SIMS Furniture – Design Document – Version 1.0

Design Document – Version 1.0

An interactive, user-centric system for furniture design
Table of Contents

1. Executive Summary ........................................................................................................... 2

2. Introduction ...................................................................................................................... 2

3. Preliminary Research ........................................................................................................ 2
   3.1 Introduction ................................................................................................................. 3
   3.2 Existing Competition from the Furniture Industry ....................................................... 3
   3.2.1 Traditional or Non-Interactive Systems ..................................................................... 3
   3.2.2 Basic Interactive Systems ......................................................................................... 5
   3.2.3 Advanced Interactive Systems .................................................................................. 10
   3.3 Similar Examples from Other Industries ....................................................................... 16
   3.4 Existing Standalone Software Solutions ....................................................................... 17
   3.5 Conclusions .................................................................................................................. 17

4. Front-End .......................................................................................................................... 19
   4.1 User Flow Diagram ...................................................................................................... 19
   4.2 Paper Prototype .......................................................................................................... 19
   4.3 Virtual Model Test ...................................................................................................... 19

5. Back-End .......................................................................................................................... 21
   5.1 Class Structure .......................................................................................................... 22

6. Conclusion ......................................................................................................................... 22

Appendices ............................................................................................................................. 23
1. Executive Summary

This document outlines the process taken so far in the design of the SIMS furniture design web-based application. It includes an introduction to the project, an overview of the preliminary research undertaken, as well as a look at the iterations and proofs-of-concept in the development process of the front (user) and back (server) ends of this application. Relevant appendices have also been included.

2. Introduction

The furniture industry is facing a number of issues that will change how business is conducted and how furniture is produced. With an increase in design awareness among the public, consumers are eager to have more accessible, affordable choice than what is currently provided by retailers like IKEA, the Brick, and department stores. However, most consumers are inexperienced in sourcing or designing their own custom furniture, or communicating this information to a maker. Furthermore, the expense of customized furniture is prohibitive for most customers, and costs can only be reduced when furniture is mass-produced. The furniture industry is also struggling to become more sustainable. Traditionally, the furniture industry has created items that serve only one purpose, that are heavy and require shipping over long distances, and that are made of unsustainable materials and in a way that is waste of those materials.

The Scalable Interactive Modulable System (SIMS) furniture project will address these weaknesses by proposing a furnishing system based on a digitally supported design, fabrication, and delivery model that takes advantage of local resources. The end goal will be the development of a web site where consumers personalize furniture orders by arranging modular components and by choosing different dimensions, colours, and finishes.
3. Preliminary Research

3.1 Introduction

In order to create this website, an industry scan of existing competition and best practices in this field was conducted. The most relevant results were sorted into three categories: traditional or non-interactive systems, basic interactive systems and advanced interactive systems. As well, examples of online customization tools from other industries were also surveyed. Existing standalone software solutions were also surveyed. These are intended for furniture fabricators and retailers more so than consumers, but have been included in the research for comprehensiveness.

3.2 Existing Competition from the Furniture Industry

There are a number of furniture manufacturers and distributors offering some form of customization of their products online today. The most extensive customizing potential understandably comes from those manufacturers and retailers specialising in modular furniture, but companies dealing in more traditional furniture are also offering some level of customization through their websites. The level of customization varies from simply selecting materials and finishes to specifying the number, organization and dimensions of modular components. A scan of existing companies’ websites which allow users to customize furniture yielded results which can be classified into three groups, based on the level of interaction they provide to the user:

- Traditional, non-interactive systems
- Basic interactive systems
- Advanced interactive systems

3.2.1 Traditional or Non-Interactive Systems

These systems tend to offer little more than product catalogue information on their websites. On Custom Furniture Online’s website, the company states “We are not an “Internet company” with a shopping cart on our site. Most of our furniture is “made to order” ... Our products will require some consultation to make sure you are getting
exactly what you want. The best way to contact us is by phone so our customer service representatives can better understand your design criteria, budget, timeframe, and vision for your particular project...". This seems to be a common trend among ‘artisan’ companies that market their furniture as ‘hand crafted’ or ‘one-of-a-kind’. Figure 3.2.1.1 shows this company’s website.

These sites tend to follow the traditional process of furniture making whereby a customer must contact the manufacturer to provide the specifications of the furniture they desire. Wood Craft of Michigan\(^2\) is an example of the most basic form of interaction in this category. Their website provides features and configurations of their products (for example the ‘Nomic Station Computer Desk’) which can be custom ordered by telephone or by mail. Similarly, Custom Furniture Designs\(^3\) caters to architects, interior designers and contractors, and follows the traditional model of requiring that customers request a quote or send drawings of the furniture they desire. Even more high-end retail furniture manufacturers such as Montauk Sofa\(^4\) provide little in the way of interactive systems or ways for users to customize their own furniture within the site. In this case, they provide a list of 5 steps for users to personalize their selected furniture (this amounts to selecting a style of sofa, standard or custom measurements, and fabrics) but do not provide any tools.

---

\(^1\) [http://www.customfurnitureonline.com/a_cfo_how_to_order.htm](http://www.customfurnitureonline.com/a_cfo_how_to_order.htm)

\(^2\) [http://www.hardwoodfurniture.com/contact.htm](http://www.hardwoodfurniture.com/contact.htm)

\(^3\) [http://www.customfurnituredesign.com/](http://www.customfurnituredesign.com/)


SIMS Furniture – Design Document – Version 1.0

January 29, 2010
for users to visualise or create their custom furniture on the website. Again, users are asked to provide their furniture specifications in the traditional way to the manufacturer and very little if any of the design process takes place online.

3.2.2 Basic Interactive Systems

These systems allow some parts of the design process to take place within the website, or by downloading a small piece of software. This is typically limited to the selection of materials and finishes and usually provides a two-dimensional representation of the furniture being customized. The customization experience here is most similar to the online tools used by companies in other industries such as automotive and apparel (see section 3.3) to include users in the design process. These are the online tools with which users may be most accustomed because of their ubiquity in other industries.

A straightforward example of this form of interactive design process is the ‘Planner’ tool from Dedon\(^5\), a high-end retailer/manufacturer of outdoor furniture. Although the tool is only used to plan the layout of existing furniture pieces and does not allow for the customization of the furniture, it is still worth mentioning for its simple yet effective workflow. This example allows users to specify the dimensions of the space with which they are working and then interactively place different pieces from the company’s various lines into this space. The tool presents space in an orthographic plan view with which architects and interior designers are familiar. Small full-colour thumbnail images of the furniture from a perspective view are also provided in the right margin for reference when a user hovers over a piece of furniture in the plan view. Figure 3.2.2.1 shows this online tool.


SIMS Furniture – Design Document – Version 1.0

January 29, 2010
A tool that allows for customization of different module combinations as well as finishes and materials yet forgoes any graphical representation of the furniture pieces during the design process is the Viesso Customizer⁶. In this process, users select a product range they wish to customize then select combinations of modules within that range and finally select applicable options such as materials, finishes and hardware. Prices are provided for the customized pieces and the option to proceed to purchasing the object online is provided as well. Figure 3.2.2.2 shows the Viesso Customizer.

Norwalk Furniture provides a Room Planner\textsuperscript{7} similar to Dedon’s ‘Planner’ tool in that it provides a plan view of a space and the ability for users to place a variety of furniture pieces in the space with the ability to rotate the furniture as well. There appear to be some limitations to this tool, however, such as the apparent inability to specify the room size. Other functionality, such as saving created plans by having user accounts, is available however. Another tool provided by Norwalk, the Variations sofa customization tool\textsuperscript{8}, allow users to specify the style of sofa they desire and then select fabric, cushion and arm options as well as welting and base options. This tool functions in much the same way as online customization tools from other industries such as automotive customization tools (see section OTHER INDUSTRIES) in that a 2-D graphical representation is presented for reference and is dynamically updated as users continue to select and alter their choices.

Ego Paris provides an interesting twist on the customization process by providing users with 3-D interaction within a PDF format that can be viewed in the user’s browser with their My EGO Configurator tool\textsuperscript{9}. Although the level of customization is still limited to

\textsuperscript{7} http://www.sofastyler.com/RoomPlanner/RpMain.asp?intBrand=4
\textsuperscript{8} http://www.norwalkfurniture.com/build.asp
\textsuperscript{9} http://www.furniture-egoparis.com/index.php/tailor-made-furniture/my-ego-configurator

SIMS Furniture – Design Document – Version 1.0

January 29, 2010
materials and finish colours, it is a novel way of presenting product information and custom visualisation of a user’s piece with the ability to orbit and adjust the piece of furniture in three-dimensions. Users are provided with the ability to save their specifications to be sent for ordering from the manufacturer. Figure 3.2.2.3 shows the My EGO Configurator.

Some other interesting customization tools in this category include BioFit’s BYOC (Build Your Own Chair) Configurator\(^\text{10}\), Set26’s AluOffice Storage Rack configurator\(^\text{11}\), and Massbett’s bed configurator\(^\text{12}\). BioFit’s configurator works under a similar template as Viesso’s customization tool, forgoing much graphical representation until the final design stages. The tool allows users to custom design task chairs for industrial applications. The manufacturer provides a high level of detailed information regarding the specifications and materials used in their products, clearly catering to a discerning, detail-oriented clientele. Both set26 and Massbett’s online tools are not provided in English so it is difficult to determine what the various customization settings mean, but thanks to their

---

\(^{10}\) http://www.biofit.com/swf/FLA/start.html
\(^{11}\) http://www.set26.ch/konfigurator.html
\(^{12}\) http://www.massbett.de/bettkonfigurator
highly graphic depictions, it is easy to see the changes being made as the user progresses through the design process. While set26’s customization tool is fairly simple (users can specify the form and colours of the storage units they desire, interestingly the forms are based on the letters of the alphabet), Massbett’s application appears to be quite complex, allowing the user to specify bed dimensions (with certain obvious restrictions) while providing graphical and price feedback. Figures 3.2.2.4 and 3.2.2.5 show set26 and massbett’s configurators respectively.

![Figure 3.2.2.4 - set26 Configurator](image)
These systems allow for more parts of the design process to take place either within the website, or by downloading a small piece of software. Such specifics as furniture component dimensions, orientation, hardware, materials and finishes can be chosen by the user. The users’ iterations to the design of the furniture piece are visually represented through rich, interactive three-dimensional graphics that can convey relative scale of the components of the furniture to one another and also to their surrounding environment.

An example of a prototype system in this category which appears to contain all of the above mentioned components but is almost unusable due to shortcomings in its interface is the Furniture Configurator Beta by BSS Web Consulting GmbH\(^\text{13}\). The system provides an array of options to the user regarding the room size and furniture dimensions of the wardrobes that can be created. This online tool is hamstrung, however, by poor error management and avoidance as well as little to no documentation or instructions for use. The interface looks

\(^{13}\) \url{http://www.bss-consulting.de/kundenserver/rauch/}

3.2.3 Advanced Interactive Systems

Figure 3.2.3.5 - Massbett Configurator
simple, and although the graphics are mainly two-dimensional, different perspective views can be achieved of the furniture being created. As this is a beta release, it is presumably being improved upon for better functionality in the future. Figure 3.2.3.1 shows the BSS online tool.

Two more robust designs (although while still being far more advanced than the previous example, admittedly one is a beta) come from Smart Furniture. The first is their full-release version of the Catalog Designer\(^{14} \) . This simple yet effective tool allows users to construct their custom furniture piece from scratch within the website using combinations of different modular components (in this case all components are flat panels with grooves to interlock). While this is essentially a two-dimensional representation, the illusion of three dimensions is given through the orthographic projection of the furniture pieces. This tool also provides consistent error management by preventing users from assembling the pieces unacceptably. The pieces essentially ‘snap’ together when the user drags a new piece into an acceptable connection point with the existing components. The tool is fairly simple though and doesn’t allow for a change of perspective or any reference

\(^{14}\) http://www.smartfurniture.com/shop/catalog.designer.asp

SIMS Furniture – Design Document – Version 1.0

January 29, 2010
to the space in which the user may want to place this furniture.

The company’s second online tool (a beta release) is their Smart Designer\textsuperscript{15}. This tool features a more rich 3-dimensional experience by employing a new in-browser 3-D engine from Google Labs to provide an interactive 3-D environment in which users can place and customize (some pieces more than others) the furniture pieces they desire from an existing furniture library. Prices and specifications are provided for the pieces and users can save their room and furniture configurations and have complete three-dimensional control over their view of the space. While there are slight bugs to be worked out with the interface and navigation, this is a remarkably robust tool for a beta release and uses an interesting open-source software solution to provide rich 3-D content to users. Issues with using a relatively new software library such as this are the lack of documentation for the development process, and the need for the user to download plug-ins to use the tool. Figure 3.2.3.2 shows the Smart Designer Tool.

\textsuperscript{15} http://www.smartfurniture.com/shop/smartdesigner/smartdesigner.asp

USM Modular Furniture provides another interesting in-browser 3-D engine for viewing and customising table
and storage furniture configurations. This tool employs drag-and-drop functionality and a rather innovative interface to allow users to pull and arrange their furniture components into the configuration they desire. Of course material and finish options are provided but so are hardware and add-on options which allow for a robust amount of customization options. The downside to this tool is that while it is designed to run within a user’s browser, it is only currently programmed for Microsoft’s Internet Explorer Browser and is thus unavailable to Mac users who do not run a Windows OS. It is not desirable for a tool such as this to be platform, or operating system dependent. Figure 3.2.3.3 shows USM’s online tool.

![Figure 3.2.3.3 - USM online tool](image)

The most robust and usable interface of any of the online tools surveyed belongs to Artmodul’s Configurator. This web-based application allows users to begin by choosing the furniture component they wish to construct and then to customize each of the modular component parts. If customising container systems

---


(storage combinations) the user can click and drag to alter the dimensions of the furniture components and see them update in real-time. Users can also easily specify the dimension and number of modular components they desire through a simple grid diagram in the upper-right of the interface. The system provides error management by not allowing users to extend the dimensions of a furniture component beyond the structural limitations of the piece. Indicators guide the user to indicate where additional furniture modules can be attached (for example shelves, doors and drawers). The interface is clean and simple while still providing the necessary amount of guidance and information to users. While the interface is not true 3-D and does not allow the user to orbit around the furniture, the option is provided to view the furniture at different cross-section planes (front view, shelf view and back view) to allow for manipulation of the components at various depths. A variety of materials and finishes are also offered and the user can not only determine prices for their furniture combinations, but they can also order the furniture directly from the application. Figure 3.2.3.4 shows Artmodul’s Configurator.

IKEA’s Home Planner\(^{18}\) is perhaps the most widely-used configuration program in the consumer furniture industry due to IKEA’s huge market share in comparison to

\(^{18}\) http://www.ikea.com/ms/en_CA/rooms_ideas/splashplanners.html
the other manufacturers profiled here. While it is not a web-based application (it is a software download from the company’s site) and it is not technically used to customize furniture pieces but more to plan spaces with furniture from IKEA’s catalogue (much like the Dedon application mentioned earlier) it is still worth mentioning for its user interface and widespread use. Users can create their room space and then fill it with furniture from IKEA’s catalogue, assembling modular components such as kitchen cabinetry and shelving as they go. Error management is integrated so that users do not assemble modular components incorrectly. Users can choose to view their layouts in plan and also in full 3-dimensional perspective. Colours and finishes are all customisable and users can receive a list of their selected pieces so that they may purchase them. Interior space planning tips are also provided and the overall ease of use and straightforward interface make it simple to learn to use this tool. Figure 3.2.3.5 shows IKEA’s Home Planner.
3.3 Similar Examples from Other Industries

In order to obtain a more comprehensive understanding of existing online configuration tools, examples from several other industries were surveyed. Three in particular, which were among the top ten most popular configurators online today\(^\text{19}\), were selected from three distinct industries – Apparel, Automotive, and Food – in order to provide some examples of competition in other fields.

The YourReebok configurator\(^\text{20}\) allows customers to personalise their footwear based on several different criteria. The tool provides quite a high level of specification possibilities. For example, when configuring the men’s EX-O-FIT shoe, more than nine parts of the shoe’s upper, four parts of the shoe’s sole, eight parts of the shoe’s top and three parts of the shoe’s back can be customized in up to nineteen colours.

Users can also place an order for their pair of shoes online once they are satisfied with their creation and can also view shoes created by other users and share their own. The configurator provides a simulated 3-dimensional experience through dynamic representations of a user’s shoes that can be orbited to view from many angles. An interesting feature of this configurator is that it is also available as an iPhone application for mobile customization.

The “Build Your Own”\(^\text{21}\) tool on Mini Canada’s website provides users with a way of customising their own vehicle before proceeding to a dealership to purchase their creation. Due to the cost of a vehicle, the option to purchase online is not available. However high-end furniture could often cost as much or more as a new vehicle and some of the online furniture configuration tools mentioned above do provide the option to order online. The automotive industry’s decision not to offer online purchasing could have to do with their interest in supporting the existing network of dealerships.

Users begin by selecting the model of car they would like to configure – hatch, wagon or convertible – and which trim line they desire. Exterior paint colours and decals are selected next, followed by interior upholstery and trim materials and colours. Other custom packages and individual options are specified next and finally users have the ability to print off a specification sheet, calculate their monthly payments, and send their specifications to their local dealer.

The tool does not allow for 3-dimensional visualisations of a user’s customized vehicle, but rather provides several exterior and interior view angles between which a user can toggle.

---

\(^{19}\) According to www.configurator-database.com

\(^{20}\) https://www.reebok.com/GB/#/YourReebok

\(^{21}\) http://www.mini.ca/en/Model_Range/MINI_Cooper/Build_Your_MINI/default.aspx

SIMS Furniture – Design Document – Version 1.0

January 29, 2010
Perhaps the most unexpected of online configurators comes from Mars Incorporated, with their “Personalized M&M’s”
online customization tool. Users can order custom batches of the candy. Such options as colour, text, graphics and users can even upload their own photo to be printed on the candies. Custom packaging can also be customized by the user.

The interface is relatively simple and has quite a playful style. No 3-dimensional visualisations are provided but users can see examples of the candy they are creating update dynamically as they specify colour or text for example. Users are provided with such utilities as tips for uploading photos to print on their candies, creative tips, and tips to best personalise their order.

3.4 Existing Standalone Software Solutions

The “Custom Configurator”, for MISIS Sage ERP Order Entry Software suite, allows companies to create custom tools for what they call “rules-based configuration”. All of the configurator tools mentioned above fall into this category of configuration, as creations are constrained by certain pre-defined combinations of components. This software simply provides a logic framework to be used and does not build the configuration tool. It provides the ability to evaluate configurations based on a set of rules and provide feedback if these rules are not adhered to.

TeoWin’s “Wood” software provides furniture pricing and visualisation capabilities to manufacturers and retailers in the wood furniture industry. Their point-of-sale software is comprised of two modules: one to generate quotes and one to generate a three-dimensional scene with the desired custom furniture. This allows presentations and exact quotes to be generated based on a particular company’s catalogue of available furniture. The software is intended for commercial uses and not for consumers. Detailed, full colour three-dimensional renderings can be generated. The company also provides software for designing kitchen, bathroom, wardrobe, living room and bedroom furniture.

3.5 Conclusions

22 http://www.mymms.com/customprint/
24 http://special-furniture.teowin-software.com/presupuesto.html

SIMS Furniture – Design Document – Version 1.0

January 29, 2010
Most of the best practices and gaps in existing competition observed throughout this process are concerned with the general usability and interactivity of a tool.

First and foremost an ideal online configuration tool should have cross-browser compatibility and should be fully integrated into the website, without the need for downloads or obscure plug-ins.

A simple yet intuitive interface is also important, with plenty of error-management functions and succinct explanations where necessary.

Three-dimensional visualisations or a two-dimensional simulation of such renderings are appropriate in most cases to give the most robust rendering of a custom furniture piece, particularly those that are modular.

The ability for a user to dynamically manipulate, move and orbit a furniture piece, a module of a furniture piece or an entire combination of furniture pieces is also desirable.

Helpful aids such as ‘snapping’, or guiding, a user’s manipulations of a furniture piece through message hints or actual restrictions can result in a better user experience. Possibilities and limitations of a particular product can be communicated to the user this way. Many examples discussed here lacked sufficient feedback to the user when errors were made.

Many of the online tools from the custom furniture industry also lacked the ability for users to customize the most basic components of the furniture. Artmodul’s configurator was one of the few examples that provided users with the ability to alter the basic box form of their modular storage system and admittedly the interface required some practice before much of its functionality became understandable to the user.

The most effective online tools also synthesize all aspects of the furniture-making process, from design through to ordering, into the functionality of the web application. This can provide an easy way for customers to see their creations through to fabrication with minimal impediments along the way.

The SIMS online furniture customization tool should be usable in any browser, without the need for any downloadable components. It should have a simple, understandable and robust interface that provides creative freedom while preventing any unfeasible combinations of materials, dimensions or other specifications. It should also provide the ability for users to place an order for their furniture and connect with the manufacturer when necessary. In short, it should provide interactive capabilities where necessary to facilitate the furniture design process in the hands of the consumer.
4 Front-End

This section will outline the steps in the design process that relate to the user’s experience. The process began with a user flow diagram to map out key events in a user’s interaction with the tool. A paper prototype was created next, and digital models were created subsequently as a proof of concept.

4.1 User Flow Diagram

In order to map out a user’s experience as they progress through the tool, a user flow diagram was created. A standard web systems flow-chart template was used. Major actions by the user are shown in bubble icons. Diamond icons represent key decision points, with the given question shown inside. Options presented to the user are represented with drop-down menu representations, showing the proposed options. Plain text and arrows represent other inter-connecting events. This was a preliminary view of the user experience and was intended to give a high-level analysis with enough detail to begin the planning and design process. Appendix A shows this version of the User Flow Diagram.

4.2 Paper Prototype

A paper prototype was created as the next progression of the User Flow Diagram to graphically represent the user’s progression through the tool. At this stage, visual concepts were implemented. It was decided that an isometric perspective would best suit the application given the precision and detail needed. This would simplify asset creation in a mock-3-D environment. Visual assets for the benches would need to be created for each of the rotational views as well as for different material properties. To simplify matters, the bench form will be constructed from modular, replicated inserts between each end of the bench to simplify scaling of the model benches by the user. Appendix B shows the current iteration of the paper prototype.

4.3 Virtual Model Test

A preliminary test of the modeling process was conducted as a proof of concept of the approach that will be taken to model and represent the customizable benches. The preliminary model was

SIMS Furniture – Design Document – Version 1.0

January 29, 2010
created in Autodesk Maya 2008 extension 2 and was textured with a mapped jpeg image created from photographs of the Baltic Birch plywood from which existing physical benches have been fabricated. In this iteration, the bench was constructed and rendered in one piece and the repeatable insert piece was created from a slice of this model graphic in Adobe Photoshop. While this execution proved the concept, it was decided that a more streamlined approach would be to model the inserts separately from the end-pieces and render these out individually to create the benches. Figures 4.1 and 4.2 show 2 of the rotational views that were created for this stage of testing.
Figure 4.3 shows the texture that was mapped onto the digital model of the bench.

It was decided that the front-end of the tool will be created in Adobe Flash to allow it to be a dynamic, web-based application that can have relational database access to store configuration information. ActionScript 3.0 and PHP scripting will be used for the back-end of the tool, described in the following section.

5 Back-End

This section will discuss the planning process for the server-side aspect of the tool. All data regarding user selection and saved bench combinations will be stored in a relational MySQL database on the server. The front-end will access the back-end through PHP scripts executed within the actionscript 3.0 script from the Flash environment.
5.1 Class Structure

This stage of planning is still in process. A table of the class structure that will be used to define the objects and attributes that will control the user’s bench configurations within the space has been created. Essentially there are 2 classes (Room and Bench) which each have a set of defining attributes which are used to store information about instances of these classes within the application.

The Room class has 8 attributes which define the room’s Length, Width, Type and Budget. These attributes are set by the user upon initial interaction with the application. Other attributes such as numBenches, benchArr and rotY are used to store attributes of the space that the user has altered in the course of using the tool. The number of benches they have created, an array of unique identifiers for each bench in the room and the rotation about the Y axis are stored respectively in these 3 variables. Finally a unique identifier (variable ID) is given to each instance of a “room” created by a user to allow it to be stored and retrieved later for other users to see.

The Bench class has 11 variables which define a single bench’s length, height and depth, as well as the x-position, y-position, rotation about the x, y and z axis as well as material which have been altered by the user. The cost variable is determined by a calculation using another table of material properties and costs as well as the given dimensions. The material properties table has yet to be created due to missing material information. The Bench class also has an ID variable so that each individual instance of a “bench” can be uniquely identified within a “room”. Appendix C shows a table of these classes and their attributes in more detail.

6 Conclusion

This stage of the design process has been useful in defining optimal methods for achieving the desired user experience. Remaining work before a prototype can be created includes further planning of the back-end design and further proof of concept testing in the Flash environment.
Appendix A – User Flow Diagram
Q: "What is your budget?"

Q: "How big is your room?"

Q: "For what room are you designing?"

User Accesses Application through Site
User clicks to select corner to move by
User moves bench around space by selected corner
As user move bench it 'snaps' to standard dimensions in space (ex. inch tolerances)
If corner of moving bench passes over compatible corner of existing bench, moving bench snaps to compatible corner.
If moved bench intersects with an existing bench, moved bench is moved back to previous location.
User clicks again to finalise when happy with movement.

User clicks to select corner to rotate about
User rotates bench about selected corner
Rotation of bench snaps to 90-degree increments
User clicks again when happy with rotation
If bench intersects with existing bench, it will snap back to original position.

User clicks to select face to scale by
Bench is scaled along axis as user moves cursor
Scaling is snapped to grid by "standard sizings (lengths, depths, widths)"
If desired scale is not possible given chosen material, user is advised of this and bench is snapped to possible dimension.
User clicks again when happy with new scale

Price is updated
Bench is removed from the space
Price is updated
Appendix B – Current Paper Prototype Iteration
What size is your room?
What Size is your Room?

height

width

12

feet

inches

inches

submit
What Size is your Room?

Length

9

3

Width

12

6

Submit
What Size is your Room?

Length:
- 9
- 3

Width:
- 12
- 6
For What Room are You Designing?
You Designing?
For What Room are
What are you designing?
For what room are you designing?
You Desigining?
For What Room are
You Designing?
For What Room are
What is your Budget?
What is your budget?
What is your budget?
What is your Budget?
What is your budget?
Appendix C – Class and Attribute Table
<table>
<thead>
<tr>
<th>Approximate cost of bench based on current information, in dollars</th>
<th>Int</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integer relating to current x-axis rotational quadrant (0,1, 2, or 3)</td>
<td>Int</td>
<td>Ritz</td>
</tr>
<tr>
<td>Integer relating to current y-axis rotational quadrant (0,1, 2, or 3)</td>
<td>Int</td>
<td>Ritz</td>
</tr>
<tr>
<td>Integer relating to current x-axis rotational quadrant (0,1, 2, or 3)</td>
<td>Int</td>
<td>Ritz</td>
</tr>
<tr>
<td>Ritz</td>
<td>Int</td>
<td>Ritz</td>
</tr>
</tbody>
</table>

**Purpose:** Standard Plywood.

**Bench material:** Integer value corresponding to material - 0: acrylic; 1: hardwood; 2: birch; 3:

<table>
<thead>
<tr>
<th>Y-position of bench (at registration point at bottom, front left corner of bench)</th>
<th>Int</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>X-position of bench (at registration point at bottom, front left corner of bench)</td>
<td>Int</td>
<td>Post</td>
</tr>
</tbody>
</table>

**Depth of given bench, in inches:** Int

**Height of given bench, in inches:** Int

**Length of given bench, in inches:** Int

**Bench:**

- Unique identifier of each bench, referenced in array: `benchID`
- **ID**
- **Bench**
- **Array**
- **Array**
- **Array**
- **Array**
- **Array**
- **Array**
- **Array**
- **Array**

**Room:**

- **ID**
- **Attributes**
- **Var Type**
- **Description**
- **Type of room:** Integer value corresponding to room type - 0: Living; 1: Dining; 2: Bedroom; 3: Office; etc.
- **Width of room, in inches:** Int
- **Length of room, in inches:** Int
- **Width of room, in inches:** Int
- **Length of room, in inches:** Int
- **Width of room, in inches:** Int
- **Length of room, in inches:** Int
- **Width of room, in inches:** Int
- **Length of room, in inches:** Int
- **Width of room, in inches:** Int
- **Length of room, in inches:** Int