Research Article

# Parametric Modelling in Furniture Design A Case Study: Two Door Wardrobe

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## Abstract

*In the process of designing and modeling industrial products, computer technologies are used intensively in the furniture sector, as in every sector. In the past traditionally produced furniture, today enables many different stages to be handled at the same time, through the calculation of variable parameters enabled by computer aided design Thus, designers can make all kinds of changes on their design in a short time. In this paper a parametric approach for rapid assembly design is presented. Rhinoceros software and Grasshopper plugin used for the parameterization process of components and Microsoft Excel used for implementation design. Furniture manufacturers, who will use the parametric design approach, will be able to respond quickly to the changing demands of their customers and will stand out among their competitors.*
*As a case study, the author has chosen the wardrobe type furniture with several shelves, hanger section, drawer/s has two doors.*

**Keywords:** Parametric Design, Furniture Design, Rhinoceros, Grasshopper, Excel,

## 1. Introduction

In the process of designing and modeling industrial products, computer technologies are used intensively in the furniture sector, as in every sector. In the past traditionally produced furniture, today enables many different stages to be handled at the same time, through the calculation of variable parameters enabled by computer aided design. Thus, designers can make all kinds of changes on their design in a short time. Being able to produce many different alternatives in a shorter time makes the design stages more efficient [4].

After the first model is created in the production phase with traditional methods, the designer has to redesign the whole process even if he wants to change the slightest parameter. Every change prolongs the process and makes it more challenging in complex

projects. The use of parametric method can solve this situation [3-6]. In the parametric design process, the designer can reveal the versions of the project and the final product, without going back to the beginning, by establishing the parameters and establishing the relationship between the variables after creating the first model.

If a large order is needed with different sizes of the same model of the furniture, using parametric design reduces work time and possibility of error [1].

## 2.     Methodology

This article aims to support the development by creating an example of the parametric design approach in order to shorten the product development process in the furniture industry. Rhinoceros + Grasshopper software was used to create three-dimensional furniture models with different parameters. Rhinoceros is used in multiple design industries due to its ease of use and processing speed. The Grasshopper plug-in for Rhinoceros is a graphical algorithm editor that allows designers with no formal scripting experience to quickly generate parametric forms [2].

In Rhinoceros viewport, user can see the preview geometry and any changes of the model, result is immediately update. One of the most used components within the Grasshopper Editor is called a "slider". The user is able to use a mouse to "slide" along a range of numerical values and get rapid visual feedback of the geometric effect of a changing parameter [5]. However, for data entry, design tables prepared in Microsoft Excel files will be used, based on Buna, Badiu and Éles (2015) article, so that even an average computer user can easily handle it, instead of using "sliders". Since design tables modify the content of components, the 3d model is automatically modified accordingly and the new products can be manufactured immediately.

Lunchbox add-on for grasshopper is used for variables in Excel file. This add-on allows to quickly read and write data in worksheets at once. Also, this is fast and will help to push and pull entire tables of data into Grasshopper with ease.

## 3.     Case Study

As a case study, the author has chosen two doors wardrobe. In order to initiate a parametric study, different models have been created for the exterior and interior. First, versions of the three-dimensional models were created in 2D. Considering these versions, the variables were decided. The first models will be created using standard dimensions, and then they will be reconstructed according to the variables in the tables to be created in Excel.

In this study, 4 different shapes were created for the cover of a 2-door wardrobe. The second stage will be the interior layout versions of the cabinet. As shown in Figure 1,

Exterior design types: 2 doors without drawers, 2 doors with bottom drawer/s, 2 doors with drawer/s on the left or right.
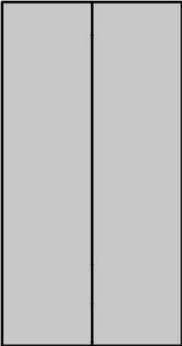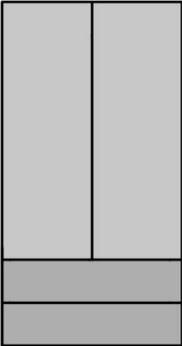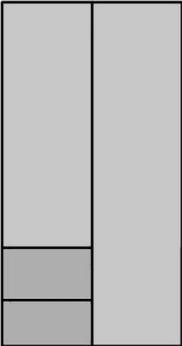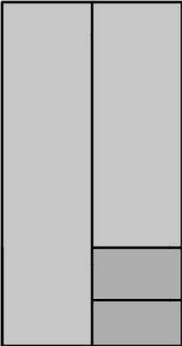
| EXTERIOR TYPES | GRAPHIC | EXTERIOR TYPES | GRAPHIC |
|---|---|---|---|
| **Type 1:**<br>Cover Only | | **Type 2:**<br>With Bottom Drawer/s | |
| **Type 3:**<br>Only Left<br>Bottom Drawer/s | | **Type 4:**<br>Only Right<br>Bottom Drawer/s | |

*Figure 1 Exterior Types in 2d*

### 3.1. Exterior Type

First, the exterior type of 2-door wardrobe is determined. The first variables of the wardrobe are width, depth and height. Since a two-door model was chosen for this study, there is no need for another variable for the first type, the door-only cabinet. For the second type, the model with drawers, the variables are the number of drawers and the drawer height. Other dimensions will be automatically arranged according to these criteria. For the third type, the left-hand drawer model, the variables are the number of drawers and the drawer height. For the fourth type, the same variables will be used as for the third type, only the direction of the drawers will be on the right.

As a result, the variables of width, depth, height, number of drawers and drawer height and cabinet type selection are the variables determined for the exterior design.

First of all, the variables tabs are opened in the Excel table and the standard values are written and the preliminary model is prepared by means of Rhinoceros + Grasshopper.

Since the number and height of the drawers should not be entered for the first type, the value of these cells in Excel is locked by setting them to zero.

Models of 4 different types were created depending on the variables taken from the Excel list by means of the Grasshopper add-on. After the type variables are selected from the drop-down list, the variables related to that type are displayed. By modifying the design table in Excel, the 3D model is automatically modified as shown in Figure 2.
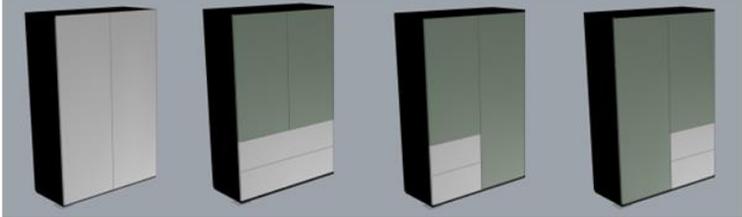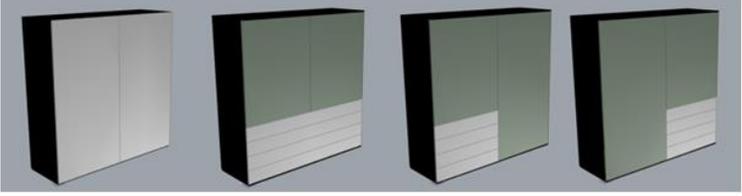


*Figure 2 Exterior Type Examples in 3d depending on Design Table*

The shell is prepared according to the exterior type appearance selection and size variables. The second stage is the selection of the interior layout. Alternatives that can be created depending on each exterior type are presented in the Excel list as the selection is made. Sub-lists of the exterior types created using the data list were prepared in the Excel list. Based on this list, an interior layout data list has been prepared. When each exterior type selection changes, interior layout selections are presented accordingly. And depending on the interior layout changes, the graph also changes. The following code has been written for this. In order to write this code, developer properties must be opened.

*Table 1 Excel Codes for Sub-lists*

```
Public Function DosyaVarmi(dosyayolu As String) As Boolean

    On Error GoTo Çıkış

    If Not Dir(dosyayolu, vbDirectory) = vbNullString Then DosyaVarmi = True

Çıkış:

    On Error GoTo 0

End Function

Private Sub Worksheet_Change(ByVal Target As Range)

If Intersect(Target, [a:a]) Is Nothing Then Exit Sub

On Error GoTo Çıkış:

ActiveSheet.DrawingObjects.Delete

Dim ResimDosyaYolu As String

Dim Resim As Object

For i = 2 To 3

    ResimDosyaYolu = ActiveWorkbook.Path & "\" & Range("a" & i) & ".jpg"

    If DosyaVarmi(ResimDosyaYolu) Then

        ResimDosyaYolu = ActiveWorkbook.Path & "\" & Range("a" & i) & ".jpg"

      Else

        ResimDosyaYolu = ActiveWorkbook.Path & "\yok.jpg"

      End If

    Set Resim = ActiveSheet.Pictures.Insert(ResimDosyaYolu)

    With Range("b" & i)

    Resim.Top = .Top

    Resim.Left = .Left

    Resim.Height = .Height

    Resim.Width = .Width

    End With

Next i

Çıkış:

End Sub
```

### 3.2.Interior Type

While creating interior layout alternatives, a fixed value (300 mm) is given to the upper shelf section. If a shelf is desired inside, the variable of the number of shelves is asked to the user. Shelf spacing according to the selected type was calculated by dividing the remaining height by the number of shelves. When Type 1 is selected, among INT 1-11; When Type 2 is selected, among INT A-I; When Type 3 is selected, among INT AL-GL; When Type 4 is selected, the list that the user can choose from among    INT AR-GR and the graphics that change according to this list are opened at the bottom. In order to detect this data from the Excel list in Grasshopper, the "Excel Reader Legacy" shown in the figure is used. In order for Grasshopper to detect the variables, it is sufficient to have the Excel sheet open on the computer. 3st Column, 5th line for width, 6th line for Depth, 7th line for Height; 8th line for Thickness, 9th line for Drawer Number, 10th line for Drawer Height variable value for exterior type in Excel list.
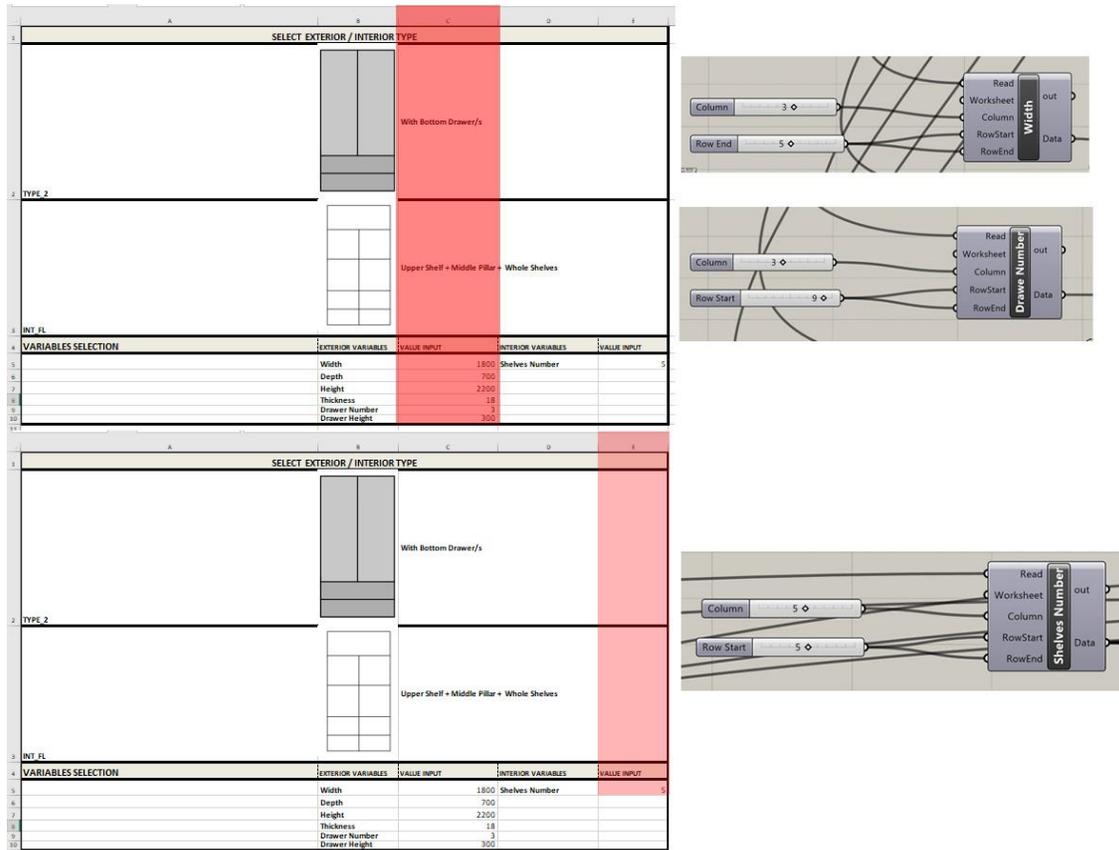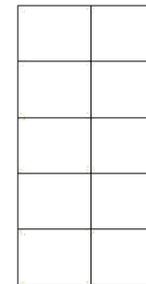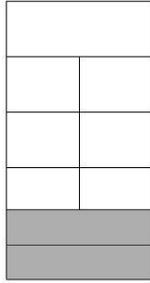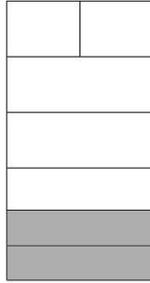


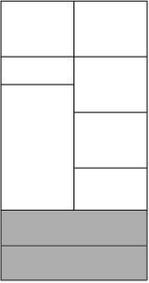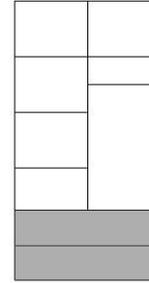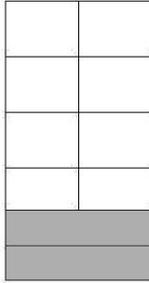*Figure 3 Excel Design Table – Grasshopper Excel Reader*

Parametric design of interior arrangement can be created by processing the 5th Column and 5th Line information of shelves number for the interior type. The study was conducted for the interior placement of all types. First of all, there is no middle pillar, the middle pillar is to the top, and the middle pillar & upper shelf is created. For the remaining spaces, a hanger on the left, a hanger on the right, a shelf on the left and a shelf on the right were created. Thus, according to the choices to be made, suitable placement alternatives for each type will be provided. The interior arrangements are given below with sample graphics and explanations.

*Table 2 Interior Types of Exterior Type 1*

| INTERIOR TYPES | Type 1: Cover Only | | | | |
|---|---|---|---|---|---|
|  |  |  |  |  |  |
| INT 1 | INT 2 | INT 3 | INT 4 | INT 5 | INT 6 |
| Only Shelves | Upper Shelf + Middle Pillar + Shelves | Upper Shelf + Middle Pillar + Left Hanger + Right Shelves | Upper Shelf + Middle Pillar + Right Hanger + Left Shelves | Upper Shelf + Middle Pillar + Right Hanger + Bottom Shelf+ Left Shelves | Upper Shelf + Middle Pillar + Left Hanger + Bottom Shelf+ Right Shelves |
| | | | | | |
|  |  |  |  |  | |
| INT 7 | INT 8 | INT 9 | INT 10 | INT 11 | |
| Upper Shelf + Middle Pillar (To The Top) + Right Hanger + Bottom Shelf+ Left Shelves | Upper Shelf + Middle Pillar (To The Top) + Left Hanger + Bottom Shelf+ Right Shelves | Upper Shelf + Middle Pillar (To The Top) + Right Hanger + Left Shelves | Upper Shelf + Middle Pillar (To The Top) + Left Hanger + Right Shelves | Upper Shelf + Middle Pillar (To The Top) + Whole Shelves | |
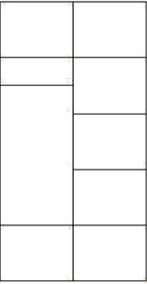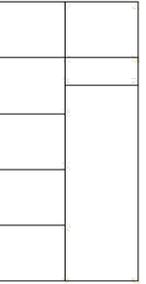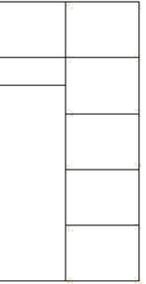
The interior arrangements of Type 2 are given below with sample graphics and explanations show in Table 3.

*Table 3 Interior Types of Exterior Type 2*

| INTERIOR TYPES | Type 2: With Bottom Drawer/s | | | |
|---|---|---|---|---|
| INT A | INT B | INT C | INT D | INT E |
| Upper Shelf + Whole Hanger | Only Shelves | Upper Shelf + Middle Pillar + Left Hanger + Right Shelves | Upper Shelf + Middle Pillar + Right Hanger + Left Shelves | Upper Shelf + Middle Pillar + Whole Shelves |
| INT F | INT G | INT H | INT I | |
| Upper Shelf + Middle Pillar only Top + Whole Shelves | Upper Shelf + Middle Pillar (To The Top) + Left Hanger + Right Shelves | Upper Shelf + Middle Pillar (To The Top) + Right Hanger + Left Shelves | Upper Shelf + Middle Pillar (To The Top) + Whole Shelves | |

By modifying the design table in Excel, the 3D model is automatically modified. As shown in Figure 4, the result model of INT 1, INT 5 and INT 10 is shared by selecting the shelves number 4.
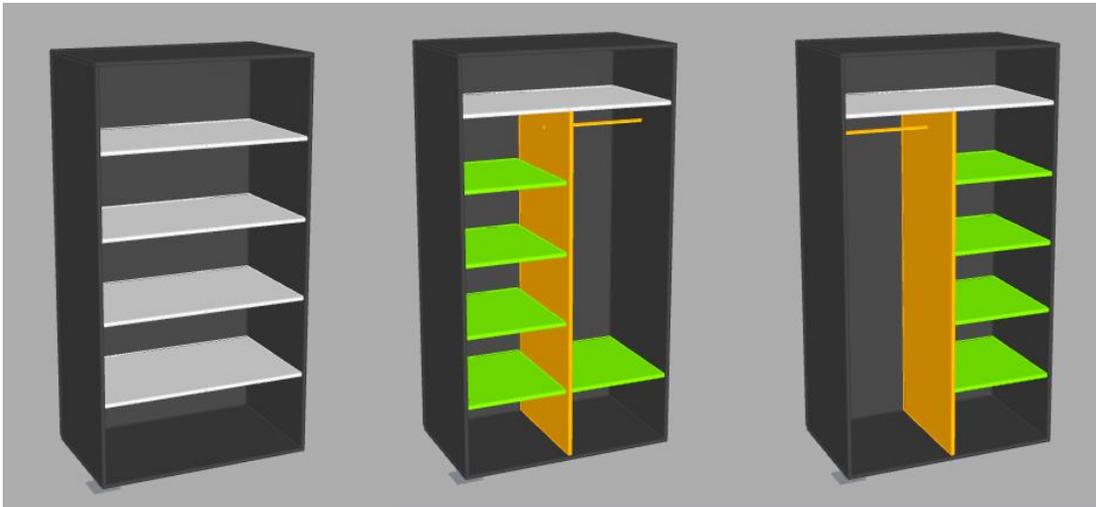
*Figure 4 Preview 3d model of INT 1, INT 5 and INT 10*

By modifying the design table in Excel, the 3D model is automatically modified. As shown in Figure 5, result model of INT A, INT C and INT H is shared by selecting the shelves number 4.
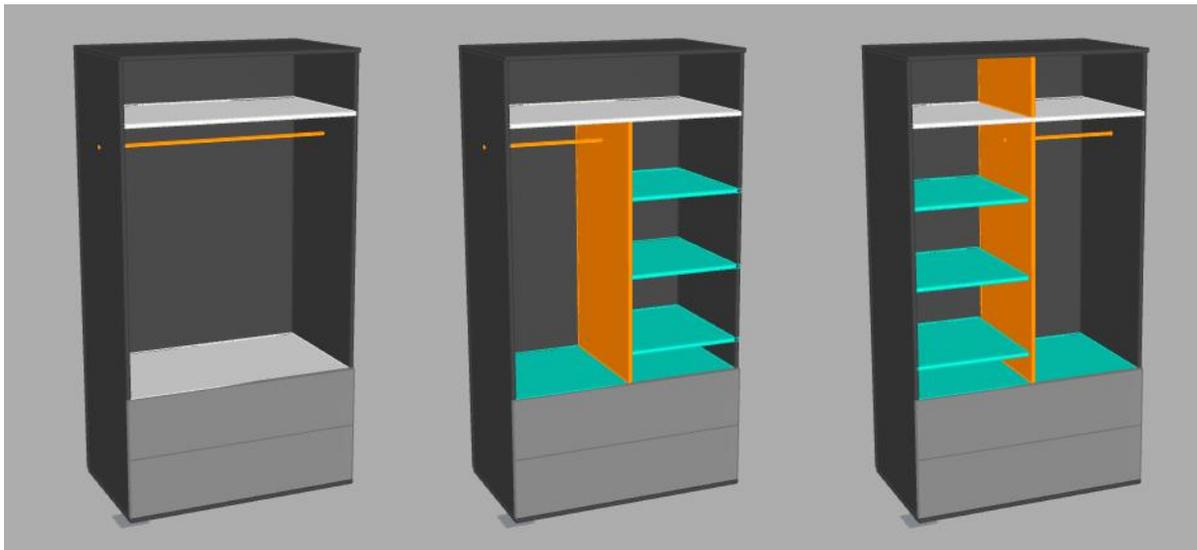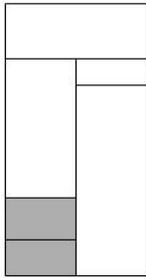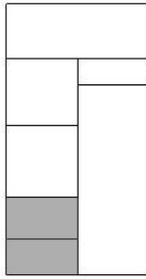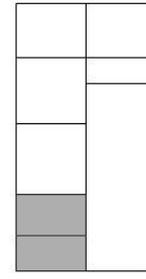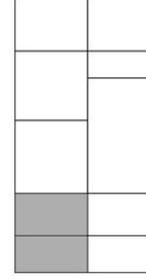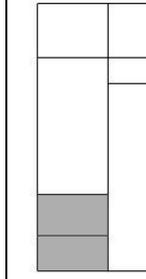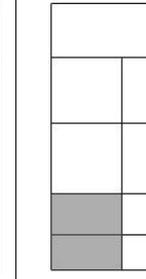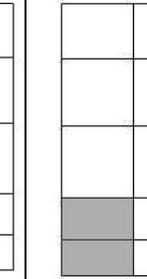


*Figure 5 Preview 3d model of INT A, INT C and INT H*

The interior arrangements of Type 3 are given below with sample graphics and explanations show in Table 4.

*Table 4 Interior Types of Exterior Type 3*

| **INTERIOR TYPES** | **Type 3:** Only Left Bottom Drawer/s | | | | | |
|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  |
| **INT AL** | **INT BL** | **INT CL** | **INT DL** | **INT EL** | **INT FL** | **INT GL** |
| Upper Shelf + Middle Pillar + Right Hanger | Upper Shelf + Middle Pillar + Right Hanger + Left Shelves | Upper Shelf + Middle Pillar (To the Top) + Right Hanger + Left Shelves | Upper Shelf + Middle Pillar (To the Top) + Right Hanger + Right Bottom Shelves + Left Shelves | Upper Shelf + Middle Pillar (To the Top) + Right Hanger | Upper Shelf + Middle Pillar + Whole Shelves | Upper Shelf + Middle Pillar (To the Top) + Whole Shelves |

By modifying the design table in Excel, the 3D model is automatically modified. As shown in Figure 6, the result model of INT AL, INT EL and INT GL is shared by selecting the shelves number 4.
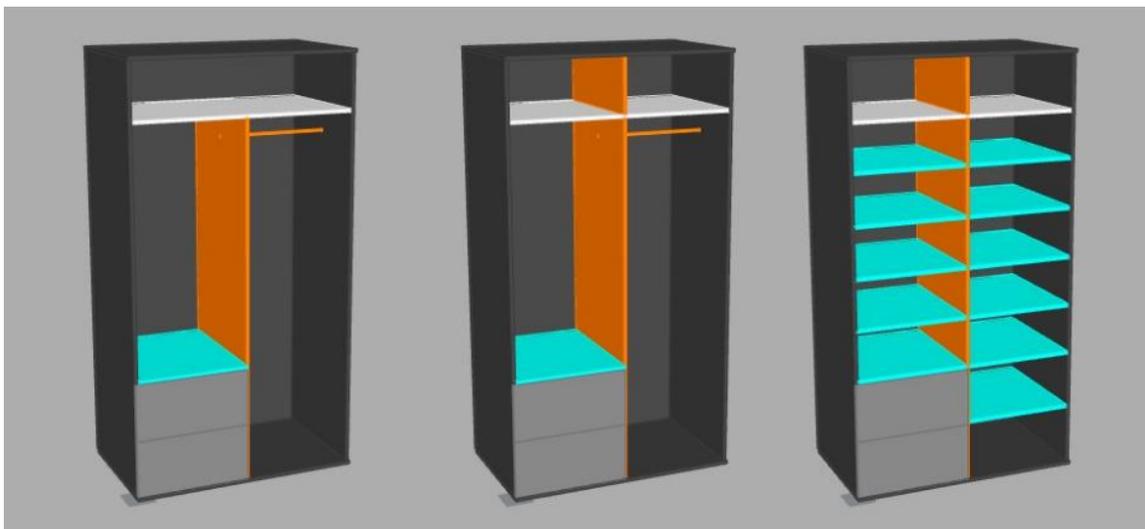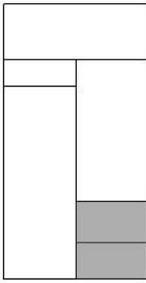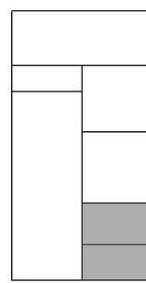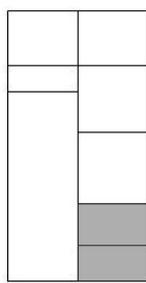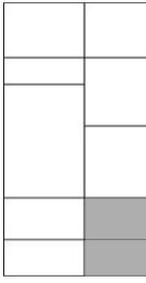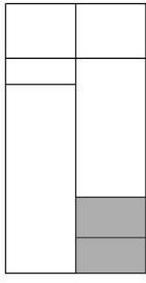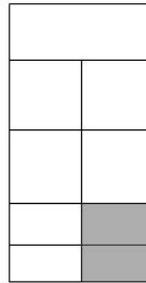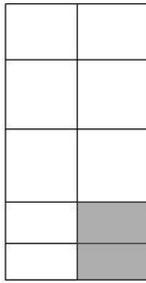


*Figure 6 Preview 3d model of INT A, INT C and INT H*

The interior arrangements of Type 4 are given below with sample graphics and explanations show in Table 5.

*Table 5 Interior Types of Exterior Type 4*

| INTERIOR TYPES | Type 4: | Only Right Bottom Drawer/s | | | | |
|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  |
| **INT AR** | **INT BR** | **INT CR** | **INT DR** | **INT ER** | **INT FR** | **INT GR** |
| Upper Shelf + Middle Pillar + Left Hanger | Upper Shelf + Middle Pillar + Left Hanger + Right Shelves | Upper Shelf + Middle Pillar (To the Top) + Left Hanger + Right Shelves | Upper Shelf + Middle Pillar (To the Top) + Left Hanger + Left Bottom Shelves + Right Shelves | Upper Shelf + Middle Pillar (To the Top) + Left Hanger | Upper Shelf + Middle Pillar + Whole Shelves | Upper Shelf + Middle Pillar (To the Top) + Whole Shelves |

By modifying the design table in Excel, the 3D model is automatically modified. As shown in Figure 7, the result model of INT AR, INT CR and INT FR is shared by selecting the shelves number 4.
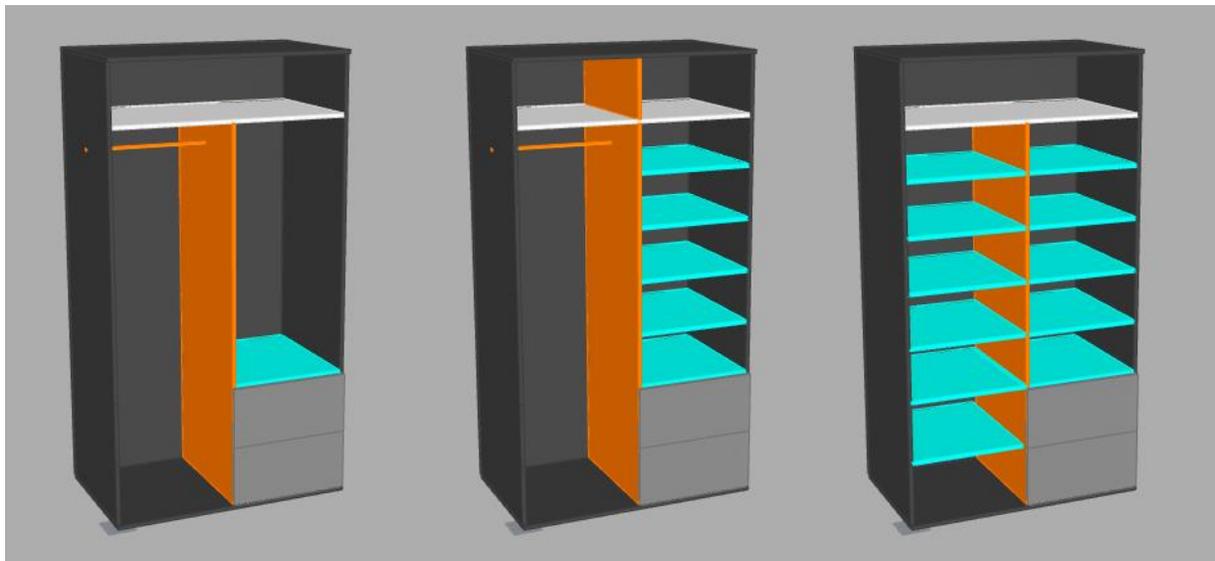


*Figure 7 Preview 3d model of INT AR, INT CR and INT FR*

## 4.      Results

When Rhino and the Grasshopper editor are used, it is possible to view the detail of changes of the algorithm directly in the 3D Rhino interface. For that reason, Rhino and Grasshopper are currently widely used in various applications, such as architectural design, interior design and furniture industry.

In this paper a parametric approach for rapid assembly design is presented. Rhinoceros software and Grasshopper plugin used for the parameterization process of components and Microsoft Excel used for implementing design. Furniture manufacturers, who will use the parametric design approach, will be able to respond quickly to the changing demands of their customers and will stand out among their competitors.

The Grasshopper components and the source code can be downloaded from an online repository accessible through the following link:

https://drive.google.com/file/d/1p3Dsgva39qJcA9Xa5b-RFM4Ez2u9BLFX/view?usp=sharing

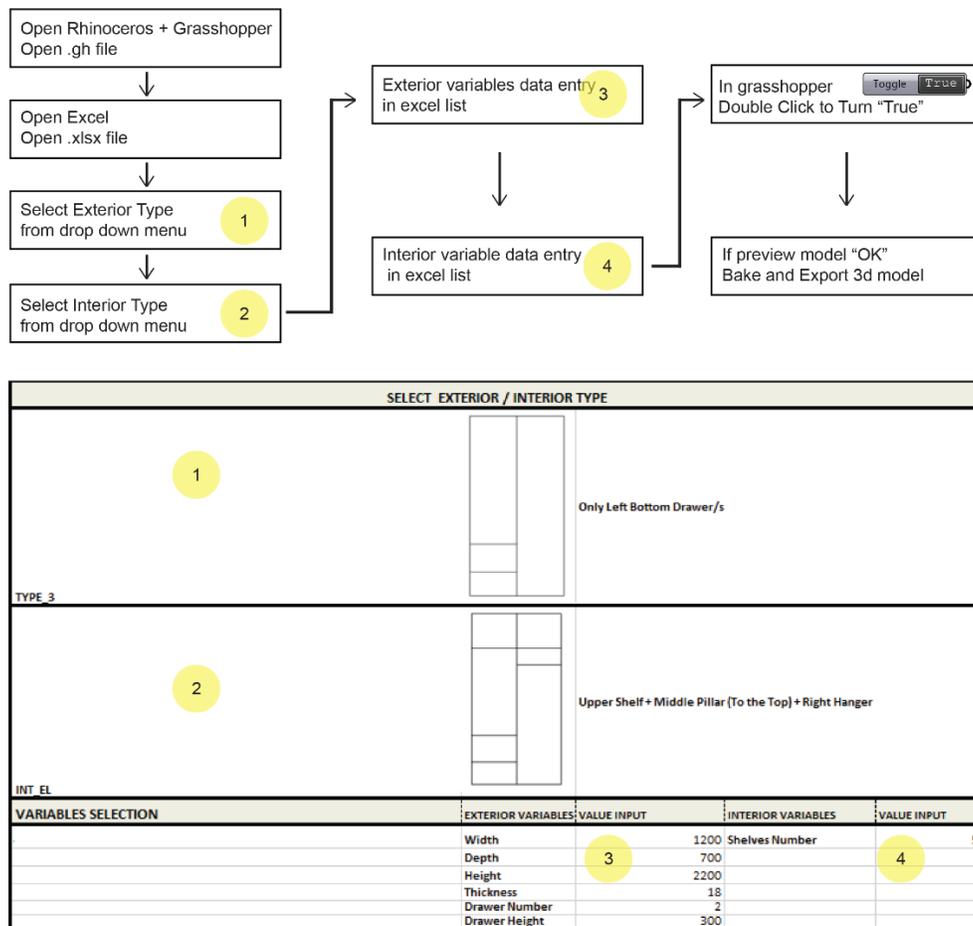The flow chart describing what to do after downloading the files is given in the Figure 8.



*Figure 8 Flow chart of the study*

## 5. Discussion

This study may serve as an example for future studies in this field. The scope of the study can be expanded and adapted to all wardrobe types and also other furniture designs.

## 6. Acknowledge

This study has been accepted and presented in ESCICONF 2022.

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