been documented. In the early 19th century tailors began to use mannequins to display their work but also there was a tailor's dummy used to aid in the construction and fit of the jackets. Alison Matthews David (2018) included in her paper *Body Doubles: The Origins of the Fashion Mannequin* a pen and ink drawing from 1826-1829 era showing a tailor's shop with the "tailors dummy" between two working tailors. She found this image in Cabinet des Estampes, in the Bibliothèque Nationale de France. This illustration shows that dress forms were being used in the workroom but because

workrooms were not well documented it is hard to determine for sure when mannequins made the transition to dress forms. (Davis 2018).

The forms that are documented during the 19th century are bust forms; most ending just below the waist. Patternmakers working with these forms would be able to test their work in progress. Wealthy patrons would pay to have a custom dummy made to their measurements. (Davis 2018). There is also much documentation from this period of tailors and dressmakers using mannequins to display their ready-made clothing.

A sculptor in Paris, Frédérie Stockman, began making female bust forms in 1869 in different sizes; the company he started is still in business today creating dress forms as well as display mannequins. It was Stockman's idea that dressmakers should have different sizes to work with while creating their dresses. His forms were made of papier-mâché from plaster castings of model's bodies. Around the turn of the century, he partnered with M. Siegel to form. The company Siegal & Stockman is still operating today and just opened a branch in New York City.

At this time in the United States, there were people making changes to improve the bust form. In 1880, John Hall received a patent for a skirt form that could be adjusted for different people so that a patternmaker could drape many sizes of patterns on the same form. (Hall 1880) In 1890, this form was featured in an advertisement in *The Delineator* (see Figure 1). The ad copy states "Every lady knows how difficult it is to drape a dress without the assistance of a second person. The Bazar Form has become the most

welcome substitute, as with it any lady can drape her own dress, and not become worn outstanding, or depend upon the taste of others."

Figure 1: Advertisement from The Delineator 1980 from the personal collection of Kimberly Phoenix

Others were making changes at the same time, each hoping to improve on the previous form. Theodore Parker Colby of Boston applied for a patent in July of 1903 to add arms to the existing bust form which before now did not have arms. In the patent application, he stated, "It has been customary in dress-forms to have the bust without arms, so the dressmaker or tailor was compelled to fit the sleeves upon separate sleeve-form and then attach the sleeve to the remainder of the garment either by guesswork or with the aid of a human model." He was granted his patent No. 791,879 in June of 1905 (Colby, 1905). Very close in time Catherine L Horton of Des Moines, Iowa was also proposing the addition of arms to the bust form; she also suggested a way to temporarily attach the bust and skirt forms to create one form. The

plate she showed for attaching the arm is very similar to the plate still used today; she was granted her patent in 1910 (Horton 1910). Between 1914 and 1915 there were applications and grants for several patents for various ways to achieve a skirt shape using the forms. One was an addition to the bust form, and two were permanently attached to the bottom of the form creating the basic shape still used today. (Nelson 1918) The Hall-Borchester Dress Form Company of New York was established in 1908. Between the years of 1911 until 1921 they applied for and were granted seven patents for improvements to the dress form. One patent was granted for an adjustable stand for the dress form; Frank B. Grainger is credited with this invention. The idea of the telescoping stand proposed by Grainger is very similar to the standstill used to support the forms currently used in workrooms. The patent shows a foot pedal to be stepped on to raise or lower the dress form. (Grainger 1918) The last patent granted to the company was for an adjustable dress form invented by Jack Carl Jankus; who described a form that can achieve a variety of sizes and proportions by adjusting he movable plates used to create this dress form. This is another

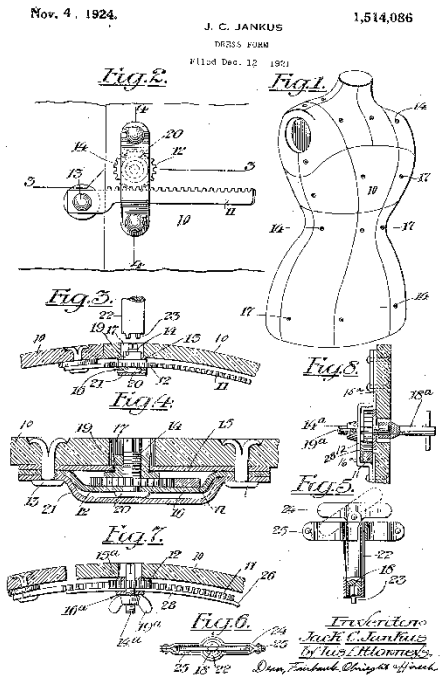


Figure 2: Image from Patent #1,514,086, (Grainger 1918)

example of an ongoing awareness of the advantage of having a form that can be customized to represent many different sizes and shapes (Jankus 1924).

In 1922, Wolf Form Company was established in New York City; unlike the earlier forms that were made of wire their forms were made from molds using papier-mâché and covered with linen. In 1931 Simon Wolf applied for a patent for the first collapsible shoulder form; in the patent, he discusses the need to remove the garment over the shoulder, citing the narrow waist making removal of the garment difficult. (Wolf 1931) The Wolf Form Company is still in business today although their doors did close for a short time in 201. (Lappin 2016) The Wolf Form Company did reopen by May of 2017. (Townsend 2017) Many designers, schools and garment manufacturers in the United States use Wolf forms.

Figure 3: Wolf Women's dress forms

Since the mid-20th century not much changed in dress form manufacturing until 2001 when Alvanon, Inc. brought their innovative approach to the dress form industry. Before Alvanon, dress forms did not represent the human shape; though they had basic bust, waist and hip sections created to match specific body measurements, the shape of the form was a shell of the inside of a garment; it was a silhouette of a figure. Alvanon designed a dress form based on real bodies, using 3D body scan technology, and creating a form that could help designers create clothing with modern silhouettes that would fit all the curves of the body.

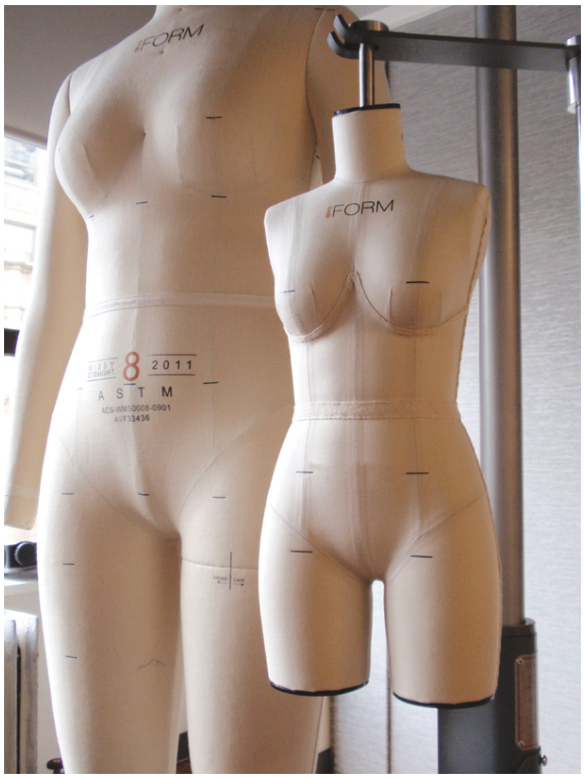


Figure 4: Alvanon full scale and half scale dress forms

2.1 Historical Perspectives of Half Scale Dress Forms in Apparel

There is a record of fashion houses producing fashion dolls with clothes to show customers what clothing could be produced as early as 1715 (Cegindir 2017); these were not specifically half scale. These dolls were shipped to customers or stores for consumers to see what dresses could be produced.

Figure 5: from Katy Werlin The Fashion Doll www.thefashionhistorian.com

Madeleine Vionnet is widely thought to be the first fashion designer to use a scaled model in designing; she used a wooden artist's model to create her exquisite and elaborate bias dresses in the 1920s. The measurements of this wooden doll were a 15 ¼ inch chest, 8 ½ inch waist, and 16-inch hips, and though it was probably not precisely half scale, it might be close. There are pictures showing Vionnet designing using this wooden figure.

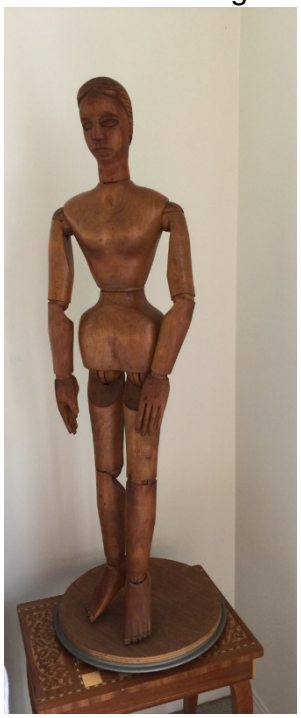


Figure 6: Madeleine Vionnet wooden figure from the personal collection of Dr. Anne Bissonnette, University of Alberta

Figure 7: Thérèse Bonney, Madeleine Vionnet and her mannequin (ca. 1923–6). BANC PIC 1982.111 ser. 1 5. Thérèse Bonney Photograph Collection, Bancroft Library, University of California, Berkeley.

Half scale dress forms have been used in education for many years; we have photos of students in the 1950s draping on half scale forms here at Cornell. As a teaching tool, these forms help with saving on the material used and the time taken to learn how to make a garment style.

Figure 8: 1950 class draping on half-scale dress forms
Cornell Photo Archives

Half scale forms are still used today in many fashion education settings; the older half scale forms are generally half the scale of the basic dress form used to create dresses and skirts. Just like their full-scale counterparts, they do not represent the human figure.

In collaboration with Susan Ashdown, a professor from Cornell, the dress form company Alvanon has created a commercial half scale form that has short 2-inch legs, so activewear and lingerie can be draped on these forms giving students more creative flexibility; these forms are used in Cornell's draping and product development classes. These forms from

Alvanon are precisely scaled down from their full-scale counterpart forms that are made from body scans of their fit models and reflect actual body shapes. This is a departure from the traditional forms that are shaped more like dress and skirt silhouettes, not like the actual body. Patterns from these Alvanon forms can be scaled up to make full-scale fitting muslins that precisely fit the full-scale forms.

2.2 Modeling Perspectives from other Design Fields: Use of Models in Architecture

Scale models have been used in Architecture for many years; there are pictures of scale models dating back to the Middle Ages, although there is a debate about whether these were scale models for use in the design process (Morris 2016). It was not until Leon Battista Alberti that we find an architect who specifically used scale models as a design tool (Morris 2016). Models are used to show what a building will look like; alternate designs can be explored, and changes can be made in these scaled models before the actual building process begins. Scale models are needed in architecture due to the cost of constructing a full-scale model, but there are also examples of full-scale modeling of architectural details made from clay and stucco as early as the 4th-century B.C.E (Moon 2005). There are other examples of partial full-scale elements of buildings being constructed prior to building construction. A bay and a half of the US Department of Agriculture building was constructed on site in 1905 in Washington DC in full scale before the construction of the

building (Moon 2005). The stairs for the St. Louis Gateway Arch were constructed in front of Eero Saarinen's office to test the walkability of the stairs (Moon 2005.) While these examples of full-scale models are noted the scale model is more the norm in architecture, whereas full-scale prototypes are more common in apparel production.

2.3 Traditional Education for Apparel Designers

Those wanting to be an apparel designer generally acquire a four-year degree followed by many years of experience working with a designer in the industry. As with any field there are exceptions; if a designer is extremely talented they may be able to find a backer and create designs with little or no formal education, but for most the path is to go to school, work in the industry as an intern, and then work for many years as a design assistant to learn the trade before becoming a designer. There are two primary paths for a designer in the industry, either as the creative designer (in an existing firm, or by starting one's design line) or as a technical designer/patternmaker for a firm. The best schools train both types of designer in patternmaking, as the pattern is critical to a successful design, and the creative designer who knows the principles of patternmaking will generally be a better designer.

2.3a Traditional Education and Training of Theatre Cutter/Drapers

Usually, those working in a theatre costume shop hold a college degree or equivalent experience in costume technology from an accredited university.

While one might hold an MFA, this is not required unless planning to teach classes within the university curriculum. There are many quality programs in costume technology across the United States; during the summer school break, students can work in costume shops along with professionals to learn more about the field than is taught at the university. Some of the most competitive summer jobs are at Utah Shakespeare theatre, Glimmerglass Opera, Santé Fe Opera, and Williamstown Theatre Festival. These programs have costume shops staffed with many talented professionals on leave from their university or regional theatre jobs for the summer. Students can gain experience from working side by side with these professionals, along with knowledge gained in their college classes. The network formed from these summer jobs is invaluable in getting a job upon graduation.

2.4 Traditional Education and Training of Architectural Designers

In order to work as an architect, a person must complete a Bachelor of Architecture degree which takes five years or a Master of Architecture degree taking between three and three and a half years, with no prior architecture education (i.e., students who hold a BA in other fields than architecture). If a pre-professional degree is held in a non-accredited Bachelors program in architectural studies, students can apply to a Master of Architecture program and receive a degree in about two years. Those who wish to become licensed must complete a three-year paid apprentice program and pass the Architect Registration Exam (ARE). This apprentice program and licensure are under

the direction of the National Council of Architectural Registration Boards (NCARB).

2.4a Model Maker in Architecture

While there is not a requirement for formal schooling to become a model maker, there is a level of expertise to be gained, learning to work with a variety of materials and model construction techniques. Like a patternmaker or draper, skills develop over the years, and the creation of carefully scaled models that represent both the design intention and potential effects of work is crucial to a project's design, and often aid in the determination of whether or not a project should proceed. In the United States, only Bemidji State University has a Design: Model Design BS degree (Moon 2005); there are others that offer certificates in model making.

2.4b New Technologies in Design Education

With the introduction of computers, changes occurred for both the apparel and the architecture industries. The introduction of Computer Aided Design (CAD) programs brought a new way of looking at drafting, drawing, modeling, and patternmaking. Recent developments in computer technology add the ability to create a virtual world.

2.5 Introduction of Computer Technologies for Apparel Design- Beginning in the 1980s

Towards the end of the 20th century, CAD classes started becoming part of the curriculum in college apparel design programs. Using technology created for engineering, programs were adapted for the apparel industry. Patterns could now be placed on a digitizing board and entered into the computer where changes could be made. With the globalization of the apparel industry companies can now send electronic patterns to their manufacturer almost instantly.

In recent years CAD software developers have been working on perfecting the virtual fit. While virtual fit can help with proportion on an avatar, it is not a realistic representation of the fabric behaviors and therefore cannot model the fit of the garment except in a very general way. The algorithms needed to correctly represent the complicated properties of the full range of both woven and knitted fabrics are still in the developmental stages.

In the early years of the 21st century, the Cornell Body Scan Research Group obtained a 3D body scanning system from Human Solutions to make a 3D digital model of anyone who could come to the campus to be scanned. This group has continued to work and develop new uses for the scanned images; one of these new developments was creating half scale forms from the 3D body scans, producing a custom form of an individual. The first half scale form created by Cornell was exhibited in 2017 at the MoMA in New York City as part of their fashion exhibition "Items: Is Fashion Modern?" (D'Angelo, 2017)

These forms have the advantage of allowing the creation of a pattern that fits the individual's specific measurements, body proportions, and actual body stance by draping on the form. Once a perfect fit is obtained the pattern can be digitized into an apparel CAD pattern software program; the pattern is perfected and scaled up to full scale. A fitting muslin can be created using this scaled up a pattern that it is hypothesized will provide a better fit than patterns draped on traditional dress forms.

However, the use of these forms was restricted as long as 3D body scanning is only available from large, expensive stand-alone 3D scanners such as the Cornell Body Scan Research Group's scanner. The development of inexpensive, effective handheld scanners such as the Structure® Sensor make new uses of half scale forms possible, such as that being studied in this project since the persons being scanned do not need to travel to a scan site; the scanner can be brought to them.

2.6 Introduction of Computer Technologies for Architecture-

About the same time that fashion education was adapting to the computer world Architecture was doing the same thing. One of the early programs was FormZ, used in many Architecture programs; as students were exposed to these programs in school they wanted to continue to use them in the working environment after they graduated. (Morris 2016) These programs give clients the ability to walk through a building before the design is finalized, facilitate animations, and provide the basis for many 3D modeling techniques. However, without careful attention to settings and frequent printed verification, these programs that are based on abstract formal compositions are intrinsically scale less, with students frequently unaware of the scalar implications of size. They can be working in a scale that is indefinite, either too big or too small, so that printed plans are ultimately useless, especially for the purposes of material estimation and construction.

CHAPTER 3

Research Design

3.0 Overview of Research Design

This study was designed with the goal of comparing the use of custom half scale dress forms as a tool to create patterns to standard full-scale dress forms. To judge the effectiveness a pilot test was conducted with seven undergraduate students to establish the study procedures and test data collection methods.

In the main study, we worked with professional, experienced cutter/drapers in the theatre setting. These professionals can work using a traditional patterning method alongside the use of a custom half scale form. This was a way to compare the two different methods directly. By documenting the process for each method, it is possible to compare the time and money spent on each, to find out if custom half scale forms save time and money, and if they impact the design process to provide a better fit over traditional methods of creating costumes.

To accomplish the study of custom half scale as a tool for draping and designing, three professional drapers from costume shops in the northeast area were recruited. Working with these drapers a 3D scan of their client was captured. These 3D scans were processed in the Cornell Body Scanning lab and files were prepared for use with the laser cutter. The slices from these files were cut from half-inch high-density foam. Once the foam was laser, cut the forms were assembled and covered. These half scale forms were given to

the draper to work with to create a half-scale pattern and a full-scale fitting muslin. Each of the drapers was able to decide how to scale the pattern created on the half-scale form. The options are manually scaling using the radial point method or digitizing the pattern pieces into a patterning program to be scaled in the computer. The manual method involves taping the pattern pieces to paper and using a ruler, making points to be connected. If the draper wanted to scale the pattern digitally, they digitized the pattern using a digitizing board connected to the digital patterning program Optitex. Once the pattern was in the patterning program, they were able to scale the pattern to full size and plot the pattern to paper.

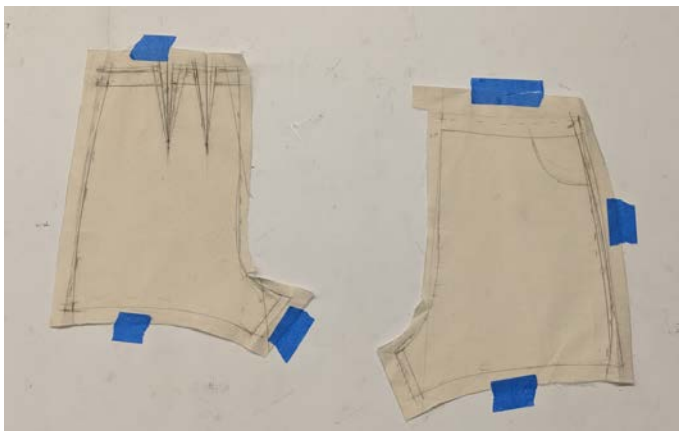


Figure 10: pattern pieces taped to a digitizing board

Figure 9: an example of radial point method

They were also instructed to create patterns for a second muslin for the same client in the traditional method used to create initial patterns and first fitting muslins. A journal was given to each draper with a section to record their daily activity using the half-scale dress form, and another section for the full-scale

work; (See Appendix C) they were also asked to document their process by taking photos of the work in process. The items recorded in the journal were: time spent, process and muslin used in creating each pattern, and any thoughts on the new process as compared to the traditional process. After the pattern was created from the custom half scale form and perfected they were instructed to scale up this pattern to full size and to create a fitting muslin. Fitting muslins using the traditional patternmaking method were to be created as well. The drapers were instructed to continue to keep journal notes on subsequent time refining, and if necessary re-fitting the patterns along with photo documentation of issues when practical. A final assessment was made of the success of each pattern when it is completed.

3.1 Recruiting Participants

To recruit patternmakers from theatrical costume shops as participants, a link was posted to a private costumer's Facebook page with her permission. Although this drew much interest in the project with 22 responses, in the end, none of them were viable participants as they were located too far from Ithaca and budget and time restrictions precluded traveling to scan their actors. However, this survey helps frame the study with

Figure 11: Facebook recruiting post

information on general interest in the process, and results will be discussed later. (See Appendix B)

Four local theatres were contacted to recruit participants, through emails, personal visits, and phone calls. Though most did not respond to the emails, some did express interest. However, all but one declined to participate in the end, some because the timing was not possible, others decided that the build period would be too hectic. The one local theatre
that agreed to participate was a good fit in terms of timing. Unfortunately, after several unanswered emails and phone calls, a visit to the shop was made to see what was happening. In the end, the shop was too overwhelmed with the fast pace of show turnover and the lack of experience of the shop manager to be able to participate although this was never formally communicated. In the end, three participants from the Ithaca area were recruited through personal contacts and by word of mouth.

3.2 Setup of Research

Once the participants, hereafter referred to as drapers, were selected, the custom half scale dress forms were created for each of their clients for the drapers to use in the study. Each of the three clients was 3D scanned using the structure scanner attached to an iPad. The software used to capture the image was 3D Mirage, an application (available from the Apple App Store) created by two Cornell alumni that improves the speed of acquisition and

quality of the scans and allows the scans to be saved directly on the iPad. These images were then processed using GeoMagic Wrap.

This process involved patching the images, trimming the form down by cutting away the head, arms and most of the leg, creating a symmetrical form, adding dowel holes that register the slices on the XY axis to facilitate building the form, and finally creating the slices. (See Appendix D) After the slices are created the file is converted to a file format that can be read in Adobe Illustrator, as Illustrator is the program used to create a file that can be read by the Kern laser cutting machine that is used to cut the slices. This file is then loaded to the laser cutter, and the slices are cut from half-inch high-density foam. These slices are then assembled on the support dowels and glued together. After the glue sets a collar reinforcement is added the shoulders; this is done with a layer of felt in order to support the shoulders and smooth out the more extreme 'steps' that are formed by the foam layers in this area. Once this is fitted to the shoulders, the form is covered firmly with a knit fabric. Cotton tights marketed for small children are ideal for this purpose as they are the right size and already have a crotch and seamless legs. A tagboard reinforcement is added to the bottom of the legs, at the armscyes and neck to give the form some

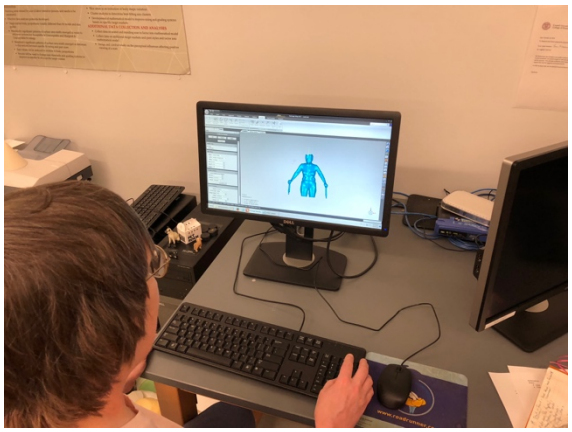


Figure 12: Working with GeoMagic in the Scanning Lab

integrity, and to glue down the edges of the knit fabric. The central dowel is left protruding from the top for ease of carrying the form. This can also be used to hang the form from a frame if needed (See Appendix F).

Each of the drapers was instructed to create one look using the custom half scale form as a tool; this involved draping the pattern on the form, scaling it up to full size and sewing a fitting muslin. They were also told to create another look using the traditional tool, a standard full-size dress form, also creating a pattern and a fitting muslin for comparison. Each was given a journal to record notes; they were instructed to take process photos; they were also given two packages containing muslin to be used for the research (5 yards for the half-scale form and 7 yards for the full-scale form) and told to save the scraps and leftover fabric from each process separately so that use of muslin for the two processes could be calculated. The drapers were also instructed to keep a strict record of the time spent on each process. Once the fitting muslin was created, they tried it on the client, documenting the alterations needed to achieve a proper fit for each muslin. Pictures were taken during the fitting process as well.

3.3 Strength of the Research Design

It was important to recruit skilled drapers to participate in this study. They needed to know the traditional patternmaking process thoroughly so that their work would be fast and efficient. They can provide feedback on the new method using the half scale forms from a position of knowledge of the process of patternmaking. Therefore, we choose to work with professionals from the theatre world. All of the participants have worked for many years in the theatre and have excellent skills in draping and construction. They are able to transform designs into well-constructed and well-fitted costumes.

It is also important to have a quality form when working in half scale that provides an accurate representation of the measurements, the proportions, and the postures of the clients. Catherine Devine, the manager of the Cornell Body Scan Research Group, runs the scanning lab and has the expertise to look at a scan and tell whether or not it is going to produce a good custom half scale form. This was a great help early in the research as the mobile scanning technology was a new way of capturing the 3D images needed for the production of the custom half scale forms. Getting a quality scan is possible using this technology, but the proper methodologies for using the handheld scanners are still under development.

3.4 Limitation of the Research Design

Some limitations to research were finding participants who were willing to try the custom half scale form in the costume shop setting. Many cutter/drapers have developed their skills over a long career and are not willing to try new things. The shop managers have a fear that this will take more time or disrupt the flow of work through the shop. The work in the costume shop is so time sensitive that any disruption can hurt the quality of the costumes produced. In the end, this study was conducted using a small sample size of three experienced drapers who were in the Ithaca area. The study takes place outside of the production of costumes, creating garments for clients instead of costumes for actors. However, the patternmaking process is the same in each case. The participants can extrapolate to discuss how this process can work in a costume shop setting.

3.5 Methods Used to Gather Data

Data for this study was collected through journals, observation, and photos.

3.6 Data Sources

Draper 1 is the Costume Shop Manager for a University Department of Theatre Arts. She teaches primarily in the BFA Theatrical Production and Design Program, teaching classes in Costume Construction and Advanced Costume Construction. She is responsible for running and maintaining the

costume shop and supervises the construction of costumes for department productions. She has worked as a Costume Shop Manager and Cutter/Draper for over 30 years. Some of the companies she has worked with include The Hangar Theatre, Cortland Repertory Theatre, The Merry-Go-Round Theatre, and Pennsylvania Stage. In addition, she worked in NYC as a freelance Draper and as a Shopper for Eaves-Brookes Costume Company.

An active volunteer in the Ithaca community, she is also a member of the Fine Arts Booster Group serving the local high school district, and a member of the Board of Directors for a community theatre company. She did her undergraduate work at Buffalo State College, her graduate work at Purdue University, and interned at The Juilliard School.

Draper 2 acquired her BFA in technical theatre and design from Texas Tech University. A native of San Antonio, Texas, she then went on to manage the costume shop at Six Flags Fiesta Texas among other ventures in her hometown. From there, she moved to Syracuse, New York to drape for Syracuse Stage, a regional theatre affiliated with Syracuse University. A chance to work at The Public Theatre in New York City brought her down to the New York City, where she then started her current job draping for the opera.

Draper 3 presently runs the costume shop at Cornell University. There she is responsible for producing costumes for the Department of Performing and Media Arts, as well as training students in all aspects of costume construction. She was the resident designer at the Kitchen Theatre Company

for several years where she designed, coordinated, and constructed costumes for over a dozen productions. She runs her own studio, designing and producing prototypes, mascots and custom clothing for film and public appearances. Previously, she had been the Textiles Coordinator and Design Associate for MacKenzie-Childs, Ltd., as well as Draper at The Juilliard School and First Hand at Eric Winterling Studio in New York.

3.7 Data Collection

Data were collected through interviews, observation, and journal entries, and contained both quantitative and qualitative information. Interviewing was done with those who interacted with the custom half scale form, finding out how they felt the half scale form impacted their work. I observed the physical fit of the muslin on the clients and made assessments based on my 20 years of experience with patternmaking and fit. I also collected data from the journal entries of those who worked with the half scale forms. The quantitative analysis methods were used to look at the data of time spent and material use, and qualitative analysis methods were used for assessing the effectiveness of each method based on the fit of the muslins and the responses of the patternmakers.

3.8 Treatment of Data

To analyze the quantitative data, I compared the time, labor hours and material used to create both the half-scale and full-scale patterns and fitting

muslins, as reported by the pattern maker. The qualitative data were analyzed by coding interviews and compiling survey answers and journal entries to find trends in the data

CHAPTER 4

Findings

4.0 Data Collection

The data from the main study could not be interpreted in the manner intended because only one of the study participants followed the provided instructions to drape on both the half scale of full-scale form, and this draper made two very different garment styles on the two forms (a dress and shorts). Although the study did not go as planned, it did reveal some useful information about how people interact with the half scale forms. In the following chapter, comparisons will be made where possible and insights shared. What was yielded is a rich resource for future studies

4.1 Pilot study

A pilot test was conducted in the fall 2017 semester to finalize technical issues in making half scale forms, and to test the process of documenting results and collecting data from the patternmakers. We recruited seven freshmen involved in the Cornell Fashion Collective to have their models scanned and created custom half-scale dress form kits for the students. The students assembled their forms with my help before they left for winter break. The students then used these forms to work through the design process of creating a look unique to them but also conforming to the overarching theme given to all of the first-year designers. During the break, they were able to

take the forms with them and created patterns for their designs for the spring fashion show.

Once they were satisfied with their design, we helped them digitize and true their patterns in Opitex, as they had not yet learned this in their classes. We then printed out both a half-scale and full-size pattern from this digitized pattern for each student. Throughout the experience of using the half scale, the students were monitored and were asked to keep a journal of thoughts during the exercise. We also took photos of the first muslin fitting; we observed only minor alterations in their fitting muslins with most being able to proceed to the final fabric after one fitting. Photos of their final garments were taken. The designs were highly successful as a whole, and it was our feeling that some of the students used the form to their advantage to work out design aspects such as proportional relationships that benefited from having the actual body in half scale

Figure 12: Half scale fitting muslin

Figure 13: Full scale fitting muslin

Figure 14: Final Garment

4.2 Descriptive Data from Recruitment Survey

Here are the results of that online Qualtrics survey from the recruitment posting in the private Facebook group of theatre professionals.

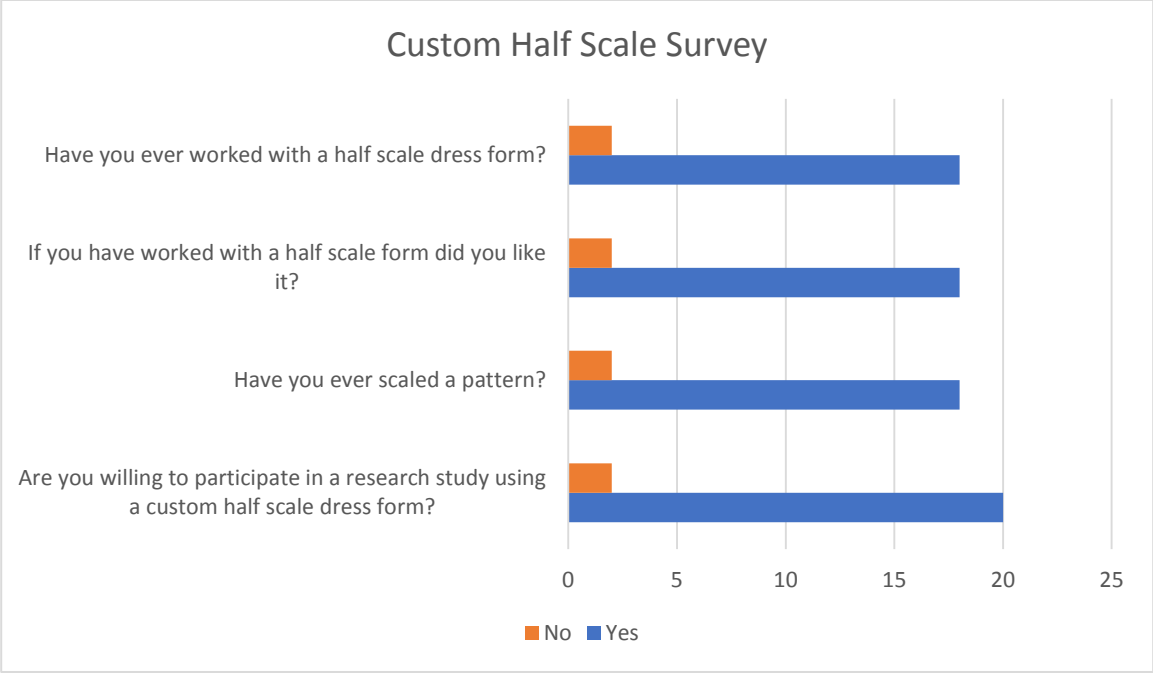


Table 1: responses to general survey questions

These were some of the reasons given by the recruits who said they like working with half-scale forms.

Time saving	6
Saves on material	10
Aids in the ability to problem solve patterning issues	7
Great teaching tool	1

Table 2: Reasons why they liked working with half scale forms

The two who did not like working with half-scale both mentioned the time needed to scale the pattern up from half-scale was the significant deterrent to working in half-scale.

Twenty of the recruits said they would like to participate in a study involving custom half scale dress forms; here is the geographical information for those recruits.

Northeast area	3
Mid-West	7
West Coast	2
No contact provided	8

Table 3: geographical information of those willing to participate in a half scale research project

4.3 Descriptive Data from the Study

The following is the data collected from the three drapers who participated in the study itself, including time spent on each stage of the process, comments from their journals, analysis of fabric use, and fit analysis of the final muslins.

This is the time recorded by each draper in their journals.

	Draper 1		Draper 2		Draper 3	
	Half Scale	Full Scale	Half Scale	Full Scale	Half Scale	Full Scale
Padding Form	N/A		N/A	1 hour 50 minutes	N/A	
Draping	2 hours 45 minutes*		1 hour 15 minutes	1 hour 50 minutes	1 hour 30 minutes	
Pin Testing	30 minutes		45 minutes	N/A	20 minutes	
Scaling Pattern/ Truing Pattern	1 hour		2 hour	2 hour 30 minutes	45 minutes	

*this was 2 pieces, a jacket and pants, so each one was about 1 hour 20 minutes.

Table 4: Time recording from drapers' journals

Figure 15: Draper 1 pin testing half scale pattern

Figure 16: Draper 3 pin testing half scale pattern

Draper insights copied from the pages of their half-scale journals.

	Draper 1	Draper 2	Draper3
Details are difficult	X		
Form hard to pin into	X		
Tools are not half scale	X		
Hard to draw on	X		
Difference between tag board and last piece of foam		X	
Digitizing was a learning curve		X	
Curves were not smooth in scaling		X	X
Printout of pattern was nice		X	
Think there are some practical applications for the half scale		X	
Disadvantage to not have a stand for the half scale form			X
Subtle curves are difficult to transfer to larger pattern			X

Table 5: Notes from drapers' half scale journal

These are the comments recorded on the pages of the drapers' full-scale journals

	Draper 1	Draper 2	Draper 3
Dress forms were all small finding one close to clients size was a challenge.		X	
Shoulder measurement of form was 1.5 inches wider then client.		X	
Forgot to measure how far from the waist hip measurement were taken.		X	
Question if my bust area measurements are good; bust looks big.		X	

Table 5: Notes from drapers' full-scale journal

The following chart shows the percentage of muslin used by each draper who returned the unused and fabric scrapes. I weighed the initial packages of fabric given to each draper. Once the draper was finished, I weighed the muslin returned by each participant. Draper 1 and draper 2 used both packages of fabric from completion of their part of the study

	Initial weight of fabric packages	Draper 1 Returned fabric	Draper 2 Returned fabric	Draper 3 Returned fabric
Half Scale 5 yards	659.57 g	1111.58 g	521.52 g	1273.27
Full Scale 7yards	924.81 g		642.92 g	

Table 6: Weight of fabric used during study

Following are the photos of the fittings conducted at the end of the study.

Figure 17: front view full scale fitting muslin draper 2

Figure 18: back view full scale fitting muslin draper 2

Figure 19: front view half scale fitting muslin draper 1

Figure 20: side view half scale fitting muslin draper 1

Figure 21: back view half scale fitting muslin draper 1

Figure 22: front view half scale fitting muslin draper 1

Figure 23: side view half scale fitting muslin draper 1

Figure 24: back view half scale fitting muslin draper 1

Figure 25: front view half scale fitting muslin draper 3

Figure 26: side view half scale fitting muslin draper 3

Figure 27: side view half scale fitting muslin draper 3

4.4 Analysis and Interpretation of Data

As you can see from Table 2, only one of the drapers completed the study correctly. However, when comparing the time to complete the work on the half scale form and on the full-scale form for this one draper, including preparation and perfecting the pattern, there is a significant time-saving in the half scale process. The total time for the half scale is 3 hours while the time recorded for the full scale is 6 hours and 10 minutes. Preparation for the full scale was significant, as it can be quite time consuming to pad a form. All three of the drapers completed the actual pattern draping on the half scale form in roughly the same amount of time, at one hour 15 minutes, one hour 20 minutes, and one hour 30 minutes. Draper 1 did two pieces on the half scale

form. She created a jacket and pants for her client. Each of the other drapers only created one piece for their client, draper 2 created shorts, with a slash pocket and draper 3 created a strapless sundress. Draper 1 and 2 used a digitizing board to copy their patterns into Optitex, a patternmaking program. Once the patterns were in the computer program they were able to do some truing of the pattern, scale the patterns to full size, and add seam allowances. They were then able to plot these patterns to use in the construction of the fitting muslin. Draper 3 used the manual radial point method to scale her pattern to full size. Each of the drapers had comments about the scaling process. For the two who used the digitizing method, this was new to them, so it took some time to understand what to do. In interviews about this process each said they were sure they would get faster the more they used the program. The manual method can be quick for simple pattern pieces, which draper 2 mentioned in her journal, but again it is not something you do every day so at first progress was a bit slow.

Figure 28: Half scale mockup of jacket and pant created by draper 1

There is a difference of the time recorded of the three half-scale and one full-scale drapes of about 25 to 30%. This is a very small sample size but it does indicate there might be a timesaving in using the half-scale form to

create patterns. Draper 1 has experience working with half-scale; she has several Wolf brand half-scale forms in her costume shop. Neither draper 2 or 3 had worked with half-scale forms as much so this was a relatively new experience for them.

Draper 2 was the only one who padded a full-scale form. In her padding of the full-scale form you can see she ran into an issue with the breast area, notice the difference between the half scale form and the full-scale form, with a much lower placement on the full-scale form. She provided for the narrower shoulder by giving herself landmarks to make sure the shoulder was the correct width. Although she did a nice job on the butt area as you move up the back there is a slight hunch back added at the shoulder of the full-scale form that is not seen in the half scale form, which represents the straight, flat shoulder and back configuration of the client.

Figure 29: Custom half scale and padded full-scale dress form used by Draper 2

To determine the amount of fabric used in each of the draping processes the fabric was weighted. The beginning weight was recorded and compared to the weight of the remaining fabric when the draper was finished. Draper 1 used both the packages for the one half-scale drape and fitting

muslin, in the analysis the total weight of both packages was compared to the returned fabric. The amount of fabric used for the drape and creation of the fitting muslin was about 30% of the total beginning amount for two pieces, we must remember both a jacket and pant were made for this client. Draper 2 used about 20% of the total fabric for the half scale drape and fitting muslin for the shorts she created for her clients. Finally, draper 3 used 20% for the sundress fitting muslin and pattern drape. The fabric used for the full-scale drape and fitting muslin by draper 2 was about 30%.

When assessing the fittings, it can be seen that some adjustment was made to every garment. Draper 1 had fit issues with the width of the legs, crotch length, and waist of the pants created for her client on the half-scale form. The back of the jacket needed to be taken in, so the shoulders of the jacket would sit properly on the client's shoulders. Draper 2 made an alteration at the waist of the bodice of the dress made on the full-scale form and the strap of the dress needed to be taken up about 2 inches. The shorts created on the half-scale form were too long in the crotch and one of the back darts need to be adjusted. For draper 3 the first fitting muslin made on the half scale had about 4 inches too much at the bust and 2 inches too much at the waist; she decided to make a second fitting muslin which fit well.

CHAPTER 5

Discussion and Summary of Research Findings

5.0 Conclusions

Because only one of the drapers followed the instructions to create muslins using two different methods, the data are limited. The one pair of muslins done correctly confirms that there was a substantial time saving when you compare the time each draper spent draping on the half scale to the time spent on the one full-scale drape. There was a learning curve involved in using the half scale form; with time I would expect each draper to work even faster with these forms.

However, other time-consuming tasks are part of each patternmaking technique; the process of scaling the half scale pattern up, and on the other hand padding a full-scale form to match the measurements of the client -- both require extra time. These processes can be quite time-consuming if not optimized by frequent practice. Draper 2 was rather quick in padding the form although there was an issue with the height of the breast on the full-size form. While she was able to achieve the correct circumference measurement when you look at the custom half scale form (which captures all the proportions of the client) and compare it to the padded full-size form you will see the breast apex is too low on the full-scale form. (see figure 29) Because of the full-size form's construction from solid materials, it is impossible to move the breasts

up to the proper height. The shoulder configuration is also incorrect on the padded form.

The other area that can be a time issue is scaling the half scale pattern up to full scale; draper 3 actually stated in her journal that she deliberately chose a simple design so that she could scale the pattern up quickly. The other two drapers scaled their patterns electronically, using the digitizing board to put the pattern in the CAD system. This was a new process for both of them, so they were not as fast as they would be if they had used this technology before. However, as can be seen in table 4 there is an overall time saving when using the half scale form.

The ability to compare material savings is a real challenge in this study. The first challenge is the fact only one draper did both a half-scale and a full-scale drape, as well as the fact that she did two different garments (a sundress and a pair of shorts) instead of creating two garments of the same type as instructed. The other two used both sets of fabric provided (which were intended for the half-scale and full scale respectively) to drape on the half scale and to create the full-size fitting muslin, instead of using only the fabric provided for the half-scale work. Ideally, each draper would have made two patterns, creating the same garment type in both half-scale and full-scale as instructed, but they did not. Looking at table 6 you see the half scale work used about 20% of the fabric provided. The full-scale pattern of a sundress created by draper 2 used 30% of the fabric provided; draper 3 also draped a sundress on the half-scale form so you could make some comparison between

these two models. However, though they were both sundresses, the skirts were different silhouettes and used different amounts of fabric. Although in this study we could not make a direct comparison of the fabric saved, it is still clear that if you needed a yard of fabric for a full scale, you would need a quarter of yard for the half-scale (depending to some extent on fabric width and pattern dimensions).

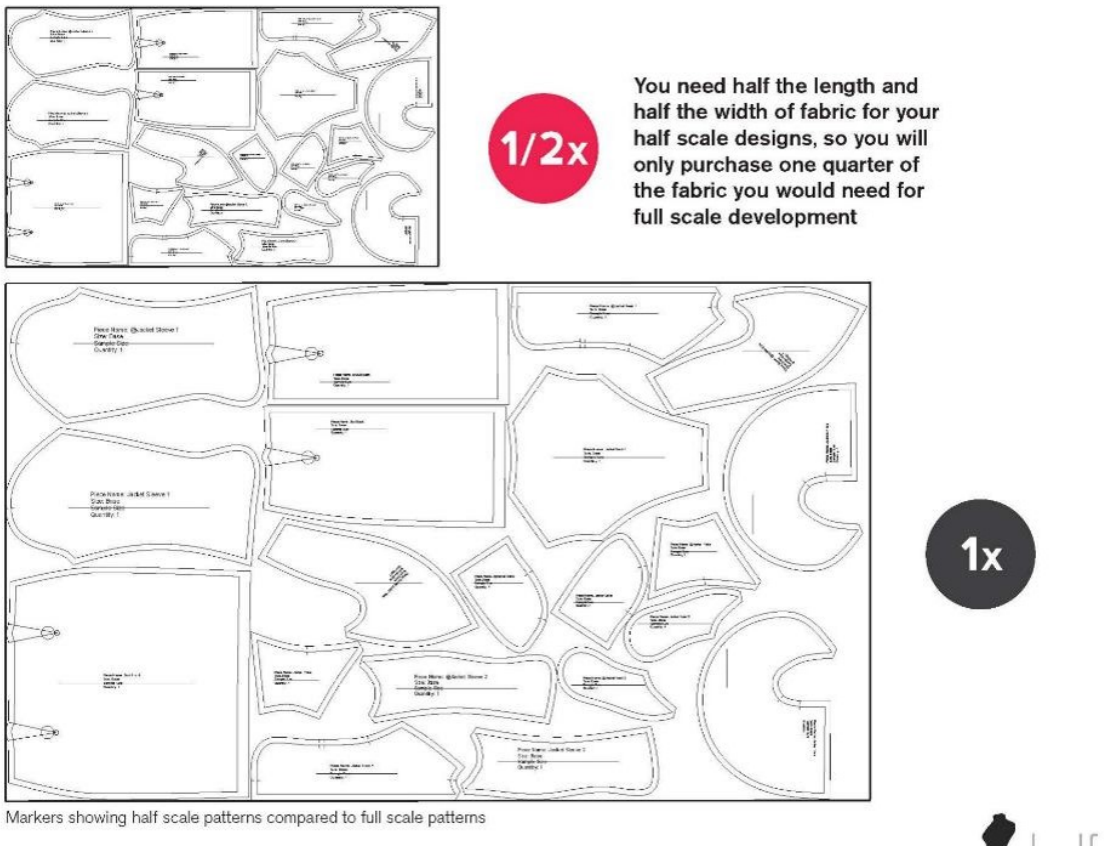


Figure 30: As can be seen in this image, patterns for a half-scale form need half the length and half the width of the fabric, resulting in a savings of 75%

Draper 2 had reasonably good fit with the patterns created using both the half-scale and full-scale form. The sundress created on the full-scale form

had an alteration at the waist, the draper noted she marked the waist too low in the back and side, but the center front was good. However it must be noted that had the style covered the bodice more, instead of having simple straps, the fit over the low bust and rounded shoulder exhibited in the padded form would have been incorrect. Differences in bust placement and particularly in shoulder and back configuration can result in an out-of-balance muslin, and could often require a new fitting muslin. However, this simple style avoided these issues.

The shorts had a fit issue with the crotch being too long; the draper noted it was not easy to get in between the legs to establish the appropriate crotch shape and placement in the half scale form (although this could have been easily corrected at the pin testing stage on the form). Overall her fit was good.

Both draper 1 and draper 2 had issues with not trusting the half scale form: they both added ease to their patterns which can be seen in the fitting photos. When I spoke with draper 2, she admitted she did not really trust the form and added some ease to her pattern before scaling it to full scale.

When comparing the results of the pilot test to the study, one finding that was very noticeable is the students, who did not have much traditional patternmaking experience, trusted the form and draped to fit closely without second-guessing, resulting in good fit outcomes. In the pilot study, most of the students had an excellent fit, while the more experienced patternmakers added excess ease in their patterns. The expert patternmakers are used to

keeping their options open by adding ease when working on the standard dress forms, which do not duplicate the proportions of their client, as it is easier to pin a muslin in to fit the body than to let the muslin out if it is too small. As people work with the custom half scale forms, they would probably learn to trust them, and their fitting would improve.

One question we had considered early in the process was if using the half scale form would encourage or allow more a creative patternmaking process as the draper can make changes to the pattern quickly during the draping process, allowing more time for experimentation. None of the drapers did this while working with the form. Each felt they were working with a client, so they needed to do what was initially discussed, and did not use the form to experiment with different pattern iterations. They also confined themselves to simple silhouettes that do not provide much scope for experimentation.

5.1 Implications for Theatre Costume Shops and Professional Dressmakers

These forms could be of use to shops and dressmakers when actors or clients have limited availability for fittings. For theatre shops I believe that as they begin to trust the custom half scale form, the need for a fitting muslin could be eliminated, removing one whole step from the development of costumes. Patterns could be draped on the half-scale form, scaled up and used to cut the final fabric for a shell fitting. For a shell fitting, the fabric is basted or sewn together just on the main seams. Sleeves, collars, facings, and linings are not added to this simple shell of the garment, allowing easy fitting

alterations before these elements are added. Going straight to a shell fitting would save time and would reduce muslin costs even further. It would reduce the number of fittings saving time for the actor as well.

Also, if a shop is working with an actor multiple times, if they return for another role or if they have many costume changes in a play, the shop could continue to use the actor's form multiple times. The forms do not take up much storage room. They could, therefore, be a particularly useful tool for a repertory company that hires a company of actors who stay with the theatre season after season.

The custom half scale forms could also be a great thing for actors to own themselves. Actors who are working at several regional theatres could ship their forms to the shops ahead of their arrival, thus allowing the shop to begin their costumes earlier, It could be possible that the shop could have their costumes ready for shell fittings in the fabric as soon as they arrive. Fewer fittings also translate to more time for rehearsals. The size of the half-scale form could help with space limitations, as fewer full-scale forms would be needed.

For dressmakers, many of the same benefits could be achieved by saving both space and time by not having to re-pad dress forms for repeat clients.

5.2 Recommendations to Other Researchers for Future Research Based on the Study

One of the most significant challenges for this study was coming up against tradition. Over the years many shops and drapers have come up with ways to get work done given the limitations they face. In the recruitment process, I came up against push back for fear this study would add to their already tight time schedule. To alleviate these fears, if time and money were not an issue, I think a virtual workshop before the study would have been good. Scanning and dress form construction could have happened before the workshop, and once the form was constructed, they would be sent to various shops for shop manager and drapers to work with. A zoom meeting could have been set up, and everyone could work together, participants could ask question and become familiar with the forms. I think this would have helped with the fear of the unknown. In addition, strict deadlines would be set in the study, and these would be set with the individual shops' timetable in mind. Lastly, I would offer help in the way of an intern if this study did slow down the workflow in a shop.

Based on the feedback from the drapers I think there are several areas to be looked into. One would be whether it is indeed possible to eliminate the fitting muslin from the process, so that shops could prepare ahead of time when an actor is coming into a show with very limited time between contracts, Another area could be making costumes for those performing in non-traditional roles, like cross-dressing or drag queen roles. Both of these nontraditional

roles present a number of challenges. Trying to fit male clothes to a female figure can present issues with narrower shoulder or hips. For Drag queens, the male body creates some issues again in the shoulders and through the chest. They also can have some fit issues through the hips. With a custom half scale form the designer and the client can discuss and test different proportional modifications to both the body and the garments, such as binding the breast, adding padding to the garment, and other modifications.

Having a custom half scale can help work out many patterning issues before the fitting. Can these forms help create better fitting costumes/garments in less time? This question is something we will continue to look at here with our students in an educational setting. The students who have used the forms while creating looks for the fashion show want to use them again. Working with the students and other patternmakers, we will continue to monitor time and material used, and creative development of patterns when working with the custom half scale forms.

APPENDIX

Appendix A
Costume shop measurement sheet

NAME:		**GENERAL INFORMATION**	
Character:		Trousers:	
Phone #:		Suit:	Shirt:
Height:		Dress:	
Weight:		Bra:	
BODY ADDITIONS		Shoe Size:	
Tattoos: Y/N Where:		Foot Problems:	
Piercings: Y/N Where:		Tights:	
TORSO		**ARM**	
Mid Neck:		Nape to Wrist:	
Base of Neck:		Shoulder to Elbow:	
Mid Shoulder to Bust Point:		Shoulder to Wrist:	
Above Bust:		Inner Arm to Elbow:	
Chest/Bust :	Expanded:	Inner Arm to Wrist:	
Bust Point to Bust Point:		Armceye:	
Ribcage:	Expanded:	Bicep:	
Natural Waist:		Elbow:	
Pants Waist:	‘‘ From NW:	Forearm:	
Hips:	‘‘ From NW:	Wrist:	
Front Width:		**LEG**	
Front Shoulder to Waist R: L:		Outseam to Above Knee:	
Underarm to Waist:		Outseam to Below Knee:	
Center Front to Waist:		Outseam to Ankle:	
Center Front to Floor:		Outseam to Floor:	
Front Waist to Floor:		Thigh:	
Shoulder Seam:		Below Knee:	
Shoulder to Shoulder:		Calf:	
Back Width:		Ankle:	
Back Shoulder to Waist R: L:		Inseam to Ankle:	
Center Back to Waist:		Inseam to Floor:	
Canter Back to Floor:		**WIGS**	
Back waist to Floor:		Head Circumference:	
Half Girth:		Ear to Ear:	
Full Girth:		Forehead to Poll:	
Crotch Depth F: B:		Hairline Circumference;	

Appendix B
Qualtrics survey

Custom Half Scale Dress Form Project

Start of Block: Default Question Block

Q1 Have you ever worked with a half scale dress form?

O Yes (1)

O No (2)

Q2 If you have worked with a half scale dress form did you...

O Like (1)

O Dislike (2)

Q10 Why did you like or dislike working in half scale?

_____

Q3 Have you ever scaled a pattern up (for example, from Janet Arnold, or another book of scaled patterns)?

O Yes (1)

O No (2)

Q4 How much do you typically build per show?

_____

Q5 What type of patterning do you prefer, flat patterning or draping? Why?

_____

Q6 Are you willing to participate in a project using custom half scale dress forms?

O Yes (1)

O No (2)

Skip To: End of Survey If Are you willing to participate in a project using custom half scale dress forms? = No

Q11 Please provide contact information.

_____

Q7 Where are you located?

_____

Q8 Where are your actors?

_____

Q9 Anything else you would like to share?

Appendix C
Journal sheets

FULL SCALE JOURNAL

Date_____

Time Spent_____

Daily Notes

HALF SCALE JOURNAL

Date_____

Time Spent_____

Daily Notes

Appendix D
How to use the mobile scanner

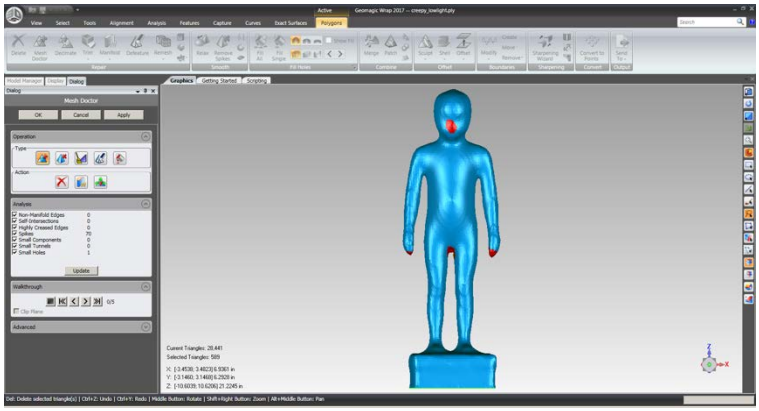
Attach the Structure Sensor® to an iPad; (For the purpose of this study we used an app by Mirage 3D Scan to capture the image of each subject). Once the program is opened create a new client using the name of the model being scanned. Remind the model to continue to look straight ahead and not to follow with their eyes/head as you walk around them. To capture the scan, you must anchor the scan to the floor, once you have done that you can move the iPad up and down while walking around the model. Pay close attention to the arm pits and crotch areas, in these areas you can get webbing which can be fixed in GeoWrap or another software for manipulation of 3D objects but starting with a good scan makes the process much better. Scan the models at least 3 times, making sure they relax their shoulders, have their hips square and are looking straight ahead. Hit done after each scan. You can email the finished scan to yourself.

Appendix E
How to process the scan

Initial Processing

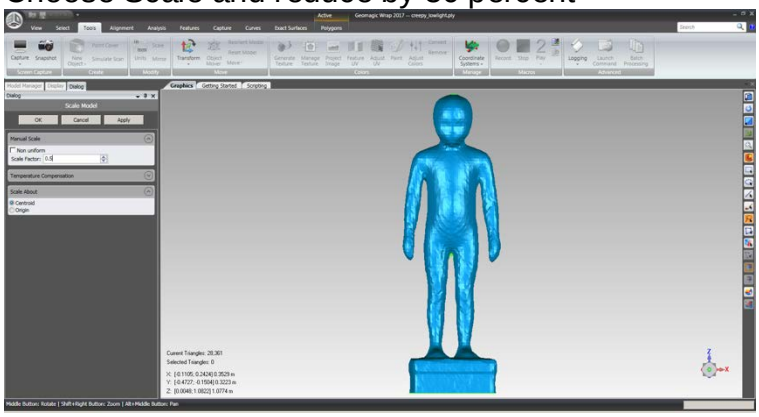
Open Geomagic Wrap – Import your STL or OBJ file making sure the initial units are meters – let the program run

Choose to run mesh doctor

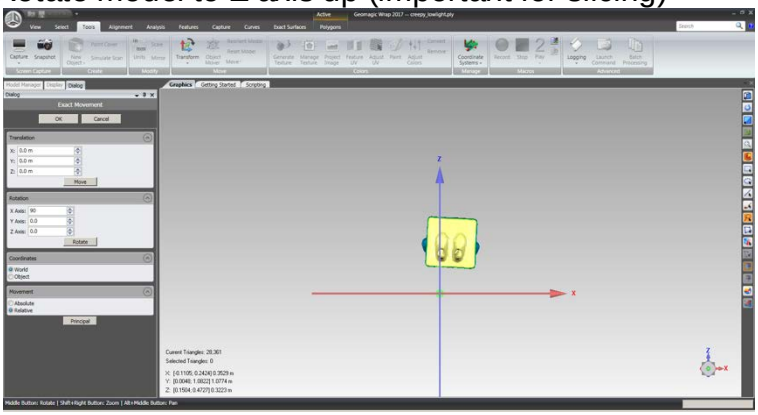


From the Tools tab:

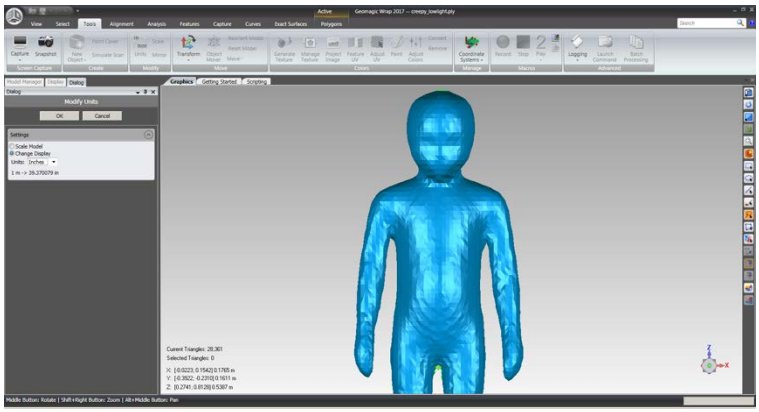
Choose Scale and reduce by 50 percent



Rotate model to Z axis up (important for slicing)

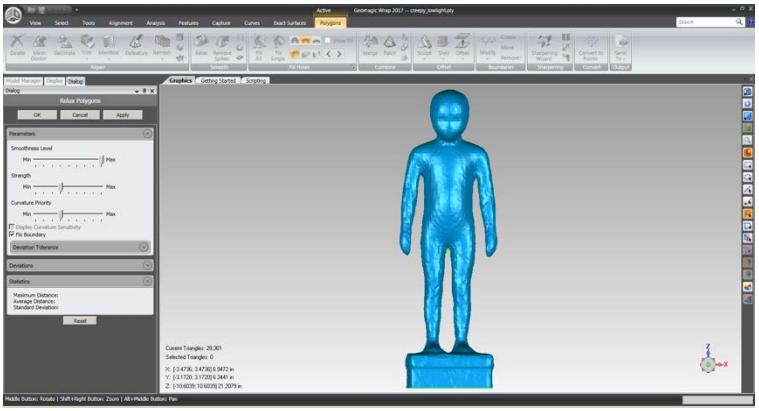


Change units to inches

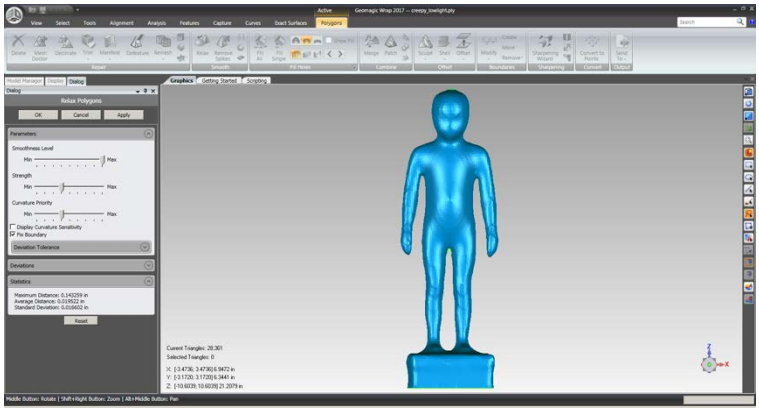


Look from top and bottom to straighten shoulders and hips as much as possible along the X axis.
Reorient model to apply the transformation matrix.
From the Polygons tab:
Smooth the model (remove wrinkles, etc.)
Using Relax, set smoothness to Max, strength to 3 or 4, and preserve curves to 3 or 4. Click Apply.

Before



After

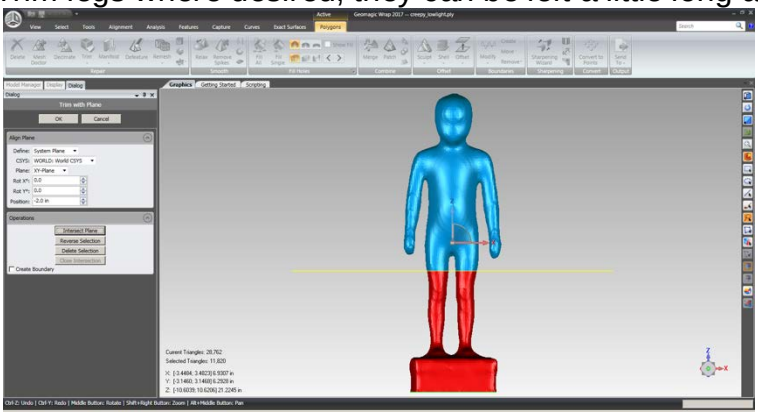


If the crotch/armhole are webbed, delete the webbing and rebuild.

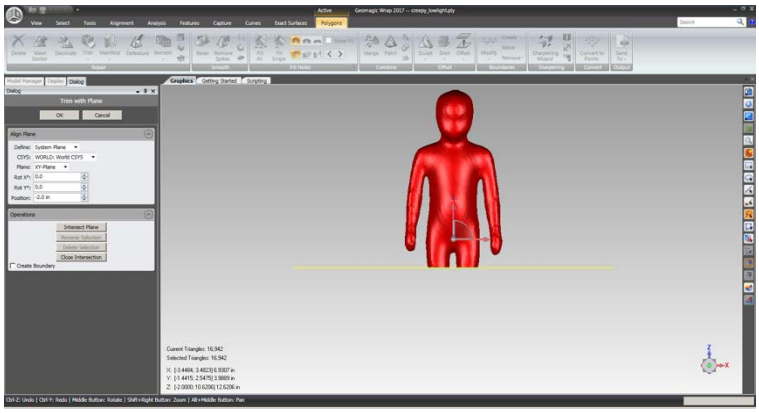
Once this is done, run Mesh Doctor again.

If there are lumps on the model you can use the LASSO to highlight the area, delete and fill the hole with full curvature

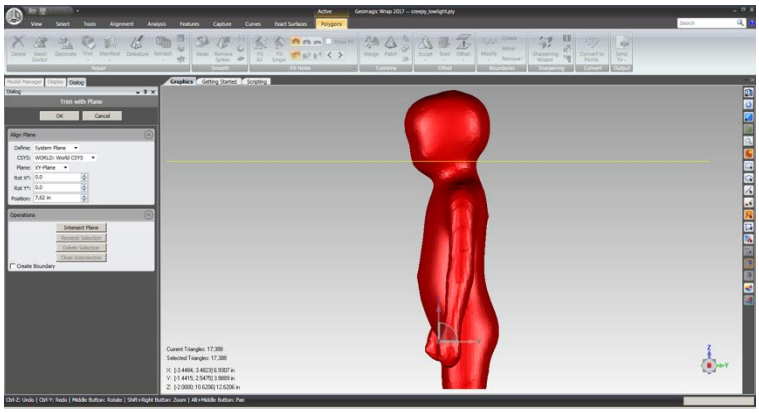
Trimming
Duplicate the model, rename it trimmed
In the Polygons tab, select trim, and trim with plane, uncheck create boundary.
Trim legs where desired; they can be left a little long at this point.

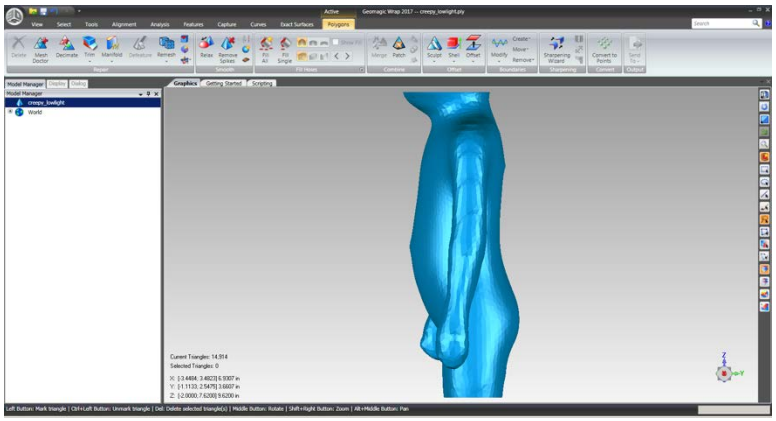


Select intersect plane, delete section and then close intersection.

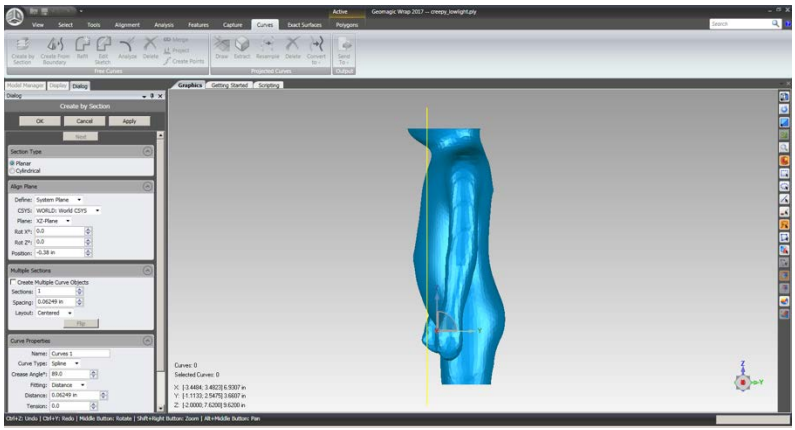


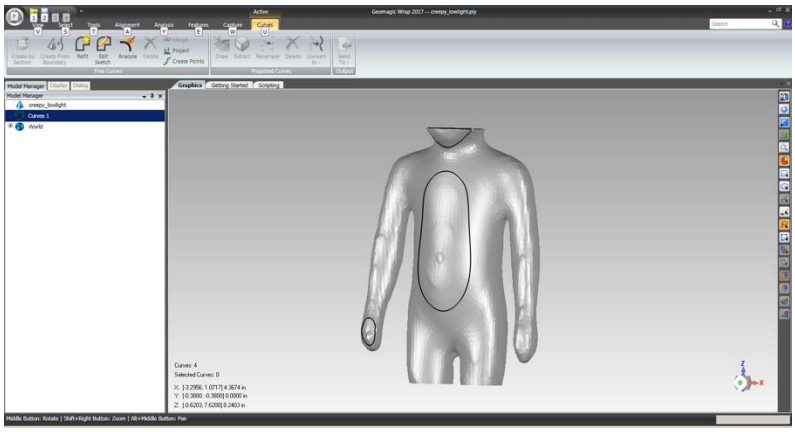
Then look from the side and trim neck as high as possible, making sure to avoid the hair.



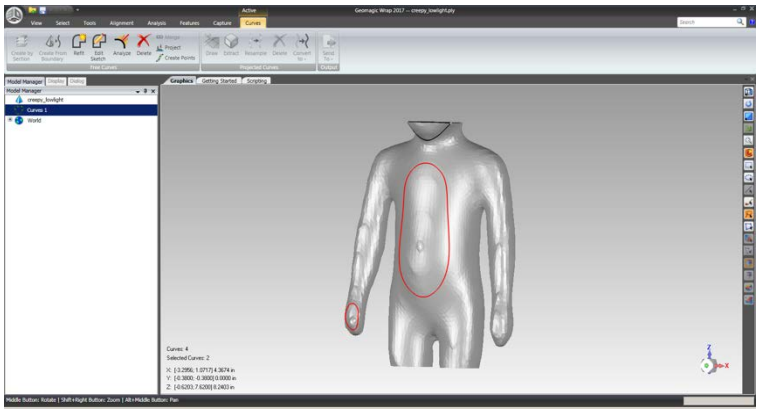


Go to the Curves tab and choose Create by Section. Use the XZ plane to make a curve where the chin protrudes from the neck.

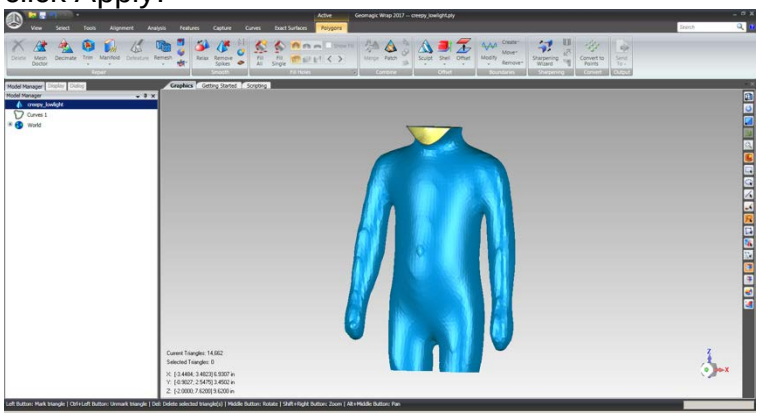




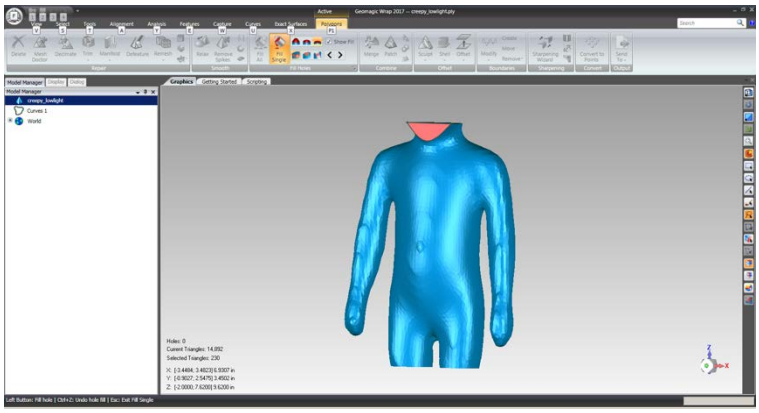
Delete parts of curve that intersect the body.

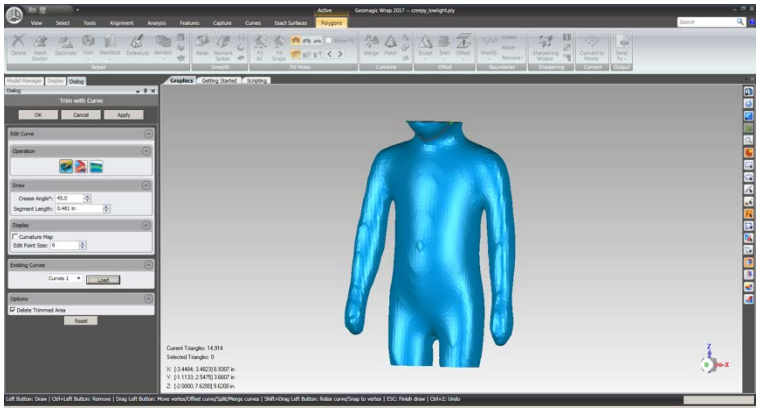


Use Trim with Curve, load the chin curve, check Delete Trimmed Area, and click Apply.



Fill the hole flat.





Set left and right armhole curves the same way but using the YZ plane. Remember to delete the parts that intersect the body. Make sure to label the curves as left and right. Trim arms off the body with the curves and fill holes flat.
Recheck hip/shoulder alignment, adjust if necessary.
Move trimmed model to origin and Reorient model. (the move is not permanent until the model is Reoriented)

Symmetry
Set curves at bust, waist, hip. Record the height in text file. It is important to record the height of the curves.
Duplicate trimmed model.
Slice with a vertical plane, no boundary. Start with the side where the shoulder is higher.
Mirror the model. Using the same z position from your original curves of bust, waist, and hip make new curves. Compare the symmetry. If the body curves are significantly off, delete.

Duplicate trimmed model again and try slicing at a different location. Moving the vertical line just a small amount can make a big difference. There is a lot of trial and error.
Some bodies are difficult. It may be necessary to cut in two above the waist, rotate one half (usually the bust in women), and rejoin.
If you have trouble with the symmetry, go back to the beginning with one of the other scans before you spend a lot of time.

Create the slices
Make half inch curves from the bottom to the top. Start at the nearest quarter inch from the bottom. These curves will help you place the dowel holes.

Dowel holes
Create two World Feature cylinders: one that is 10 mm in diameter and 2-3 inches taller than the model and the other 0.25" in diameter and 8" tall.
Convert the cylinders to polygonal models, move them to the origin, and reorient.
Duplicate the larger cylinder. It should be in the center of the body.
Duplicate the original cylinder. Use Exact Movement in X and Y to set the cylinder in the shoulder area.
It is important to make sure the cylinder doesn't protrude through the body/legs at front or back.
Turn on transparency for the model to check that the cylinder isn't too close to the edge. You want a reasonable distance when cutting the foam. Record the distance you moved the cylinder in X and Y. You can also hide the body and use the curves to check how close the cylinder is to the edge.
Duplicate the original cylinder again. Use the distances you recorded for the first (reversing the X direction) to set the second cylinder.
Duplicate the smaller cylinder and position it in Z to intersect the lowest body slice and the leg slices. Move it into the thigh area away from the larger cylinder. Repeat with a new cylinder on the other side. These smaller dowels stabilize the thigh and ensure correct assembly.
Save the file. Save As a new name and work from there. That way, if you need to move the holes, you can go back to the first file. Delete the body guide curves.

Cutting the dowel holes
In Model Manager, control-click the center cylinder and the symmetrical body. Click Boolean in the Polygons toolbar. Uncheck Create Boundary and click on one of the Subtract buttons. Subtract 1 removes the first model in Model Manager of the two you highlighted; Subtract 2 removes the second. Make sure the cylinder is the one you're subtracting.

Repeat with the left and right cylinders. The body model will now be named Intersect n, so make sure you're subtracting the cylinder.
If you get a message about non-manifold objects, go back to the Model Manager and select only the body. Click Manifold on the Polygons toolbar and choose Make Manifold (Closed). You'll be able to subtract the cylinder after this.
Repeat with the thigh dowels.

Creating the final curves
From the Curves tab, make a new set of half inch slices from the bottom to the top. These will have the dowel holes. Save the curves to a folder as igs. Duplicate the armhole curve that corresponds to the symmetrical model and rotate it 90 degrees to lie flat in the XY plane. Save it as igs.

In order to open the curves in Illustrator you need to convert from igs to a flattened svg file. Using FreeCad you can make this conversion.

Appendix F
How to Create the Half Scale Form

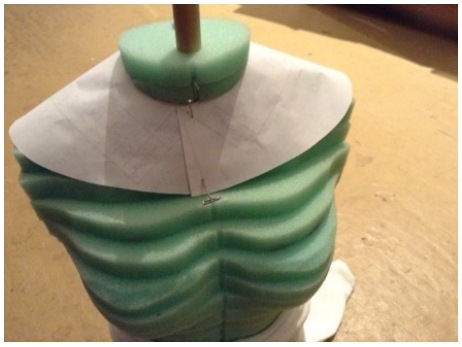
Tools and Materials:

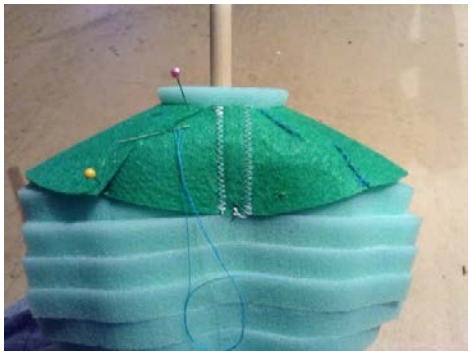
Foam slices	Baby tights
3 ½" dowels: two short, one long	Tagboard caps: two neck, four armscye, four legs
2 ¼" dowels 3 ½" long	Curved needle
Elmer's white glue	Small binder clamps
Paper pattern for shoulder felt	Style tape

Step one – You should have 40 to 45 numbered foam slices body slices are marker with a T, leg slices are marked with L and R. Start threading the slices on the long dowel, from the neck down, keeping all holes aligned. When you have all the torso slices together feed the short dowels into the holes. Feed the leg slices on the short dowels.

Step 2 – Glue the slices together with a couple of spots of the glue for each slice.. You want to avoid compressing the foam, or forming gaps because of the thickness of the glue. Keep checking the height of the form. Each slice should take up ½"; no more, no less

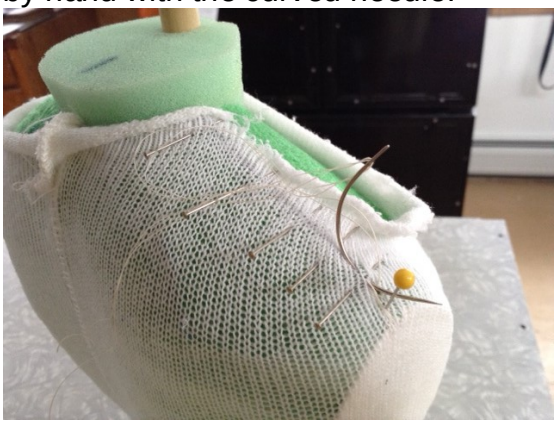
Step 3 – Check the paper pattern and make sure it fits fairly well. It should have a small overlap in front, fit snugly to the neck, and extend to the ends of the shoulders. If not, make a new paper pattern. Cut the felt, place on the shoulders, pin, and sew the center front (you can lift this off and sew by machine). Now refine and perfect the fit by cutting towards the fullest part of the shoulder blade anywhere the felt does not lie flat on the form. Overlap, pin and stitch these small ‘darts’. You can do this by hand, or lift it off and sew by machine



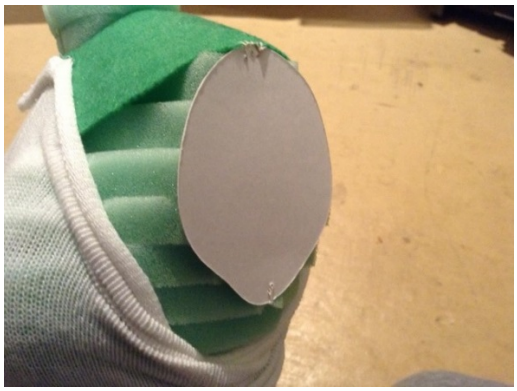



Step 4 – Cut the stitches in the baby tights that hold the elastic at the waist, being careful not to harm the knit fabric. Remove the stitches, take out the elastic, and unfold the waist. Cut out the diaper panel; surge this seam or ask Kim for help with this step. Pull the tights on over the form and see if they will reach the shoulder. Really stretch the tights; the tighter this is, the more firm your form will be. If they do not reach the shoulder, cut off the feet leaving about ¾", cut open a piece, and surge it on to the top edge to extend to the shoulder. You may want to cut off some of the length of the tights themselves, so the seam ends up under the bust.

Step 5 – Pull the knit tight over the shoulder from the back. Pin, identify the shoulder seam placement. Mark with a pencil, and backstitch along this line using the curved needle. Trim away any excess from the front, fold under the seam, and stitch. Now take a small piece of knit from the legs and make a tube that fits tightly over the neck. Trim, turn the neck seam under, and sew around the neckline by hand with the curved needle.



Step 6 – Slide the tagboard armscye pieces in place between the knit fabric and the foam. Make sure you have them oriented correctly. Tack in place with a spot of glue. Slide one of the neck pieces on the dowel. Insert one leg piece at the bottom of each leg. Now glue the outer tagboard pieces in place using the white glue, starting with the armscye pieces. Hold the pieces in place until they dry using the small binder clamps or rubber bands, keeping them as flat as possible. For the neck and legs, pull the fabric firmly over the tagboard and trim as needed. Apply glue and press until it becomes tacky and holds the fabric in place. Then glue on the outer tagboard piece. Hold in place with the binder clamps as before. The amount of glue is critical. Too much and it will squeeze out, and soften and deform the tagboard. Too little and it will not hold the fabric in place.



Step 7 – When the glue is dry, use style tape to mark side seams, pinning in place. Be sure the two sides are identical. Place the style tape from the front neckline through the crotch up to the back neckline. Measure in several places to the side seams to make sure these front and back centerlines are centered, and pin. Now add style tape at the neckline, bust, waist and hip. You are now ready to create designs on your custom dress form!

Appendix G
C Form

I am asking you to participate in a research study titled "Use of Custom Half Scale Dress Forms by Designers". I will describe this study to you and answer any of your questions. This study is being led by Kimberly Phoenix, Department of Fiber Science Apparel Design at Cornell University. The Faculty Advisor for this study is Professor Susan Ashdown, Department of Fiber Science Apparel Design at Cornell University.

What the study is about

In this study I will work with several costume shops in the northeast area, working with shops who have professional experienced cutter/drapers in the theatre setting. Theatres can provide a traditional patterning method alongside the use of a custom half scale form. This will be a way to compare the two different methods. By documenting the process for each process through journals and observation, I will be able to compare the time and money spent on each of the different methods. I will find out if custom half scale forms save time and money and if the impact the design process and provide a better fit over traditions methods of creating costumes.

What we will ask you to do

I will ask you to create a costume for the actor using both traditional method and custom half scale form to create a pattern and first fitting muslin. A journal will be given to you to record your daily activity using the form and traditional method, at the same time I will also ask you to document your work by taking photos of the work in process. Some of the things recorded in the journal will be time spent, process and muslin used. After the pattern is created, finished, and trued in half scale they will scale up this pattern to full size and create a fitting muslin. I would like photos of both the full scale and half scale fitting muslins.

Risks and discomforts

I do not anticipate any risks from participating in this research.

Benefits

We hope to show using the custom half scale form will save theatre costume shop both time and money.

Compensation for participation

There is no payment or course credit for taking part in the study.

Audio/Video Recording

Interviews will be audio recorded.

Please sign below if you are willing to have this interview recorded. You may still participate in this study if you are not willing to have the interview recorded.

☐ I do not want to have this interview recorded.
☐ I am willing to have this interview recorded:

Signed: _____

Date: _____

Privacy/Confidentiality/Data Security

I will have access to identifying information, this information will be kept on the Cornell University server.

Taking part is voluntary

Taking part is voluntary, you may refuse to participate before the study begins, discontinue at any time, or skip any questions/procedures that may make him/her feel uncomfortable, with no penalty to you or your relationship with the university.

Follow up studies

We may contact you again to request your participation in a follow up study. As always, your participation will be voluntary, and we will ask for your explicit consent to participate in any of the follow up studies.

If you have questions

The main researcher conducting this study is Kimberly Phoenix, a graduate student at Cornell University. Please ask any questions you have now. If you have questions later, you may contact Kimberly Phoenix at kah22@cornell.edu or at (607)351-4770. If you have any questions or concerns regarding your rights as a subject in this study, you may contact the Institutional Review Board (IRB) for Human Participants at 607-255-5138 or access their website at http://www.irb.cornell.edu. You may also report your concerns or complaints anonymously through Ethicspoint online at www.hotline.cornell.edu or by calling toll free at 1-866-293-3077. Ethicspoint is an independent organization that serves as a liaison between the University and the person bringing the complaint so that anonymity can be ensured.

You will be given a copy of this form to keep for their records.

Statement of Consent

I have read the above information and have received answers to any questions I asked. I consent to take part in the study.

Your Signature_____ Date_____

Your Name (printed)_____

Signature of person obtaining consent_____ Date_____

Printed name of person obtaining consent_____

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Glossary

Adobe Illustrator - is a vector graphics editor developed and marketed by Adobe Systems. Originally designed for the Apple Macintosh, development of Adobe Illustrator began in 1985. Along with Creative Cloud (Adobe's shift to monthly or annual subscription service delivered over the Internet), Illustrator CC was released. The latest version, Illustrator CC 2018, was released in March 2018 and is the 22nd generation in the product line

AutoCAD - is a commercial computer-aided design (CAD) and drafting software application. Developed and marketed by Autodesk, AutoCAD was first released in December 1982 as a desktop app running on microcomputers with internal graphics controllers.[2] Before AutoCAD was introduced, most commercial CAD programs ran on mainframe computers or minicomputers, with each CAD operator (user) working at a separate graphics terminal.[3] Since 2010, AutoCAD was released as a mobile- and web app as well, marketed as AutoCAD 360. AutoCAD is used across a wide range of industries, by architects, project managers, engineers, graphic designers, town planners and many other professionals. It was supported by 750 training centers worldwide in 1994.

FreeCAD - is a free and open-source (under the LGPLv2+ license) general-purpose parametric 3D CAD modeler and a building information modeling (BIM) software with finite-element-method (FEM) support. FreeCAD is aimed directly at mechanical engineering product design but also expands to a wider range of uses around engineering, such as architecture or electrical engineering. FreeCAD can be used interactively, or its functionality can be accessed and extended using the Python programming language and is currently in a beta stage of development.

form·Z - is a computer-aided (CAD) design tool developed by AutoDesSys for all design fields that deal with the articulation of 3D spaces and forms and which is used for 3D modeling, drafting, animation and rendering.

Geomagic - is the professional engineering software brand of 3D Systems. The brand began when Geomagic Inc., a software company based in Morrisville, North Carolina, was acquired by 3D Systems in February 2013[1] and combined with that company's other software businesses (namely, Rapidform and Alibre). Geomagic was founded in 1997 by Ping Fu and Herbert Edelsbrunner. Geomagic-branded software products are focused on computer-aided design, with an emphasis on 3D scanning and other non-traditional design methodologies, such as voxel-based modeling with haptic input. 3D Systems also markets 3D quality inspection software as well as 3D scanners under the Geomagic brand.

Mirage 3D - A better way to capture the human form. Our mobile scanning solutions help businesses capture the human body in a fast, simple, and affordable way so they can get on with building their product.

Optitex – is a computer aided patterning program, you can draft patterns in the program or import your own pattern by using a digitizing board.