

Learn to use Generative Design in Revit to perform workspace layout. Through a total of five exercises, you will generate alternatives for the placements of desks in office environments. These exercises will increase in complexity as we go along, starting with “out-of-the-box” Revit samples and working towards “built-from-scratch” studies in Dynamo for Revit.

GENERATIVE DESIGN IN REVIT

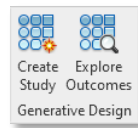
Using Generative Design for Workspace Layout after COVID-19

You can use Generative Design in Revit to quickly generate design alternatives based on your goals, constraints, and inputs. A set of sample study types (Dynamo graphs) are provided with Revit to demonstrate how generative design can be put into practice.

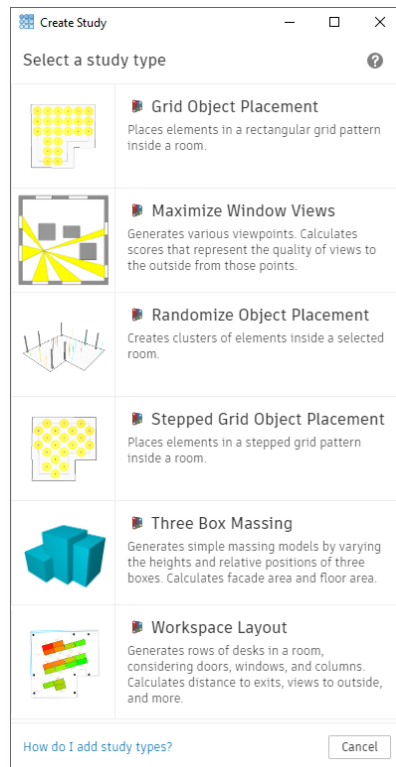
Exercise 1 – Desk Layout using Workspace Layout Study

In this exercise, you want to determine the best arrangement of desks in a large room using Generative Design in Revit. You plan to use the *Workspace Layout* study, which generates layout alternatives in rows—suitable for an office space or classroom. Your goals are to maximize the number of desks, maximize views to the outside, and minimize the distance from each desk to the nearest exit.

1. Open the *Datasets/Workspace Layout.rvt* file.
2. On the *Manage* tab, click *Create Study*.

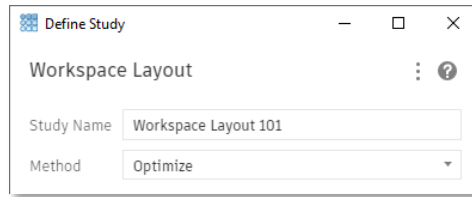


The *Create Study* dialog lists available study types. These are the examples provided by Autodesk. Using Dynamo, more study types can be added to help solve your organization’s unique design problems.



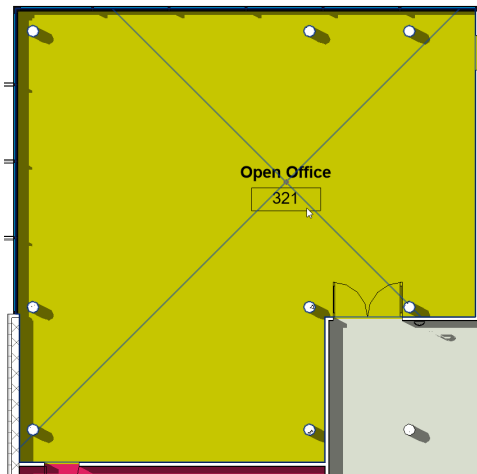
3. Select the *Workspace Layout* sample study.

4. Enter a unique name in the *Study Name* field.
5. The *Method* you select determines the logic that is used to generate design alternatives, or outcomes. In this example, you have specific goals, so you will use *Optimize*. The settings in the dialog change based on the method you choose.

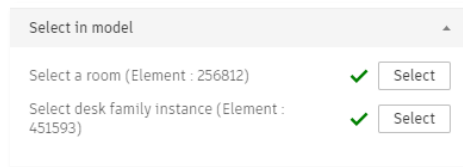


When creating a study using the Optimize method, you can choose from the following goals:

- Maximize the number of desks in the room (i.e. desk count).
 - Maximize the average score for the quality of views to outside from each desk (i.e. views to outside).
 - Minimize the average distance to exits.
6. Select a room for the study. Go to the *03 – Floor* view. Select the room *321 Open Office*. (Note: In Revit rooms can be selected only in a plan view.)

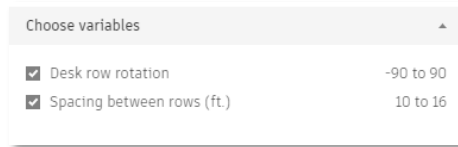


7. Select an instance of the desk family to be used in the layout. For this exercise, you will select the *Desk* family (a standard family available out of the box) sitting in the adjacent room *320 Media Review*.

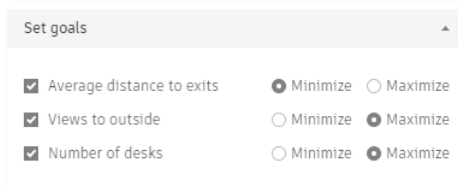




8. For *Choose Variables*, you will choose the items whose values can change when generating outcomes. For this exercise, ensure both are selected.

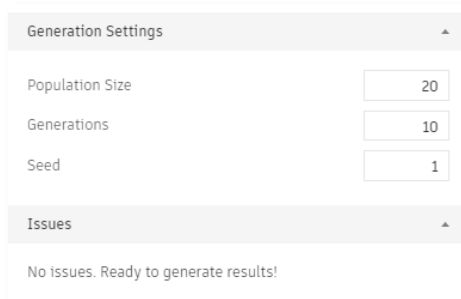


9. For *Set Goals*, you will select the goals that are important for this study as follows:



10. In addition to defining variables and goals, you can set constraints on the outcomes. In this case, you will leave the default values unchanged.

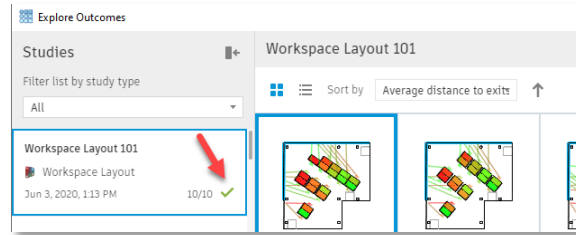
11. For *Generation Settings*, use the settings pictured below. These settings affect how the Optimize algorithm works. Check the Issues section and be sure to resolve any issues before starting the study.




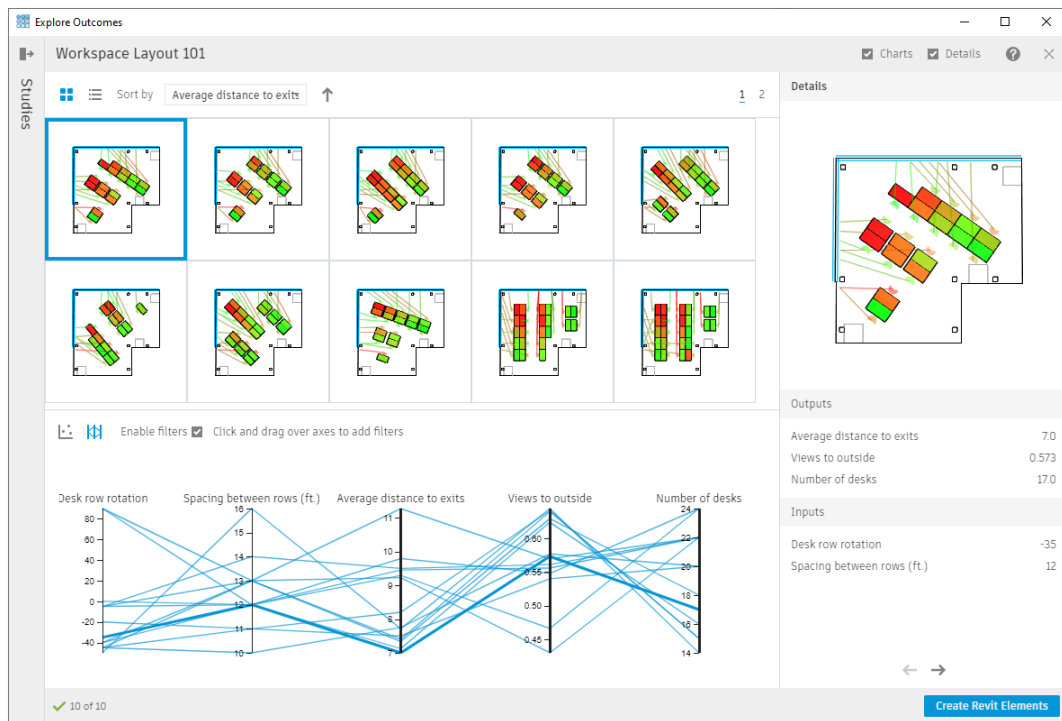
12. Click *Generate*. The *Explore Outcomes* dialog will appear, and your study will begin generating.

13. When the study is done, a green checkmark displays next to the study name. Outcomes display in the center pane, showing the design alternatives resulting from the study.

GENERATIVE DESIGN IN REVIT: Using Generative Design for Workspace Layout after COVID-19

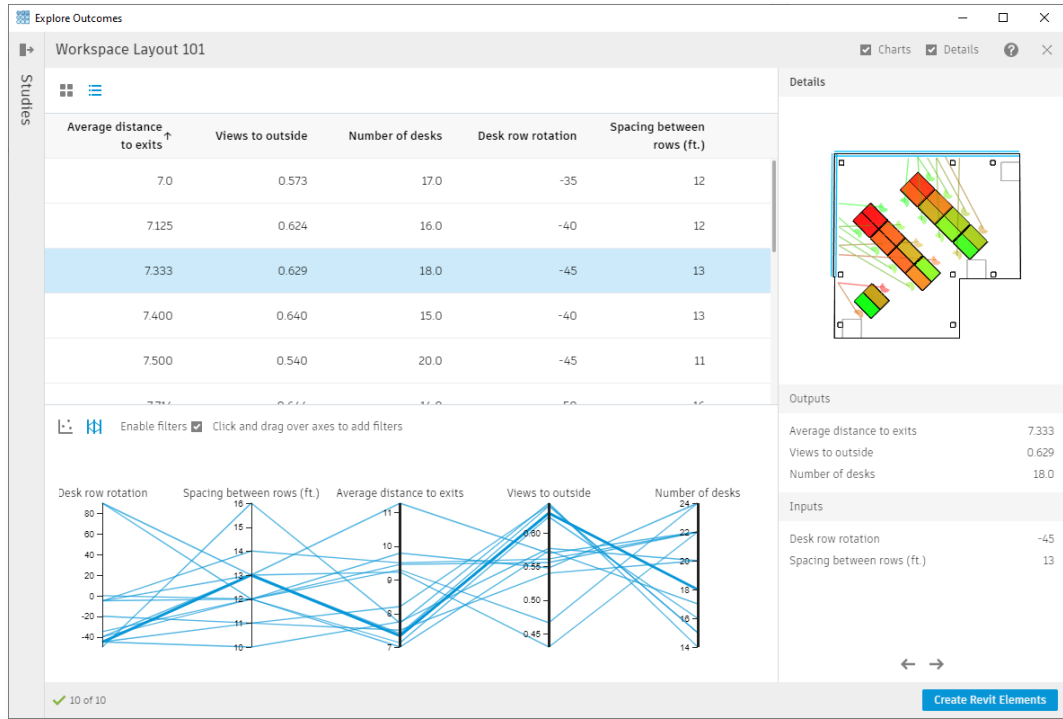


14. Click the  icon to collapse studies list.

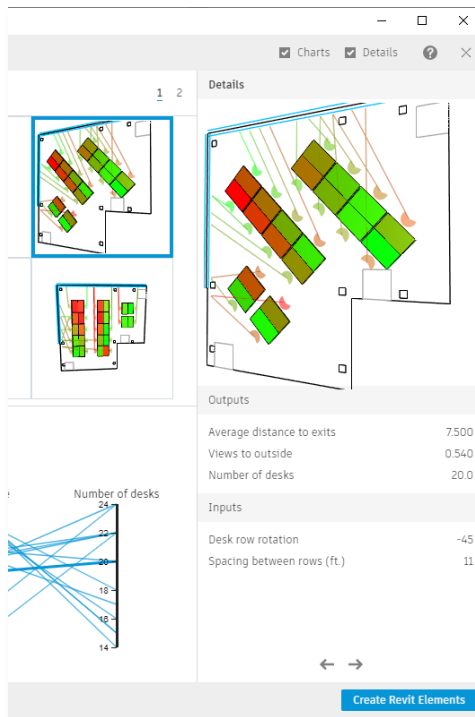


15. Each thumbnail is a live 3D view, so a limited number of outcomes are displayed at one time. Use the controls to view the outcomes as a list, sort them, or display additional pages of outcomes.

GENERATIVE DESIGN IN REVIT: Using Generative Design for Workspace Layout after COVID-19



16. Select an outcome, and make sure the Details and Charts options are turned on at the top right corner. The outcome details appear in the righthand pane. The image is a 3D view that you can manipulate. The outputs indicate resulting values for this outcome, and the inputs show the values used to generate it. Click the arrows at the bottom right to view other outcomes in detail.

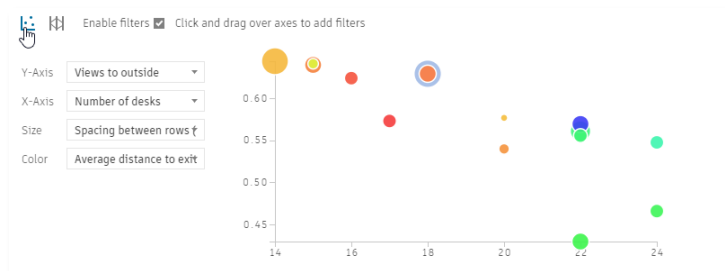


17. You can also use the chart to filter outcomes. Click and drag over one or more columns to see outcomes that meet the criteria.



18. Click *Clear filters* to display all outcomes again.

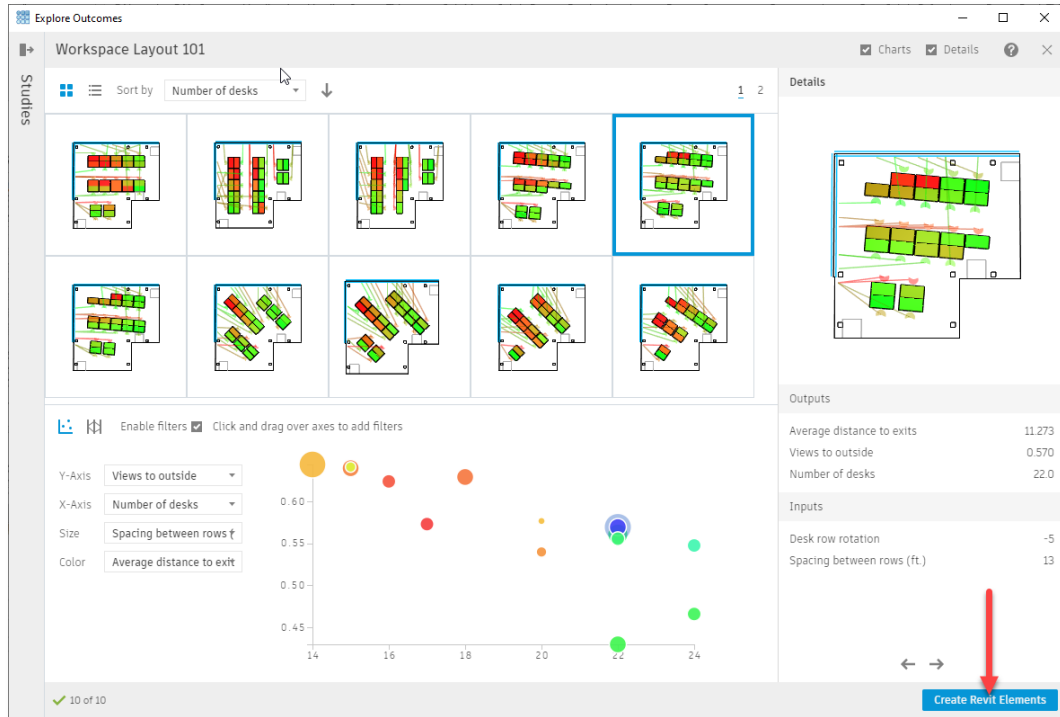
19. To review and analyze outcomes in another way, change the chart view to a scatterplot. Use the options here to change the criteria used for the X and Y axes, and to format the display of outcome values.



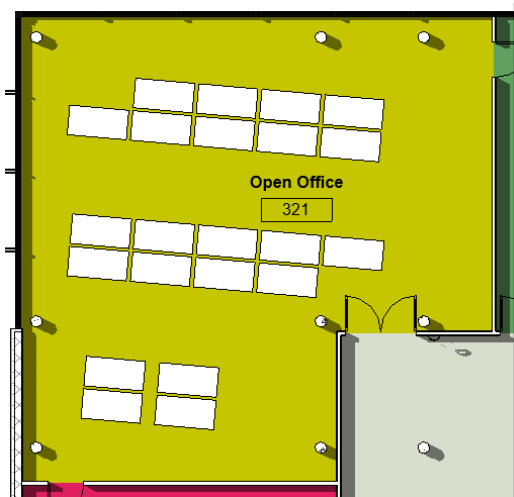
20. Click a plot on the chart to select that outcome and view its details.

21. Once you have decided on a particular outcome that you want to integrate into the model, select that outcome and click *Create Revit Elements* to add these elements to Revit.

GENERATIVE DESIGN IN REVIT: Using Generative Design for Workspace Layout after COVID-19



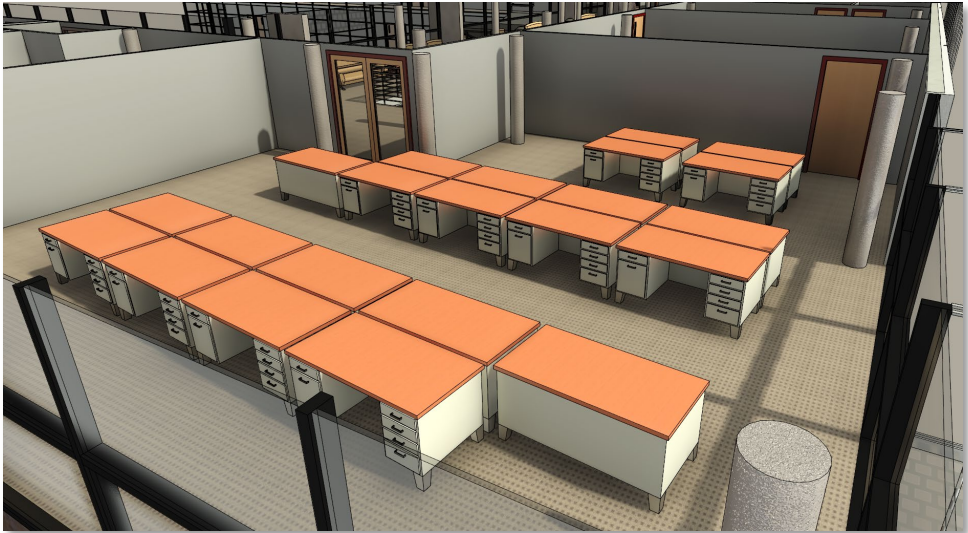
22. The resulting desk layout in the 03 - Floor plan view appears as expected.



Open the 3D view *Office Building*. Here, you notice that the desks are oriented backwards (i.e. back-to-front) from the desired result.



23. Fortunately, this rotation issue is easily solved; simply select all desks and press the *Space bar* twice.



Exercise 2a – Standing Desk Layout using Customized Workspace Layout Study

In the next exercise, you will consider the layout of a larger open office space, room 302 Office. This time, you will use a standing desk family. Using Dynamo, you will customize your generative design studies to overcome unexpected behavior and achieve desirable results.



One of the many challenges facing employers as they begin to repopulate their offices is the need to maintain a safe physical distance between employees. Using Generative Design in Revit, you will consider this basic problem: How might you configure an open office environment with safety in mind?

Your goal is to ensure that your employees maintain a minimum distance of 6 feet from each other.

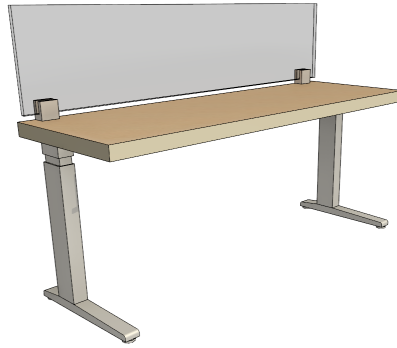
As for constraints:

- You need to accommodate 32 employees at standing desks;
- Glass panels may be attached to the desks to enable back-to-back placement; and
- Ideally, you would like to be able to use the two operable partitions currently installed in the open office space.

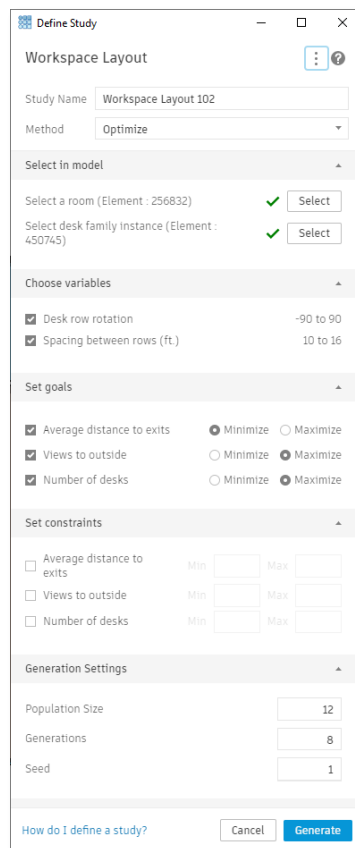
With these inputs, you decide to use the *Workspace Layout* study to lay out the desks.

GENERATIVE DESIGN IN REVIT: Using Generative Design for Workspace Layout after COVID-19

1. In Revit, load the family *Furniture_System-Standing_Desk-Rectangular_w_Partition.rfa* from the *Datasets* folder. This is a nested family containing two out-of-the-box families: *Furniture_System-Standing_Desk-Rectangular.rfa* and *Furniture_System-Partition-Privacy_Panel.rfa*.

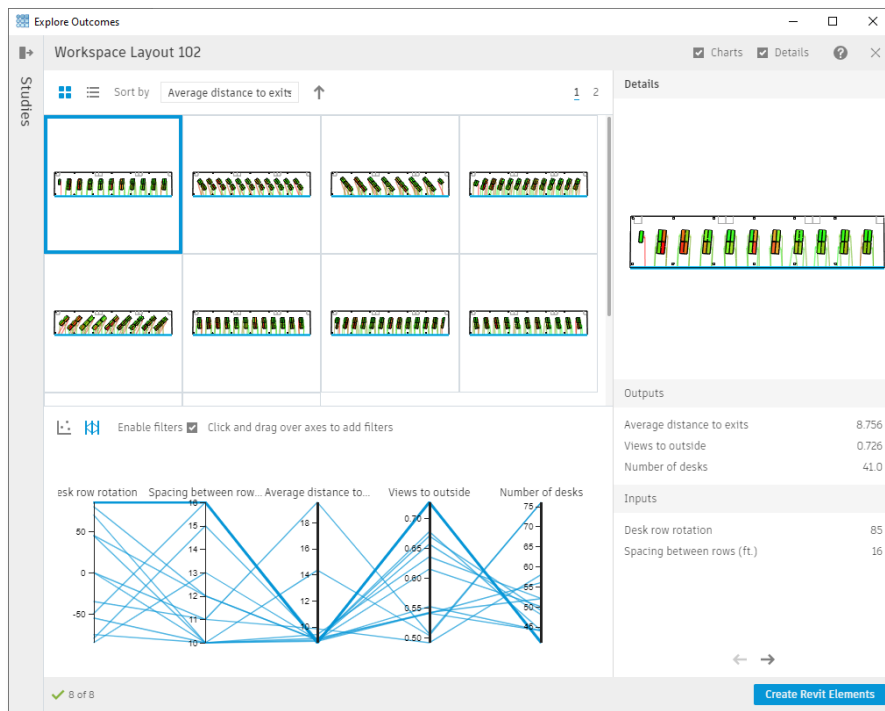


2. Place an instance of this family in *329 Corridor* so that it will be selectable in the next step.
3. Create a new *Workspace Layout* study:

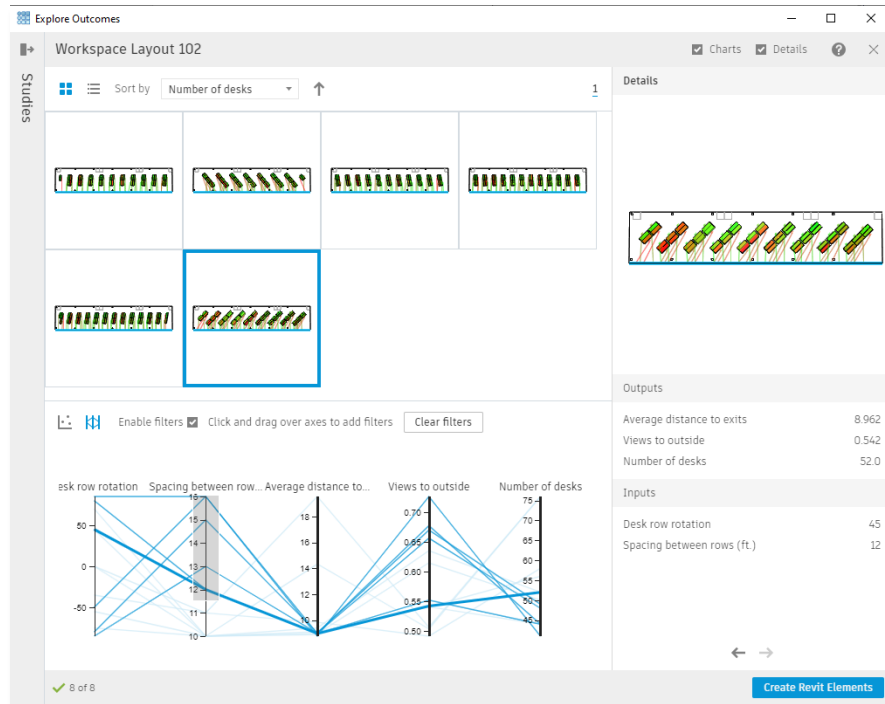


4. Make sure everything is set up as shown, and then click the *Generate* button.

5. You should see the following outcomes appear; take a moment to review them:

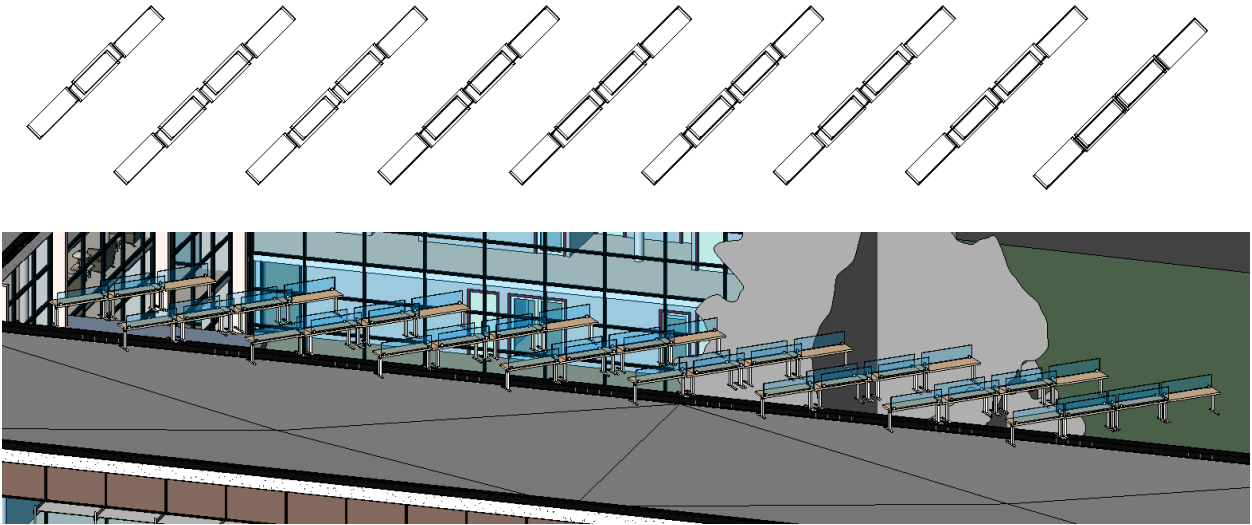


6. Select the outcome shown (52 desks, 45-degree rotation) and click *Create Revit Elements*.

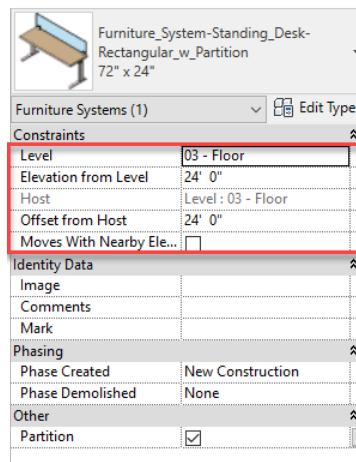


GENERATIVE DESIGN IN REVIT: Using Generative Design for Workspace Layout after COVID-19

7. You receive a message stating that the elements were successfully created, but they do not appear in the *03 - Floor* plan view.
8. Open the *Site* plan view, and you will find the desks. Note that two problems have arisen: (1) the desks are floating in the air, and (2) the desk layout does not match the outcome that you selected.

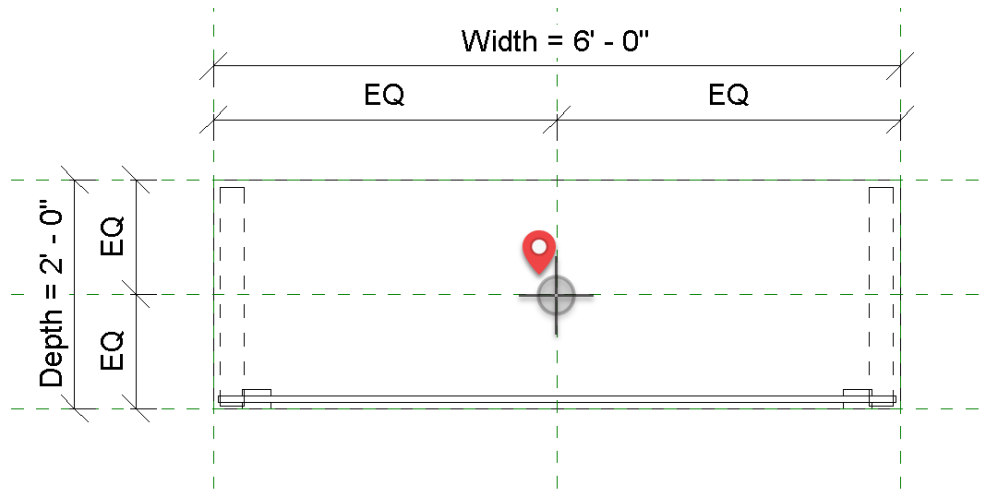


9. Select one of the generated standing desks. As you can see, the desk has been placed on the correct level (*03 - Floor*) but the *Elevation from Level* parameter is 24' 0" instead of 0'.



The *Desk* family worked well in the previous exercise, as the *Elevation from Level* parameter in that family is not editable and always remains 0'. The family used in this exercise behaves differently, as this parameter is editable.

10. Select the standing desk family and click *Edit Family*. In the *Family Editor, Ref. Level* view, you can see how the family is defined, particularly with respect to its origin.



Note: the *Furniture_System-Standing_Desk-Rectangular_w_Partition.rfa* family has its origin defined differently than the *Desk* family. However, you will not need to modify the family to get desks laid out properly. This will be done with Dynamo.

11. Close the family without saving changes, return to the project, and remove all standing desks that were previously generated. Close the *Explore Outcomes* dialog.
12. Now, you can quickly fix the issues you have just come across by making some adjustments to the *Workspace Layout* study definition.

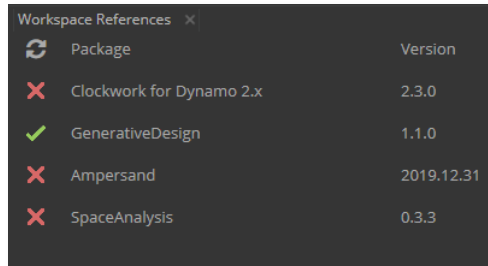
Note: All Generative Design studies are defined in Dynamo. From Dynamo, you can make more study types for use with Generative Design in Revit, or you can adjust the existing ones. Editing and/or adding studies is typically performed by someone who is familiar with Dynamo for Revit.

When you install and launch Revit, the sample graphs are stored in the following location on your local computer: `C:\Users\\Documents\AEC Generative Design`.

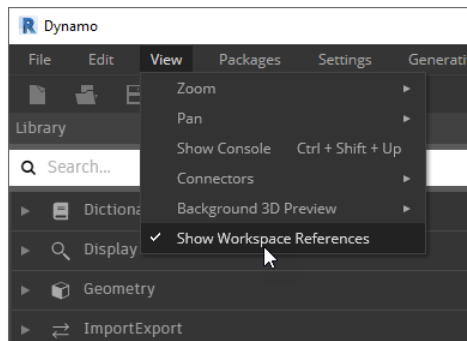
Launch Dynamo for Revit (*Manage* tab > *Visual Programming* panel > *Dynamo*) and open the `C:\Users\\Documents\AEC Generative Design\Workspace Layout.dyn` file.

13. This script uses custom nodes from several packages. Dynamo finds any required packages in the refreshed *Workspace References* viewer and automatically notifies you if any are missing. The viewer lists the packages used in your graph, along with their version and status:

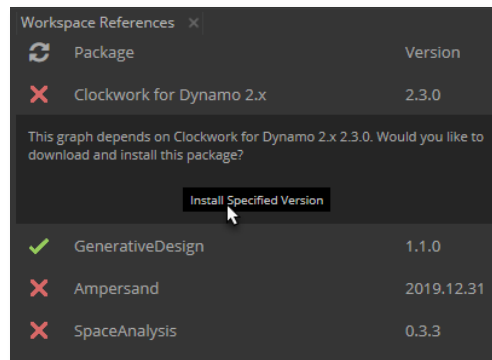
GENERATIVE DESIGN IN REVIT: Using Generative Design for Workspace Layout after COVID-19



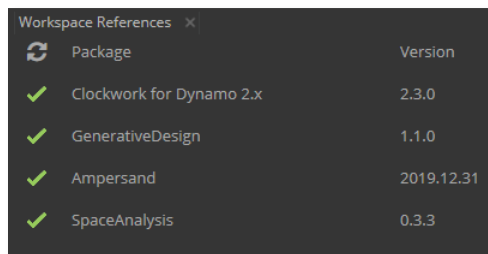
14. If you do not see the *Workspace References* viewer click *View > Show Workspace References*.



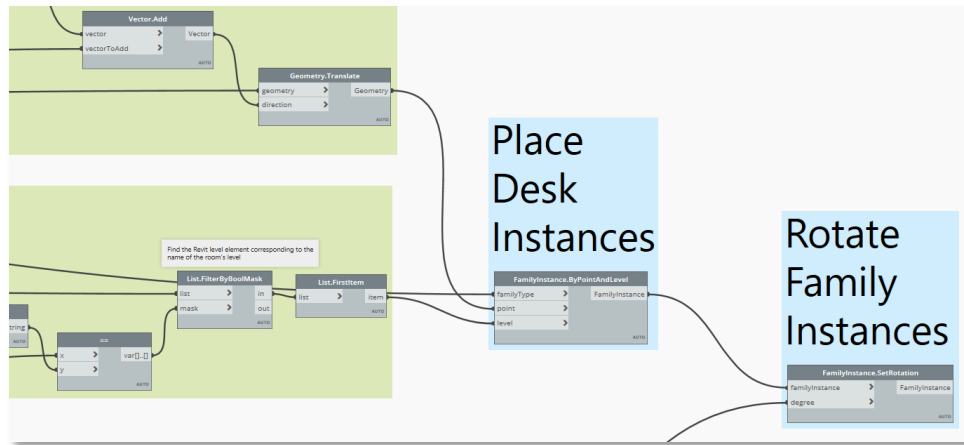
15. Select each missing package  and click *Install Specified Version...*



...proceeding until all missing packages have been installed:

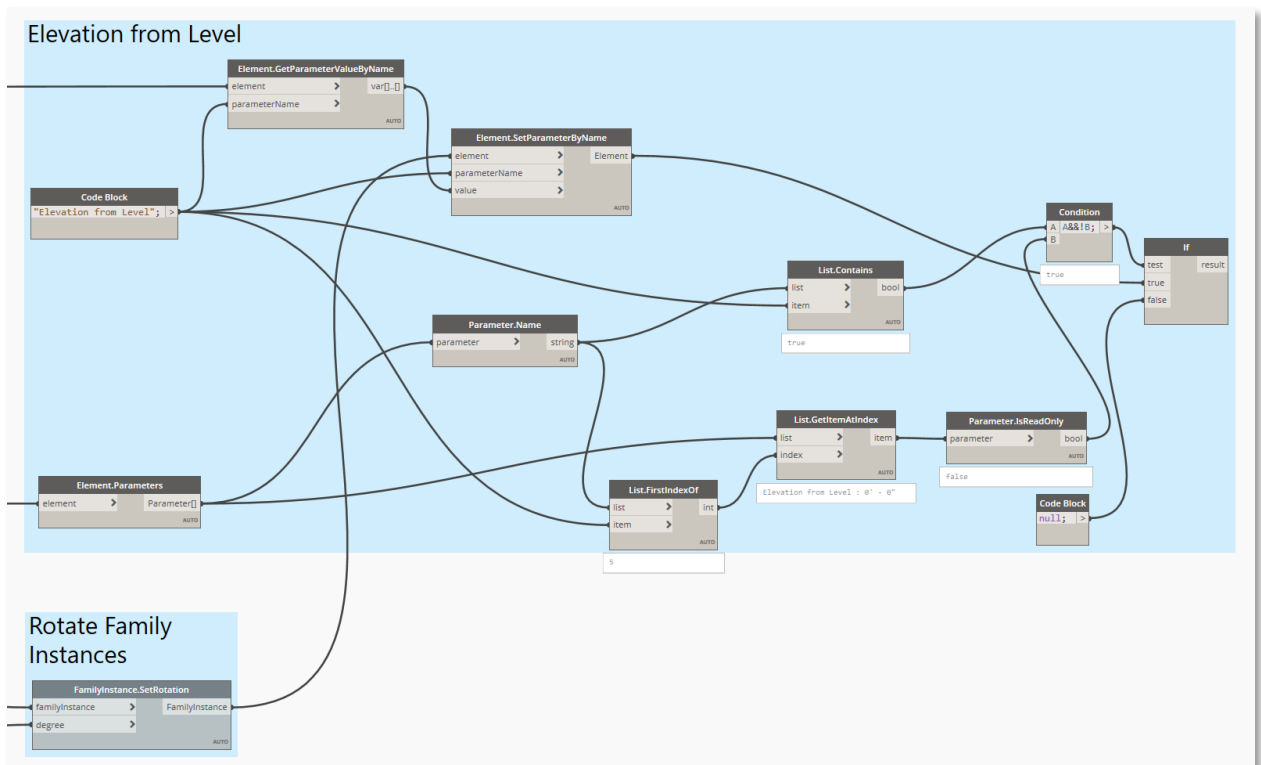


16. Zoom into the *Place Desk Instances* section.



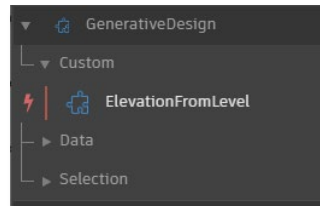
17. This script needs to be adjusted to obtain the right value of the *Elevation from Level* parameter for generated elements. The updated script will check to see whether the selected instance of the system furniture family has the *Elevation from Level* parameter defined. If the parameter exists and is editable, then the script will retrieve a value of the *Elevation from Level* parameter from the selected instance and assign that value to newly created instances.

If you are comfortable in Dynamo, add the nodes below to accomplish this task. If you want to save time, skip ahead to step 18. If you have no experience with Dynamo, skip to step 28.

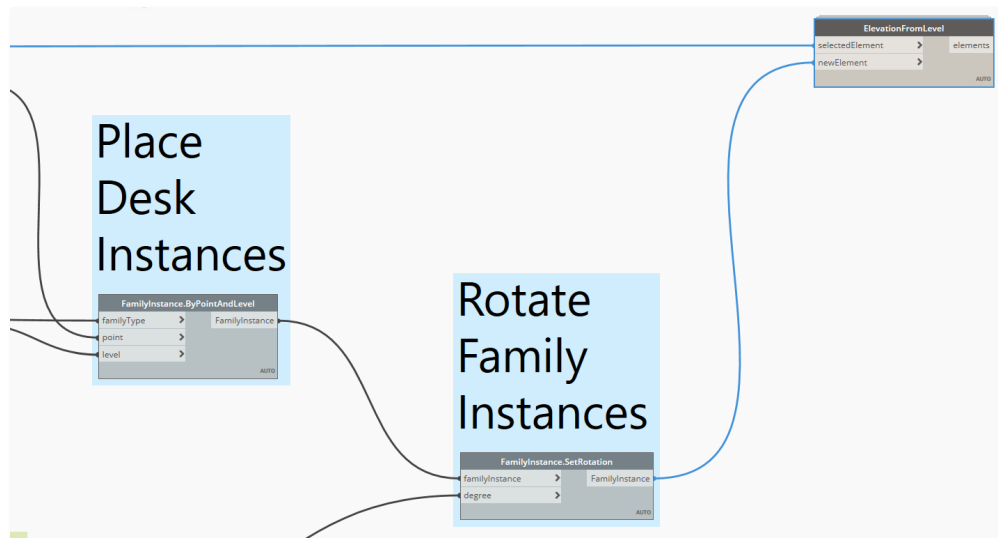


18. If you are a novice with Dynamo or wish to save time, please follow the simplified instructions below. If you have no experience in Dynamo, skip to step 28.

In lieu of creating the nodes in step (17) yourself, you may import a custom node called *ElevationFromLevel*. Copy the *ElevationFromLevel.dyf* file from the *Datasets* folder to *C:\Users\\AppData\Roaming\Dynamo\Dynamo Revit\2.5\definitions*. After restarting Dynamo, you will find this node under the *GenerativeDesign > Custom* category:

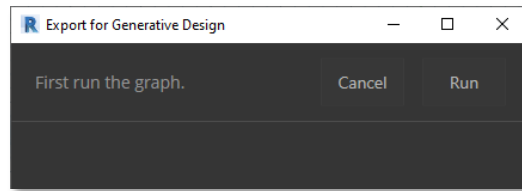


As its inputs, this node takes the selected element (desk) and newly created Revit elements and returns new elements with the updated *Elevation from Level* parameter value. Connect this node accordingly.

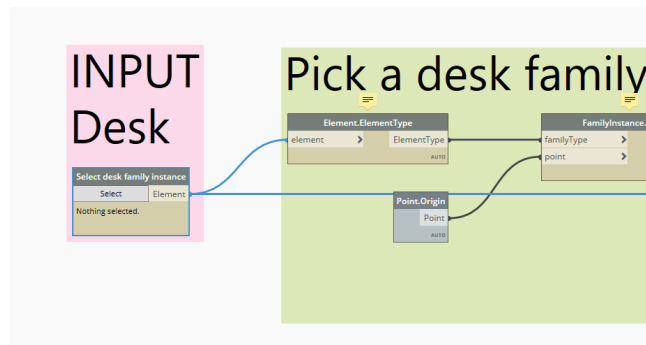


19. Once you have completed your modifications to the sample study in Dynamo for Revit via steps (17) or (18), you will need to export the updated study for use in in Generative Design in Revit. First, use *File > Save As* to save the graph with the new name *Workspace Layout - Standing Desk.dyn*.
20. In Dynamo, select *Generative Design > Export for Generative Design*. Note: When you export a graph, any previous graphs with the same name are overwritten.

21. If the dialog displays "First run the graph," click *Run*. This allows Dynamo to validate the graph before exporting it.

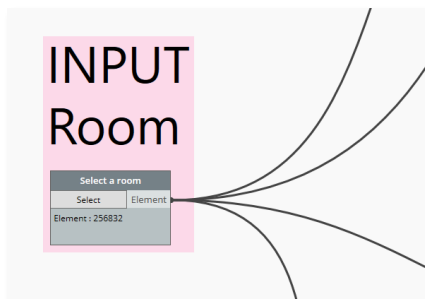


22. If the dialog lists any issues, you will need to resolve them before proceeding. You might need to set nodes as inputs or outputs, for example, or fix name conflicts. In this case, you have missing input selections:

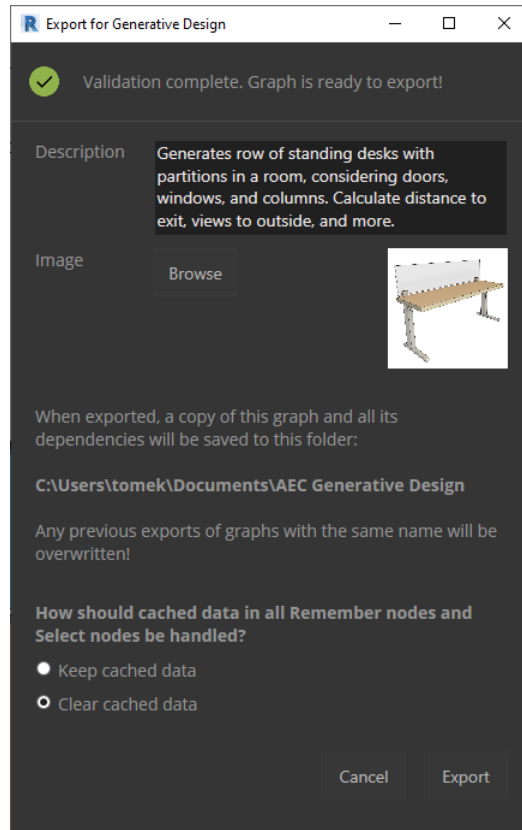


Note: If you encounter errors in steps 21-22, you may wish to skip ahead to step 28 to save some time.

23. Close the *Export for Generative Design* dialog and select inputs in Revit (i.e. desk and room):



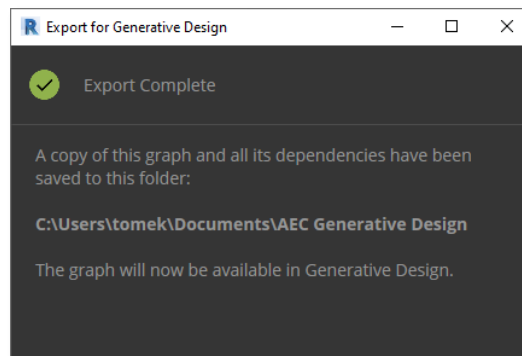
24. Run *Export for Generative Design* again and click *Run*.
25. In the export dialog, fill out the *Description* and add an *Image* in the fields provided (you may want to use *the standing-desk-w-partition.png* file from the Dataset folder). This information will appear in the *Create Study* dialog in Revit.



26. Select *Clear cached data* at the bottom of the dialog.

Note: If you select *Keep cached data*, any data in the study that is specific to the Revit model you have been using with the graph will be retained. When someone creates a study, it uses this data unless they specifically change it. If you select *Clear cached data*, any data in the study that is specific to the Revit model you have been using with the graph will be removed. When someone creates a study, they are prompted to select new data in their current model.

27. Click *Export*.



The graph is exported to the folder indicated in the dialog, along with any dependencies needed to run it. Any graph residing in that folder will appear as a study type in the *Create Study* dialog.

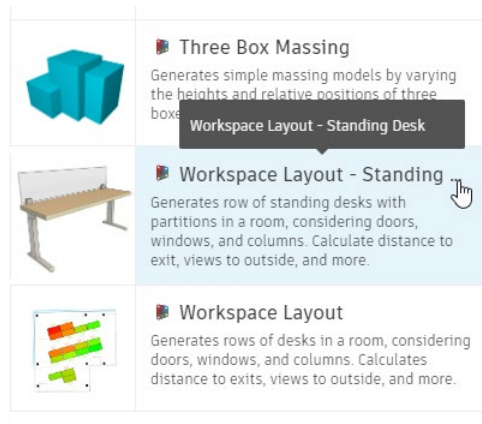
The Dependencies folder contains the following:

- *info.json*: the study type description that appears in the *Create Study* dialog
- *study_type.png*: the thumbnail image that appears in the *Create Study* dialog
- *packages*: a folder containing the Dynamo packages used by the graph
- *definitions*: a folder containing any exported custom nodes

Note: If other team members want to use the new study type, send them the exported DYN file and its Dependencies folder. Ask them to place the files in the following location on their computers: *C:\Users\. While you can share study types with team members, generated outcomes cannot be shared with others.*

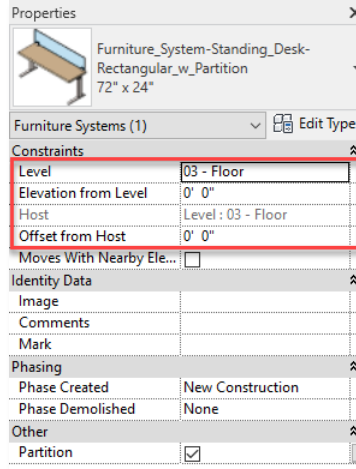
28. If you opted to skip steps 17-27, or if you ran into difficulties, you may simply copy the *Workspace Layout - Standing Desk.dyn* file and *Workspace Layout - Standing Desk.Dependencies* folder from the *Datasets* folder to the location specified above (i.e. *C:\Users\).*

29. Close Dynamo for Revit and click *Create Study*. You will see the new study that you have just created:



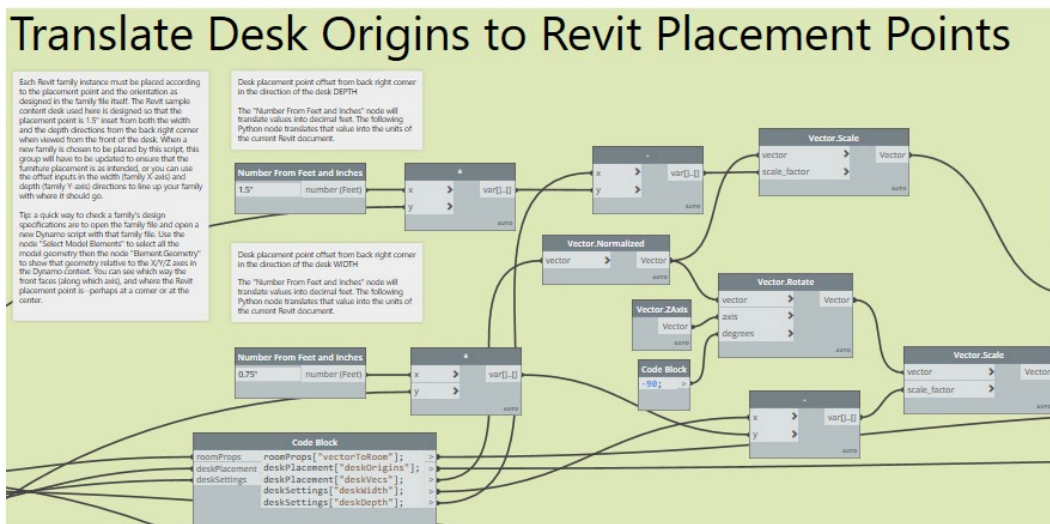
30. Repeat steps 3-7 using this new study and the same settings as before. All desks are now placed at the right level. However, they are still not laid out as expected. You will fix that in the next few steps*.

**If you previously opted to skip steps 17-27 and followed the instructions in step 28, please skip ahead again to step 40.*



31. Reopen the *Workspace Layout - Standing Desk.dyn* in *Dynamo for Revit*.

32. Zoom into the *Translate Desk Origins to Revit Placement Points* section:

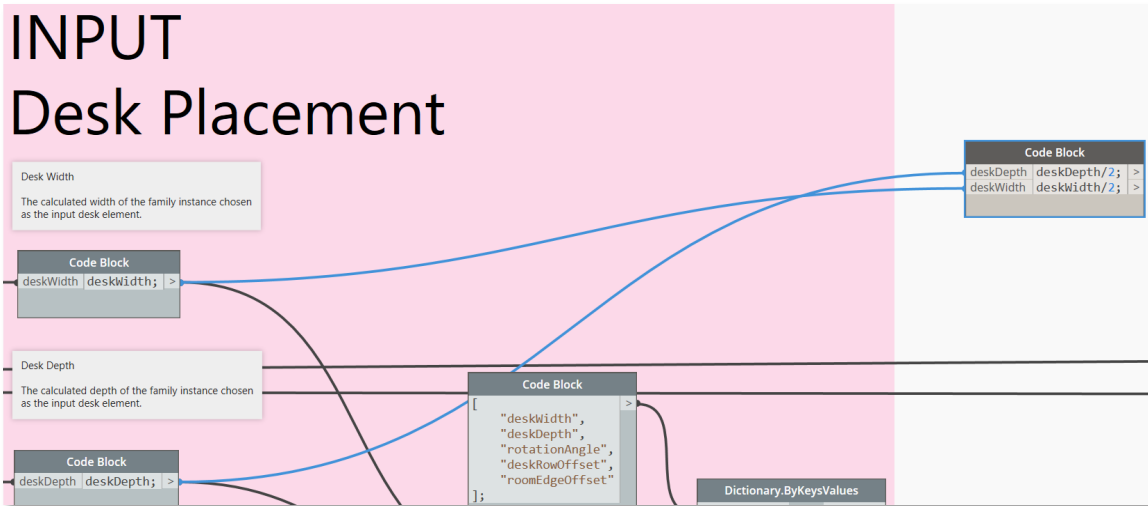


33. Review the Dynamo notes in this section. As you have already seen, the *Furniture_System-Standing_Desk-Rectangular_w_Partition.rfa* family has its origin located in the middle of the desk. You will need to make a few script modifications to take into consideration how the family is defined.

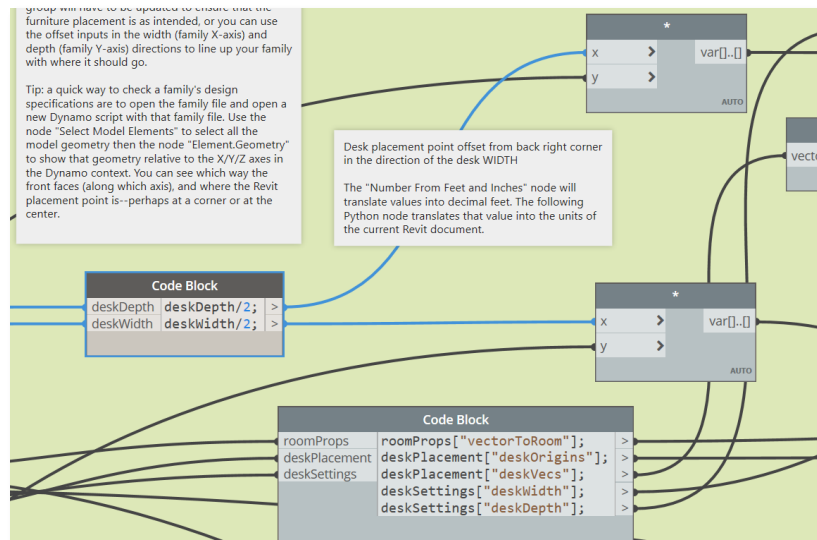
34. Create a new Code Block:

Code Block	
deskDepth	deskDepth/2; >
deskWidth	deskWidth/2; >

35. Connect its inputs as follows:



36. Next, move the Code Block to the *Translate Desk Origins to Revit Placement Points* group and connect outputs as follows:

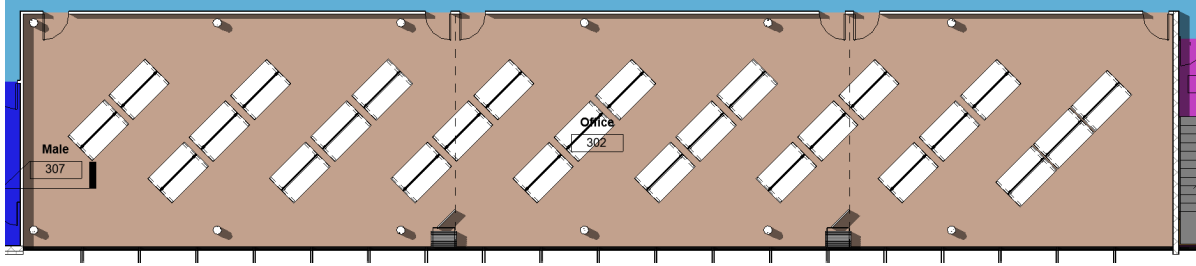


37. Click *File > Save*.

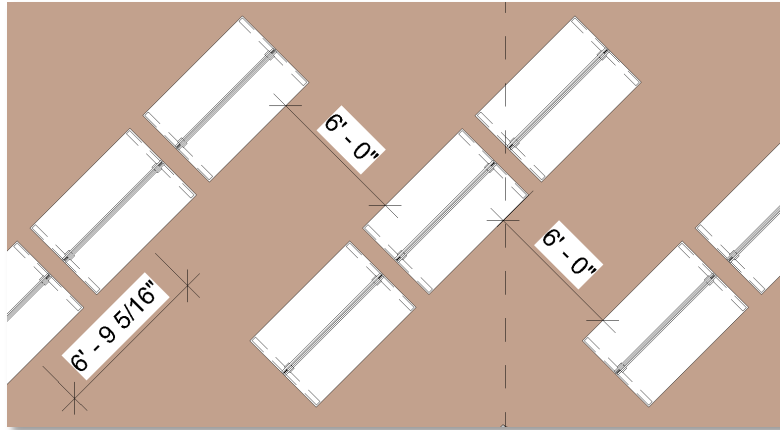
38. Repeat steps 20-27 to export the study.

39. Optionally, if you need to catch up, you may copy all files from the *Workspace Layout - Standing Desk.zip* file to *C:\Users\<username>\Documents\AEC Generative Design*.

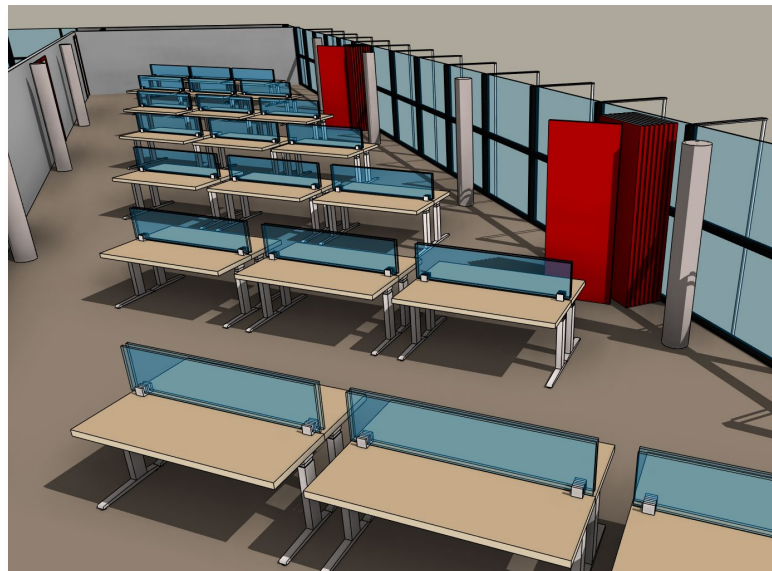
40. Repeat steps 3-7 once again. You will see that the desks are laid out as indicated in the *Outcomes* dialog:



And they are aligned appropriately to each other:



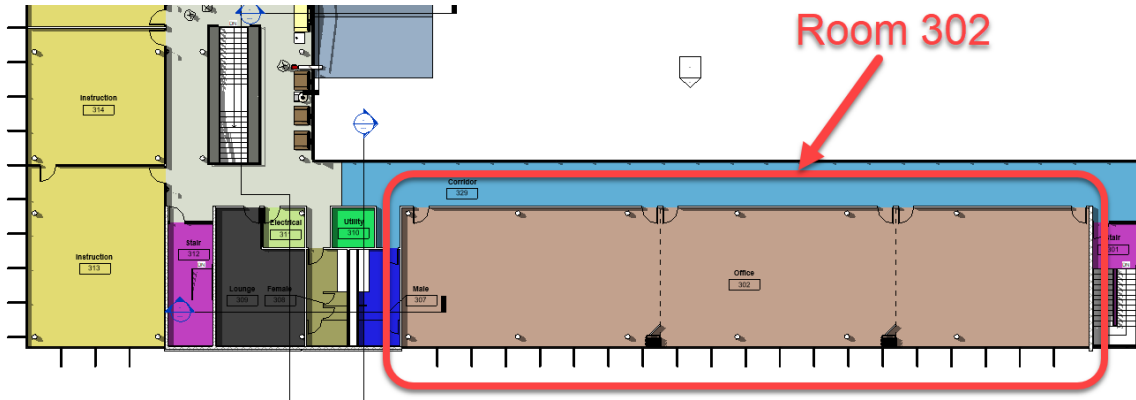
In this exercise, you found a result that accommodates up to 52 employees positioned at a 45-degree angle in the space. This outcome meets your goal to maintain a 6' minimum spacing between employees (laterally, as the glass panels enable back-to-back desk placement).



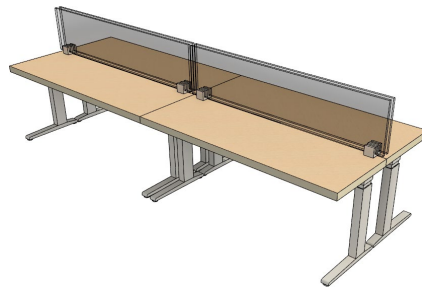
However, the angled layout might not be ideal for egress, and both operable partitions are obstructed. Perhaps another type of layout should be considered.

Exercise 2b – Standing Desk Layout using Customized Grid Object Placement Study

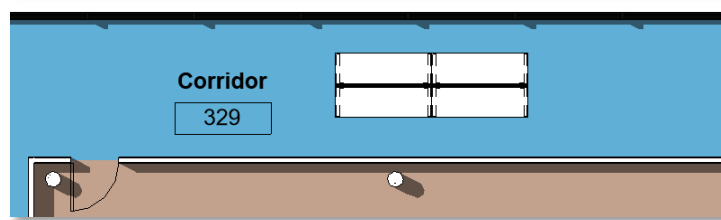
In the next exercise, you will try a new approach using the *Grid Object Placement* study to lay out desks in the large open office space longitudinally (i.e. along its length).



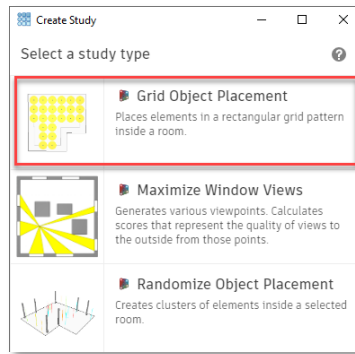
1. To begin, load the family *Furniture_System-Standing_4_Desks-Rectangular_w_Partition.rfa* from the *Datasets* folder into the *Workspace Layout.rvt* project. This family comprises a set of four desks.



2. Place an instance of this family in room 329 *Corridor* so that it will be selectable in the next step.

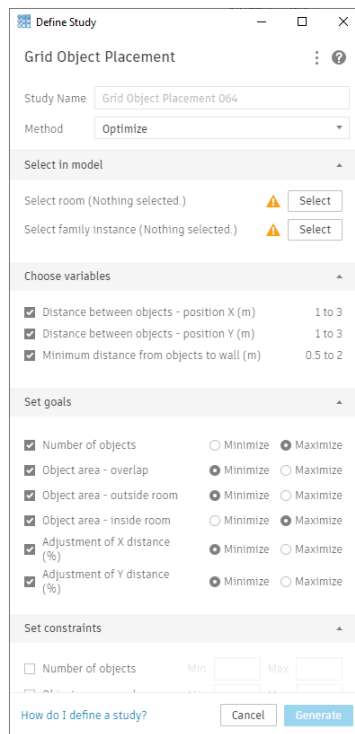


3. On the *Manage* tab, click *Create Study*. Select the *Grid Object Placement* sample study.



This sample study can be used with Generative Design in Revit to generate alternatives for placing objects in a room using a rectangular grid.

4. Review the settings that are available for this study type:



Notice that this study has variables in metric units, while your project uses imperial units. Additionally, the study measures distances between objects from their insertion points, and the ranges provided are relatively small (i.e. 1 to 3, 0.5 to 2). These are important considerations. In fact, if you were to proceed with the default study parameters, you would find it impossible to lay out your desks without clashing. This is a situation where adjustments to the sample study need to be performed to achieve meaningful results. In the next few steps, you will update the variable ranges and their units.

GENERATIVE DESIGN IN REVIT: Using Generative Design for Workspace Layout after COVID-19

5. Close the *Define Study* dialog box.
6. Open the *Grid Object Placement.dyn* script in Dynamo for Revit (refer back to step 12 in Exercise 2a for the script folder location). Note: if you wish to skip the Dynamo portion of this exercise, please skip ahead to step 15.
7. Zoom into the following pink sections:

Static Inputs

The radius of the circle around each placement point that will be used to calculate intersections with the room surface, and overlap with other elements.

Center point sphere radius (m)
0.100

Refinery Seed Values

Offset distance from wall to grid of elements
1.25

Minimum distance from objects to wall (m)
1.25

Target distance between elements in the X direction. Actual distance will vary slightly to ensure equal spacing between objects.
Distance between objects - position X (m)
1.89

Target distance between elements in the Y direction. Actual distance will vary slightly to ensure equal spacing between objects.
Distance between objects - position Y (m)
1.73

8. Update the nodes (names and values) as follows:

Static Inputs

The radius of the circle around each placement point that will be used to calculate intersections with the room surface, and overlap with other elements.

Center point sphere radius (ft)
0.300

Refinery Seed Values

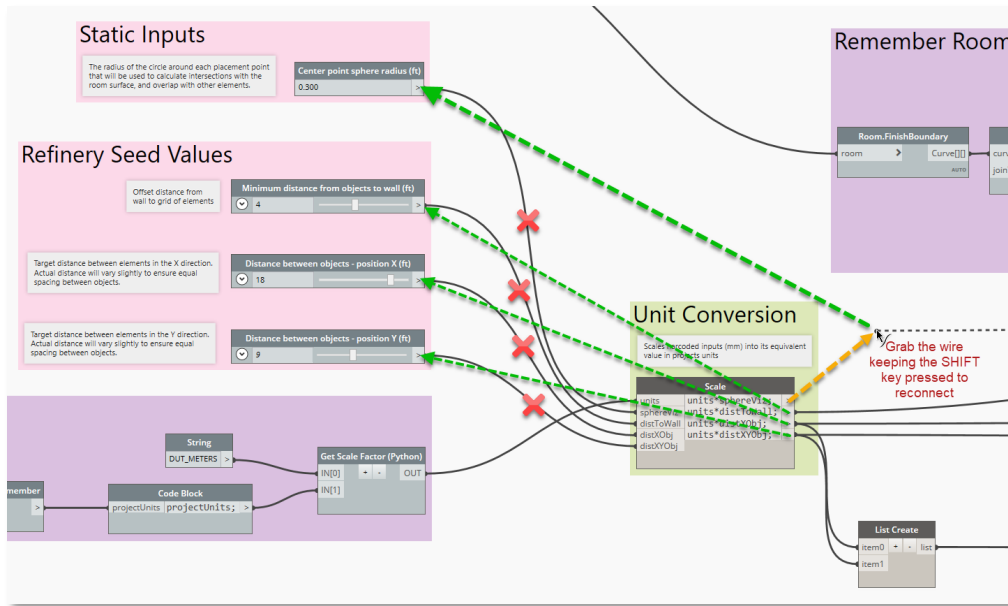
Offset distance from wall to grid of elements
4

Minimum distance from objects to wall (ft)
Min 0
Max 10
Step 0.1
4

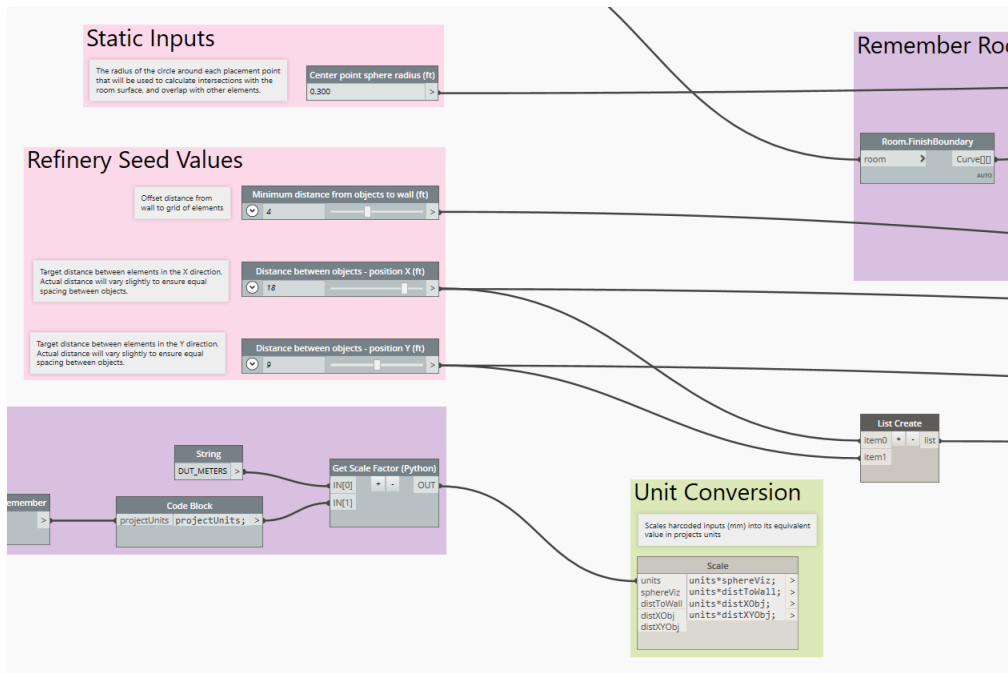
Target distance between elements in the X direction. Actual distance will vary slightly to ensure equal spacing between objects.
Distance between objects - position X (ft)
Min 10
Max 20
Step 0.1
18

Target distance between elements in the Y direction. Actual distance will vary slightly to ensure equal spacing between objects.
Distance between objects - position Y (ft)
Min 6
Max 12
Step 0.1
9

9. Next, bypass the section where the unit conversion takes place:

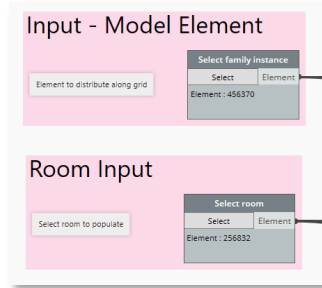


Once this is done, you can keep the Project Units and the Unit Conversion section in your script or delete them, as they will no longer be needed.

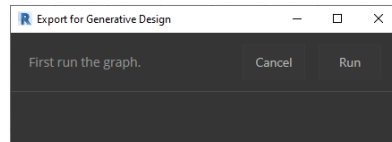


10. Use *File > Save As* to save the script with the new name *Grid Object Placement - Imperial.dyn*.

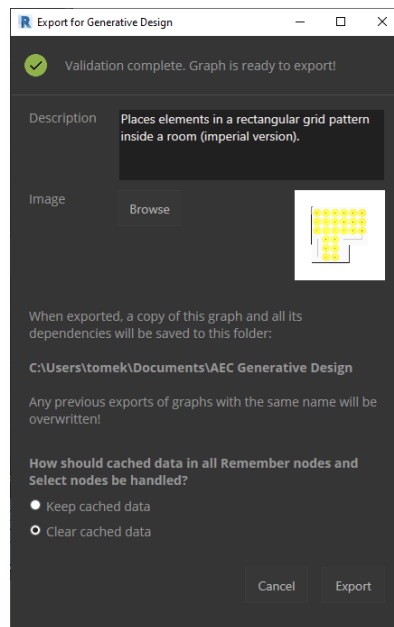
11. Select your inputs (i.e. the 4-desk family and room 302 Office).



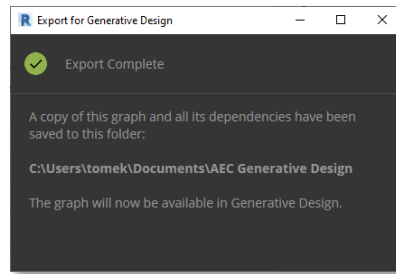
12. Use *Generative Design > Export for Generative Design* and click *Run*.



13. In the export dialog, fill out the *Description* field, e.g. *“Places elements in a rectangular grid pattern inside a room (imperial version)”* and add an image such as the one found in the Dependencies folder (*C:\Users\<username>\Documents\AEC Generative Design\Grid Object Placement.Dependencies\Grid Object Placement.png*). This information will be displayed in the *Create Study* dialog in Revit.

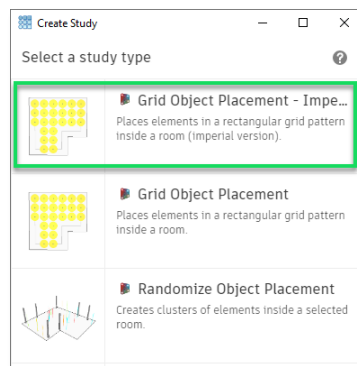


14. Select *Clear cached data* at the bottom of the dialog and click *Export*.

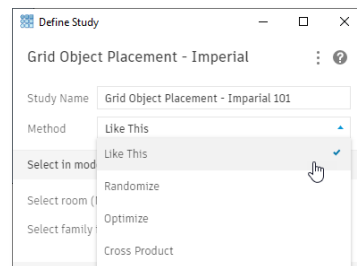


15. If you opted to skip steps 6-14, you may simply copy the *Grid Object Placement - Imperial.dyn* file and the *Grid Object Placement - Imperial.Dependencies* folder from the *Datasets* folder to the location specified above (*C:\Users\<username>\Documents\AEC Generative Design*).

16. Close Dynamo for Revit and click *Create Study*. You will see the new study that you have just created (or loaded):

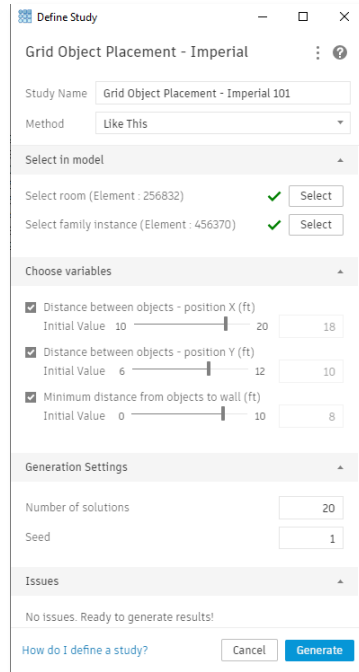


17. Create a new *Grid Object Placement - Imperial* study. This time choose the *Like This* method. This method will make Generative Design apply slight adjustments to your current input configuration, enabling you to explore variations of a design that you already like.



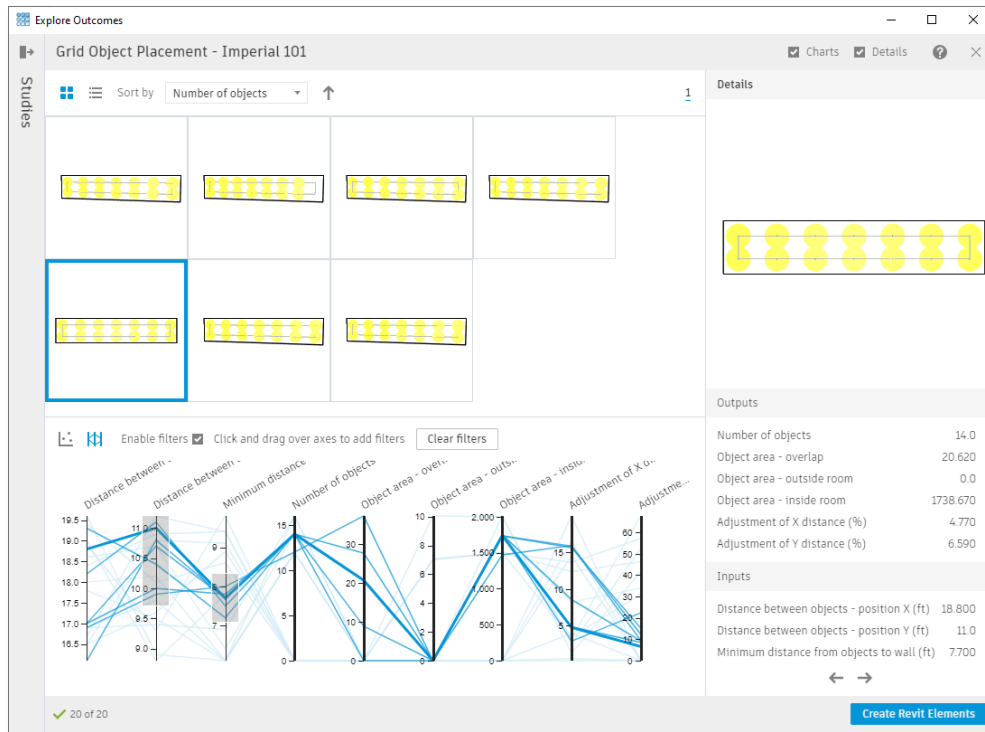
18. Select room *302 Office* and the 4-desk family, together with the following variables and Generation Settings:

GENERATIVE DESIGN IN REVIT: Using Generative Design for Workspace Layout after COVID-19

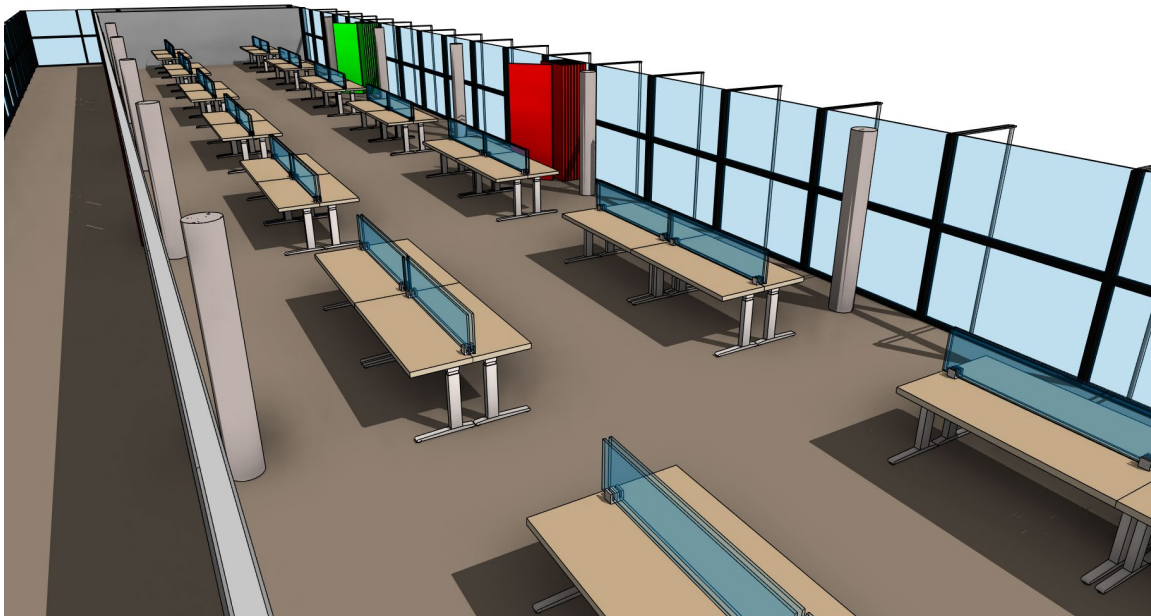
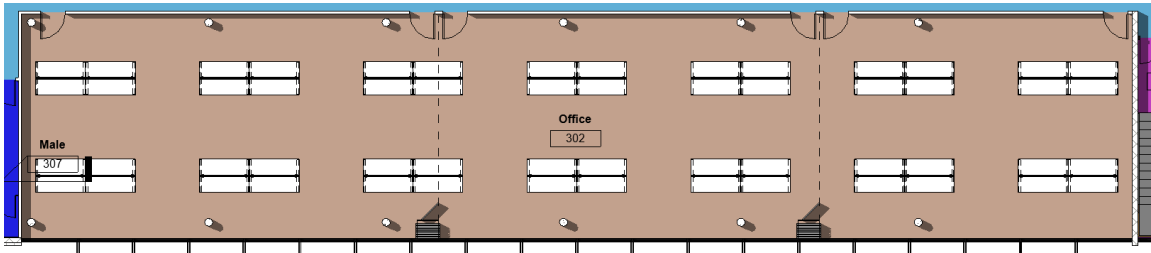


19. Click *Generate*.

20. Filter the results as shown:



21. Select one of the outcomes yielding 14 groups of desks (see above) and click *Create Revit Elements*.



This time, you have found room for up to 56 employees! But you are concerned that this layout may be uncomfortable, with half of the employees facing away from the windows. And one of the partitions is still obstructed. We have not yet found an optimal solution.

Exercise 2c – Standing Desk Layout using New Generative Design Study

In the previous example, you modified the Grid Object Placement study slightly to lay out desks with acceptable spacing. But you want to rotate the desks so that every user can see out the windows. And you want to provide more flexibility, e.g. more options to control how desks are laid out.

In this exercise, you will learn how to:

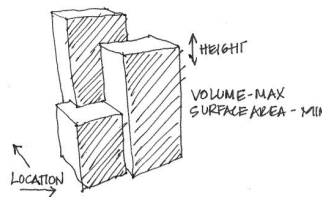
- Build your own Generative Design study from scratch.
- Change the way distances between desks are measured. The spacing between desks in both directions will be measured between edges of desks instead of their insertion points.
- Add an option to control the distance between desks and walls in both X and Y directions independently.

Every Generative Design study definition needs to contain:

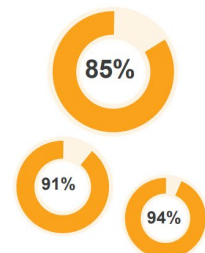
Variable parameters



Parametric model



Design goals



In this exercise case, variable parameters will include the following:

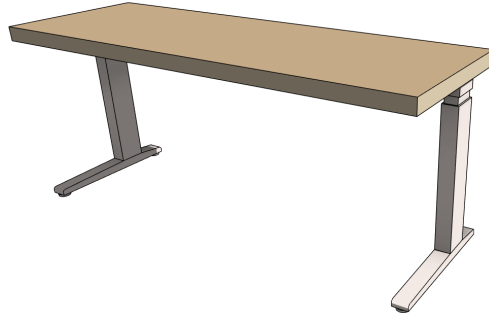
- Distance from desks to wall – X direction
- Distance from desks to wall – Y direction
- Distance between desks – X direction
- Distance between desks – Y direction

And design goals will include:

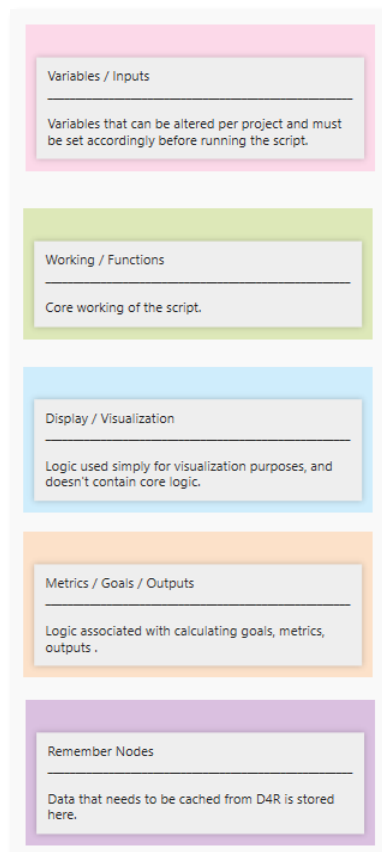
- Number of desks
- Spacing – X direction
- Spacing – Y direction

GENERATIVE DESIGN IN REVIT: Using Generative Design for Workspace Layout after COVID-19

1. Begin by loading the family *Furniture_System-Standing_Desk-Rectangular_w_Partition_V.rfa* from the *Datasets* folder into the *Workspace Layout.rvt* project. This family is very similar to the family you used in Exercise 2a, except that it is rotated 90 degrees to facilitate a transverse layout. Place an instance of this family in room *329 Corridor* so that it will be selectable later.



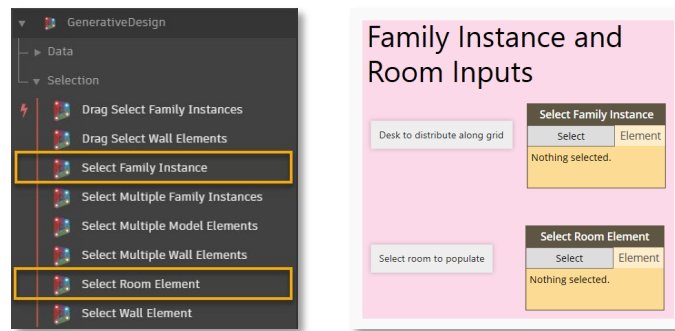
2. Open the *Grid Object Placement* study in Dynamo. You will see a color-coded legend (a set of notes) for groups:



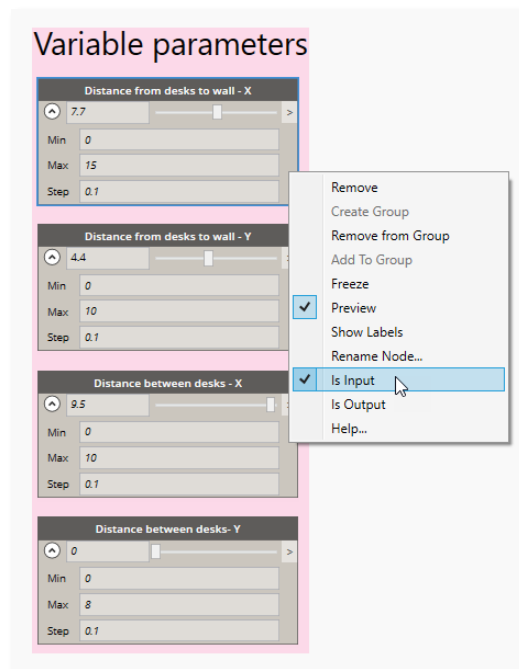
3. In your script, you will use the same convention. Copy the legend to an empty Dynamo file or remove all Dynamo nodes except the legend.

GENERATIVE DESIGN IN REVIT: Using Generative Design for Workspace Layout after COVID-19

4. Use *File > Save As* to save the file with the new name *Grid Desk Placement - 2c.dyn*. You do not need to save it into *C:\Users\\Documents\AEC Generative Design* folder; the file can be saved anywhere on your hard drive.
5. Define selection nodes for a family instance to distribute along a grid and an input node for a room selection. Use the *Select Family Instance* and *Select Room Element* nodes, found under *GenerativeDesign > Selection*.

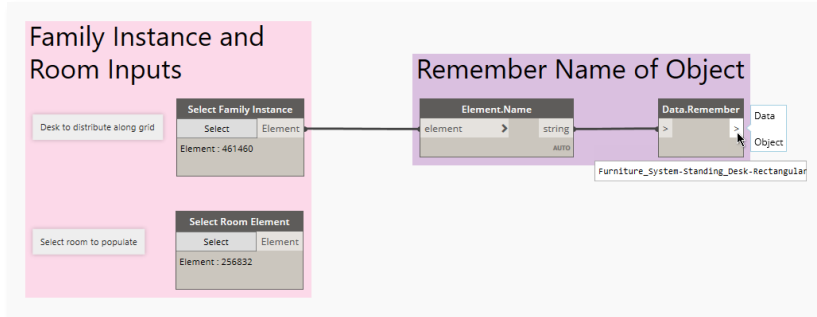


6. Define variables using *Number Slider* nodes, as shown below. To set up a Dynamo graph for use with generative design tools, right-click on each node used to drive the graph and ensure that the '*Is Input*' option is ticked.



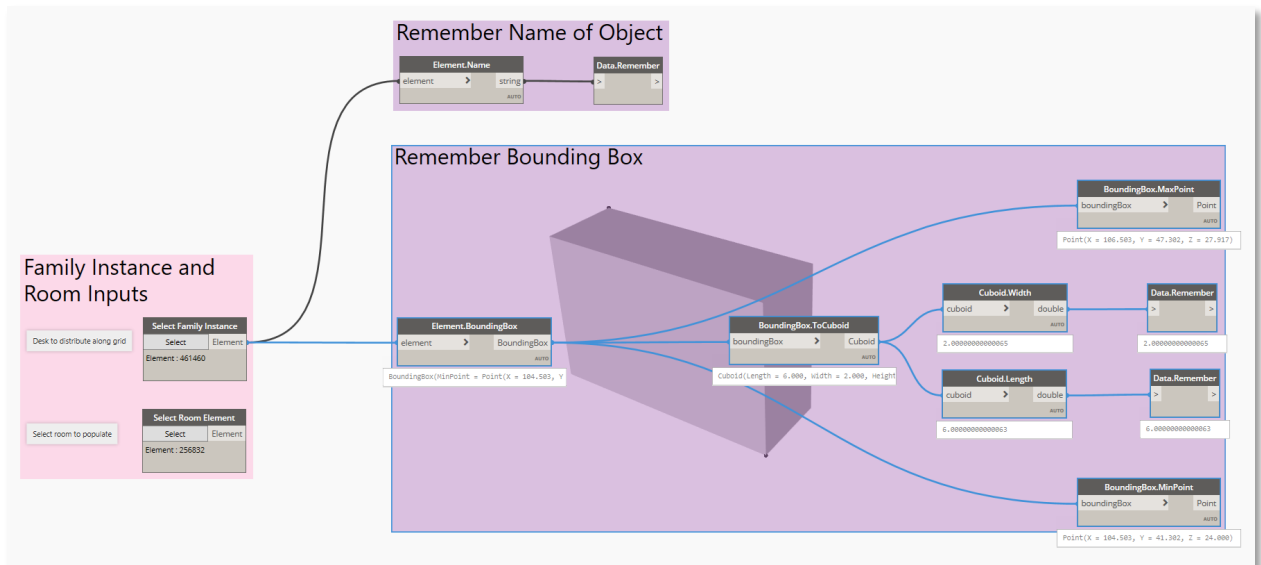
Renaming these nodes helps to distinguish these inputs in the *Create Study* dialog.

7. Select an instance of the desk family to be used in the layout and room 302 Office for testing while you continue developing the script.
8. Add the following nodes and run the script.



Note: Using Generative Design in Revit can be a very powerful approach to quickly explore multiple design options. To ensure your studies are executed efficiently, learn to use the *Data.Remember* and *Data.Gate* nodes to control the data imported from Revit and leveraged in the generative design workflow. These nodes are important because generative design is an iterative process; making each iteration dependent on Revit would add unnecessary computational burden.

9. Add the *Remember Bounding Box* group.



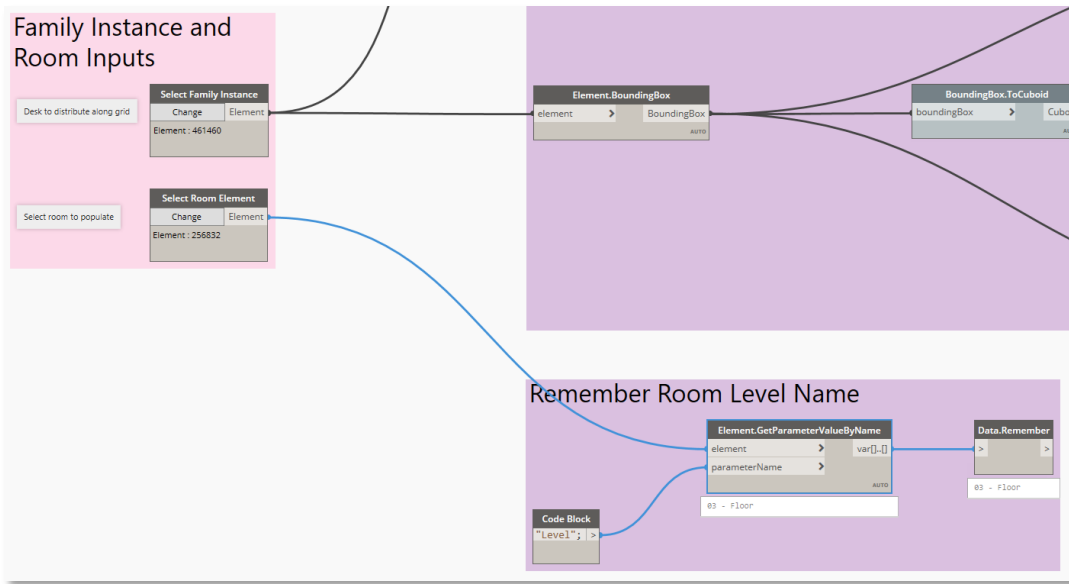
This set of nodes retrieves the bounding box from the selected desk and remembers its width and length.

Note: The *Data.Remember* node is designed to capture the output of any node and cache the results in the *.dyn* file when the graph is saved. It can hold both non-geometric data (such as strings and numbers) and geometric data (such as solids, points, and surfaces) in a serialized

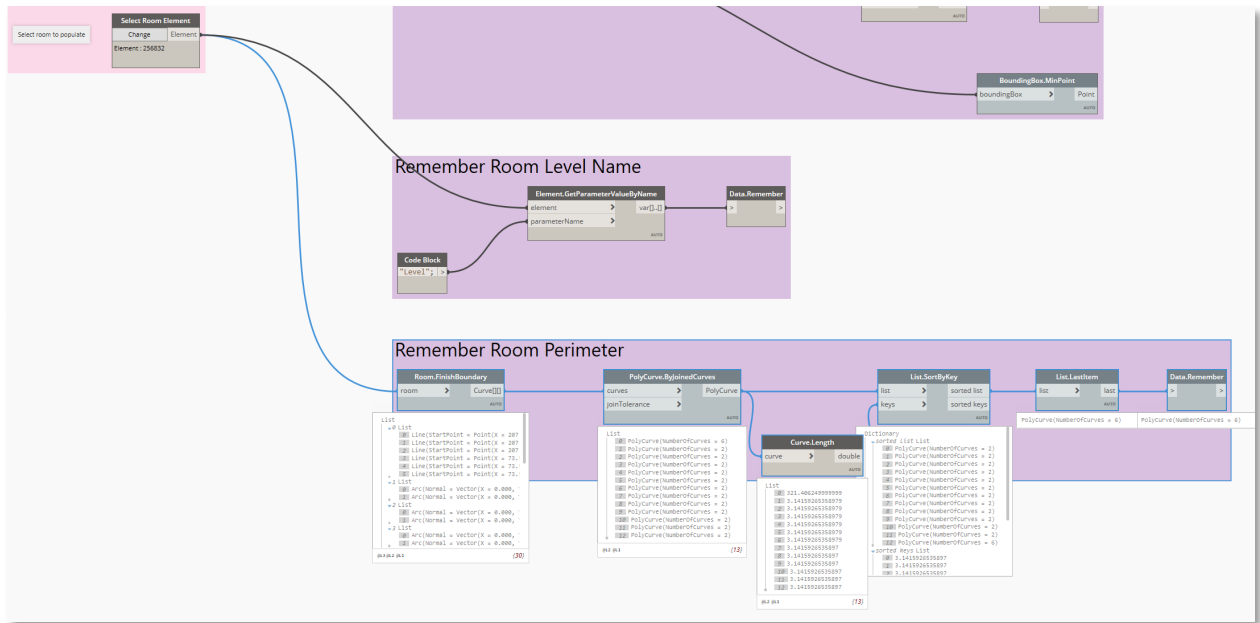
GENERATIVE DESIGN IN REVIT: Using Generative Design for Workspace Layout after COVID-19

format. This means that if, for example, you want to retain values in certain parameters or the underlying geometry of a wall or door, this node can handle both types of data. Currently, the node is limited to these data types. If you attempt to pass other data through this node, e.g. a collection of Revit Elements, Generative Design will return an error saying, 'cannot store data of type'.

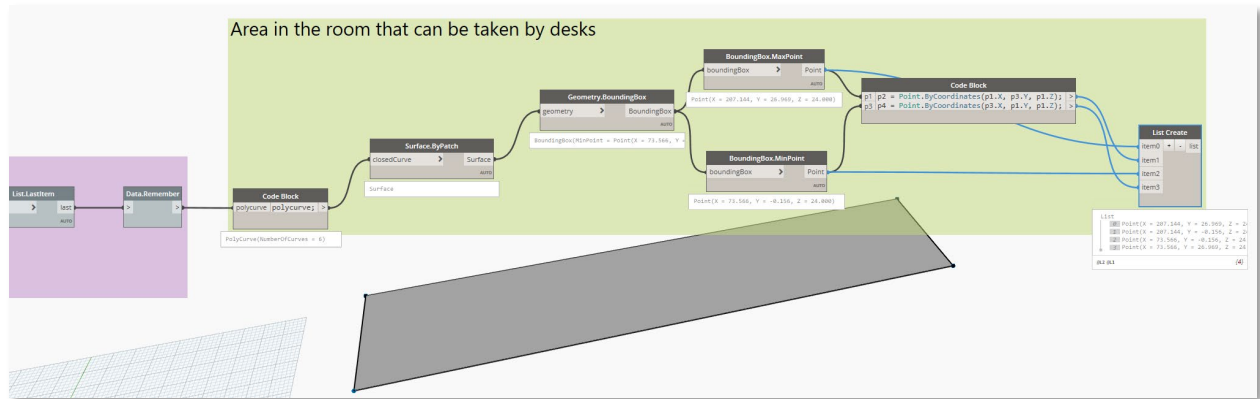
10. Remember the selected room level name.



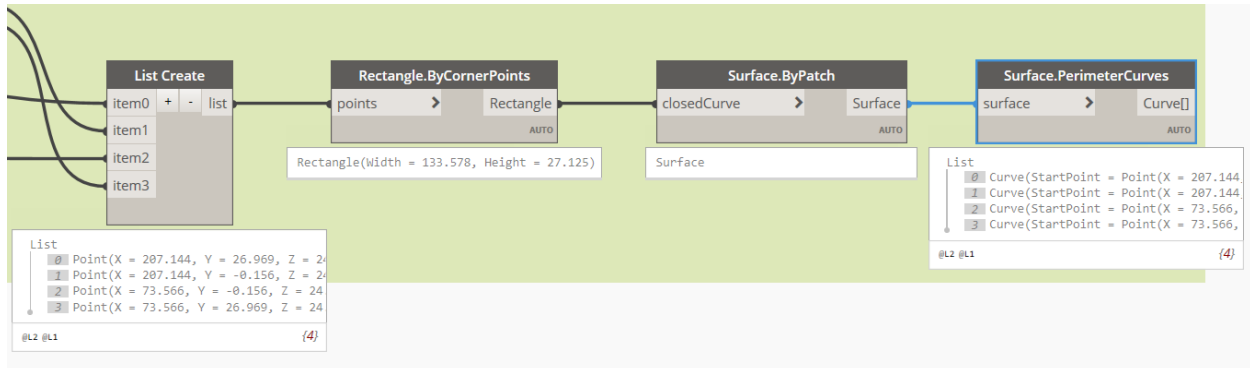
11. Retrieve and remember the room perimeter.



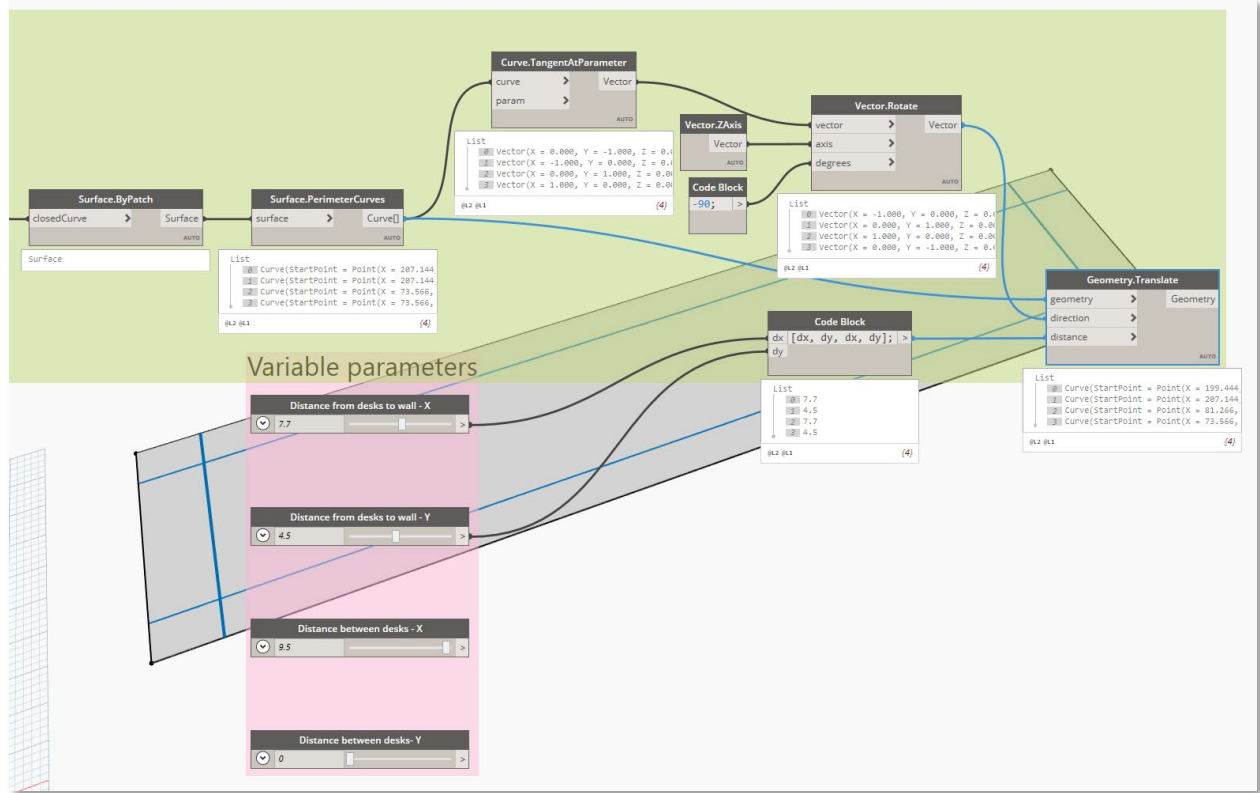
12. Now, we are ready to define the logic to calculate an area in the room that can be filled by desks. It will be an area that considers the minimum required distance from desks to walls in both directions. First, obtain the 4 corner points of the room.



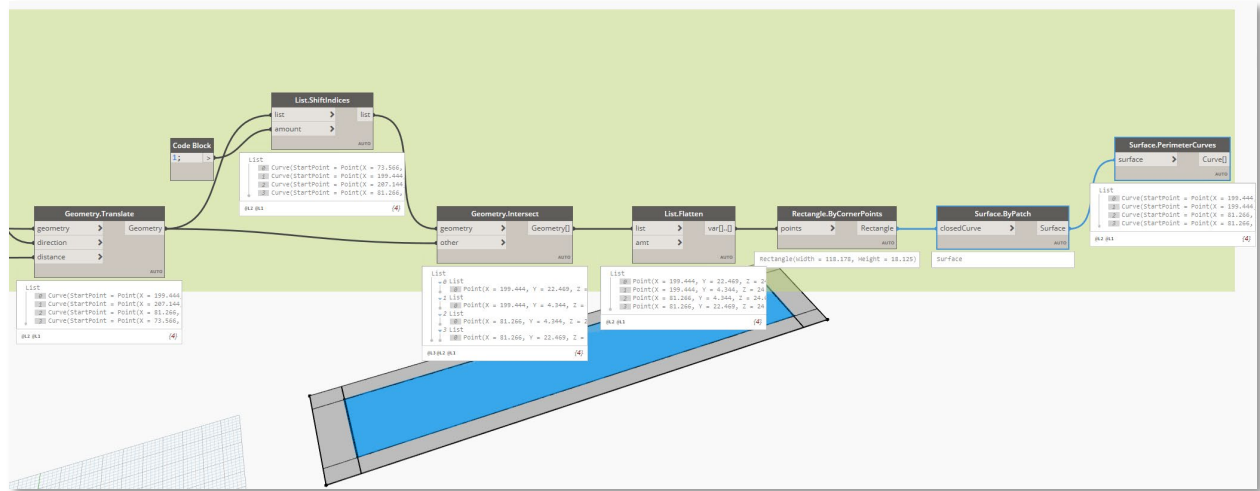
13. Then get the 4 perimeter curves of the room.



14. Offset the perimeter curves towards the inside of the rectangular area. As offset values use the *Minimum distance from desks to wall* parameters.

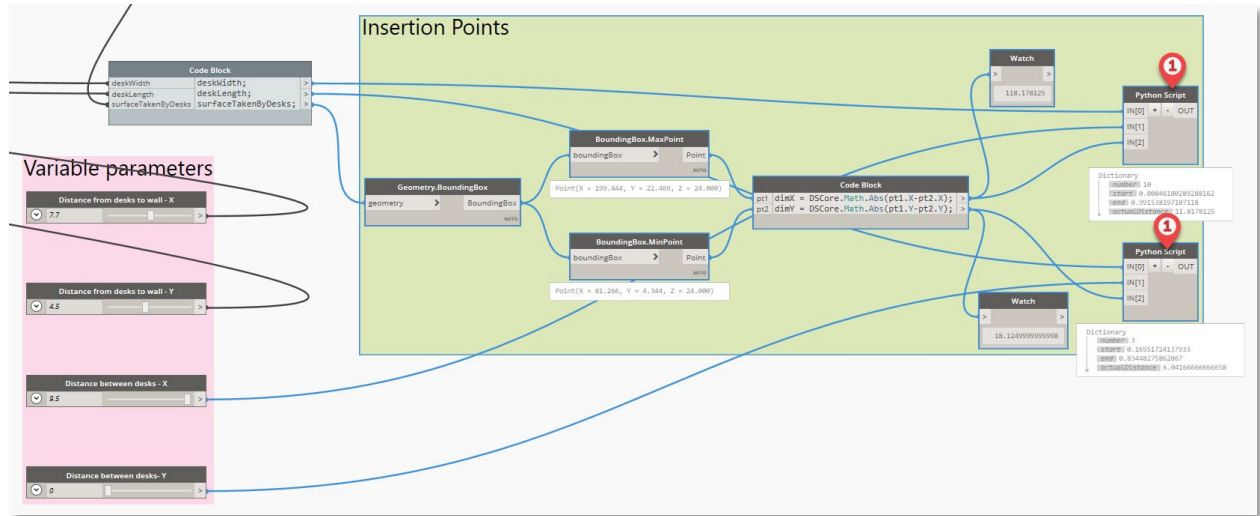


15. Find the intersections of the shifted curves and create a new surface. This is the area that can be occupied by desks based on the input variables: 1 = selected room, 2 = minimum distance from desks to walls in the X direction, 3 = minimum distance from desks to walls in the Y direction.



You have just implemented the ability to control distances between desks and walls in X and Y directions independently.

17. Calculate the insertion points using a Python script, as shown...

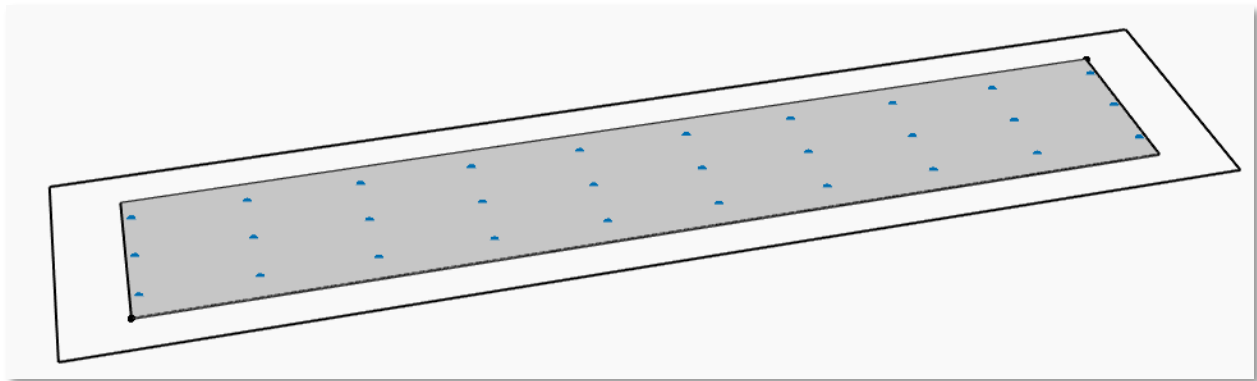
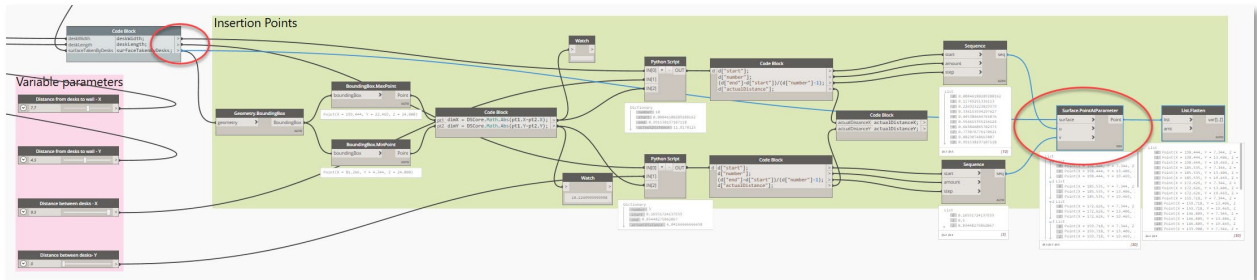
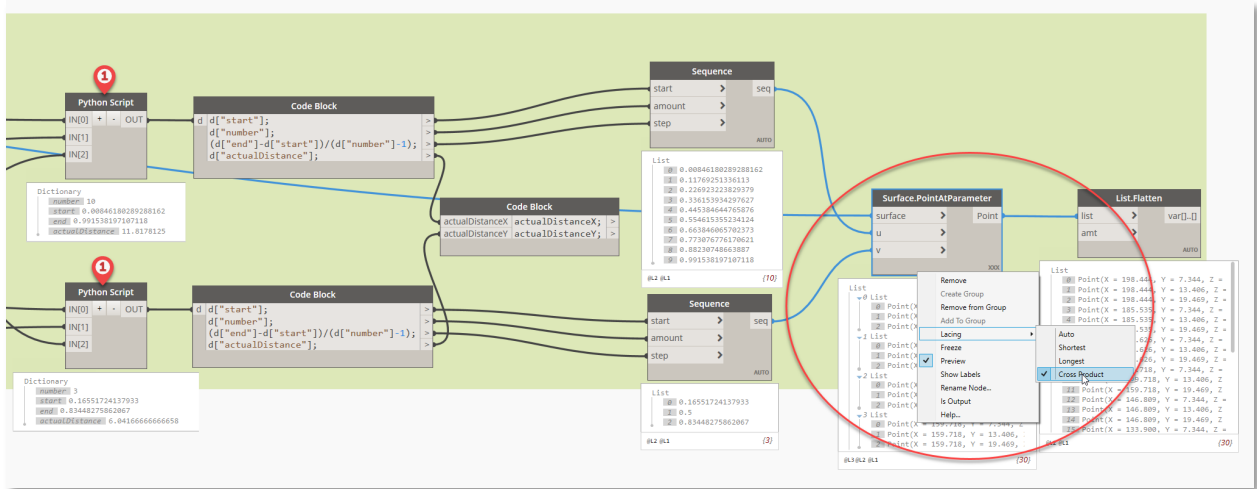


```

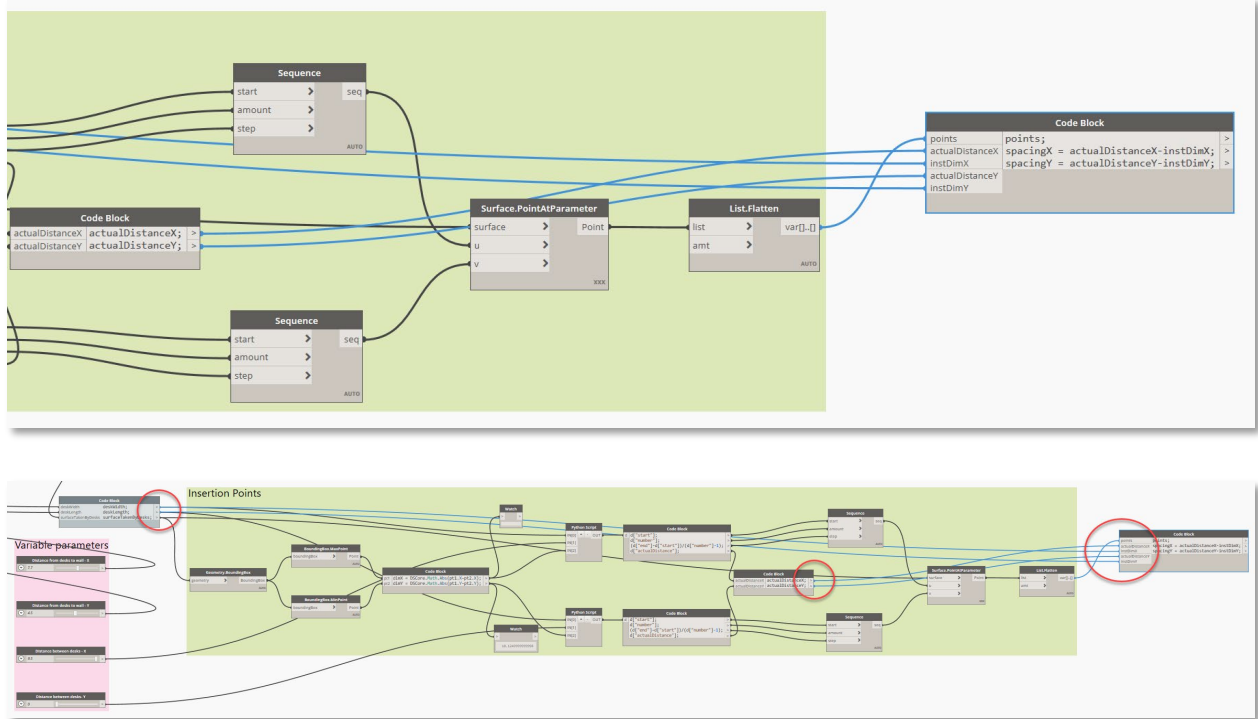
Python Script
1 # Load the Python Standard and DesignScript Libraries
2 import sys
3 import clr
4 clr.AddReference('ProtoGeometry')
5 from Autodesk.DesignScript.Geometry import *
6 import math
7
8 # The inputs to this node will be stored as a list in the IN variables.
9 dataEnteringNode = IN
10
11 deskDim = IN[0]
12 objDist = IN[1]
13 maxDist = IN[2]
14
15 objDist = objDist + deskDim
16 actualNumber = math.floor(maxDist/objDist)
17 actualDistance = maxDist/actualNumber
18
19 start = (deskDim/2)/maxDist
20 end = 1 - (deskDim/2)/maxDist
21
22
23 # Assign your output to the OUT variable.
24 OUT = {"start": start, "end": end, "number": actualNumber,
"actualDistance": actualDistance}
    
```


GENERATIVE DESIGN IN REVIT: Using Generative Design for Workspace Layout after COVID-19

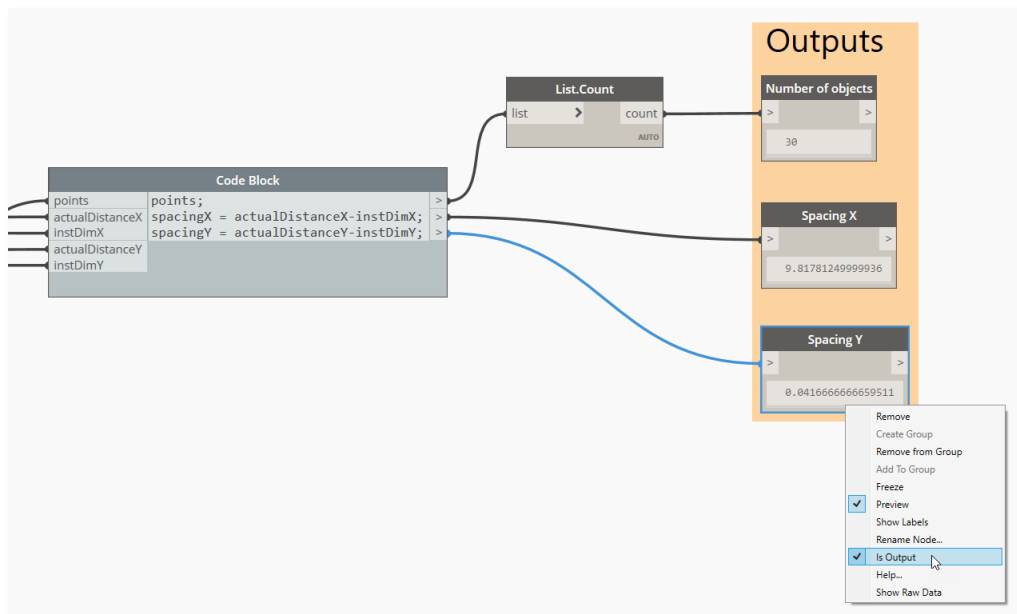
...and be sure to use cross product lacing in the *Surface.PointAtParameter* node:



18. Create the following *Code Block* to calculate X and Y spacings between desks.

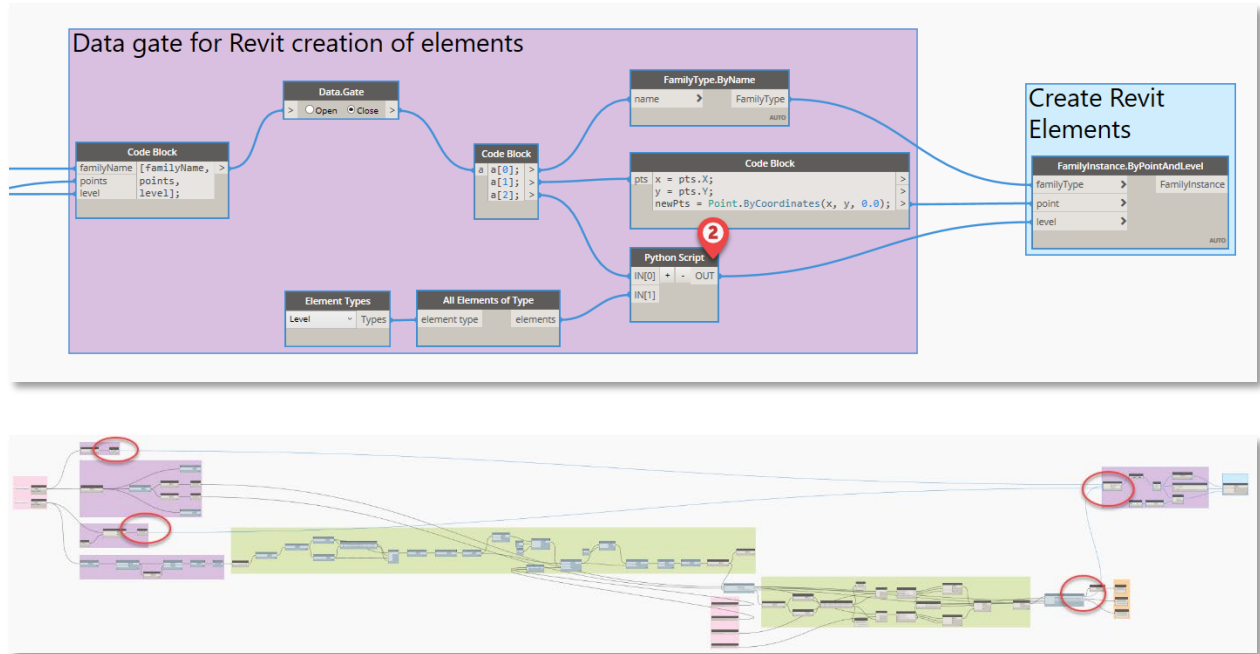


19. Define Outputs using the *Watch* nodes. To define outputs for use with the generative design tools, right-click on the Watch nodes and select the 'Is Output' option. Currently, all outputs must be Watch nodes with a 'Number' data type.



Your script is almost complete; you have just a couple of tasks remaining. You will need to create elements in Revit and implement a logic that will be used for visualization purposes.

20. Add the following nodes to create Revit elements.

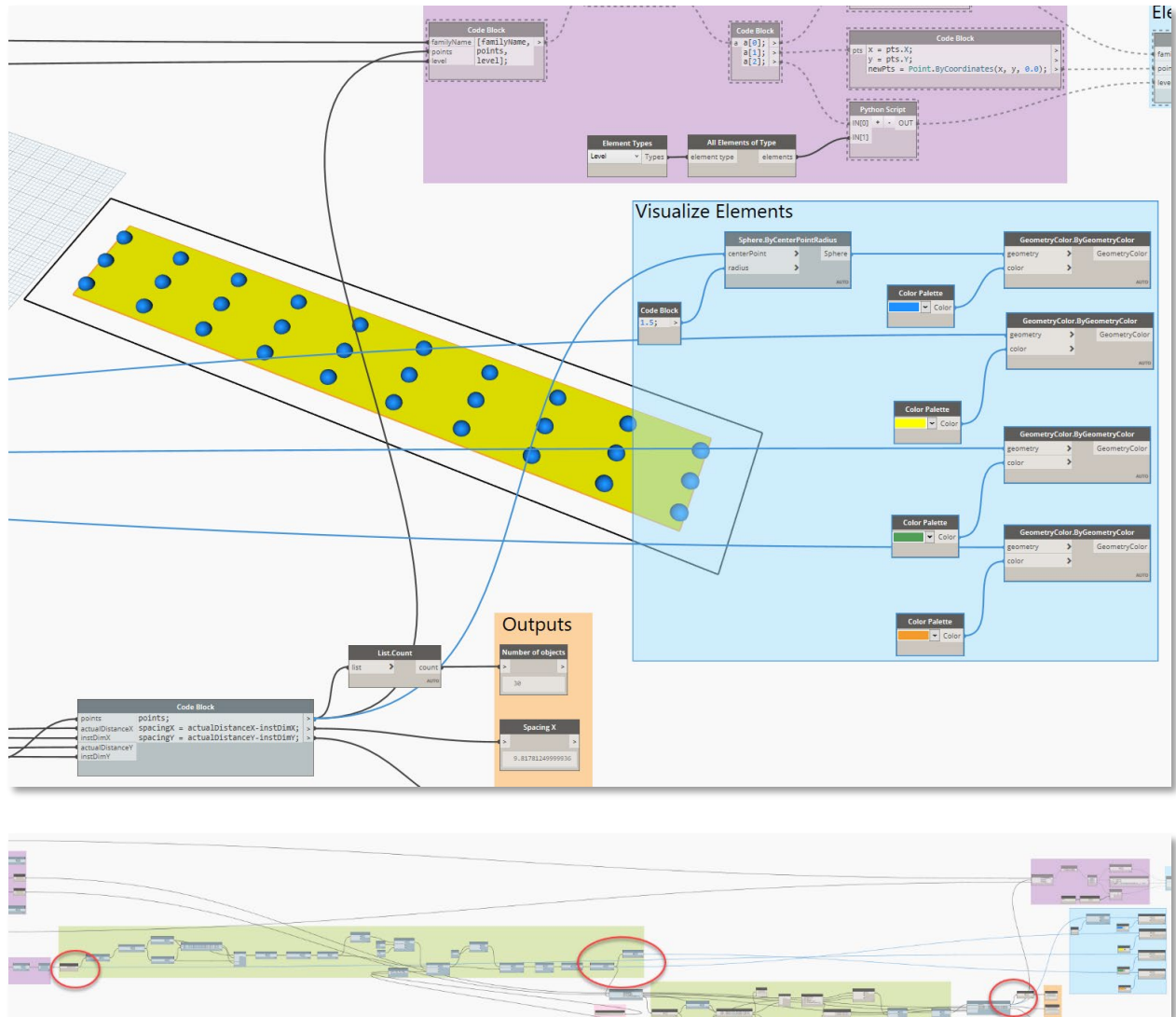


```

Python Script
1 # Load the Python Standard and DesignScript Libraries
2 import sys
3 import clr
4 clr.AddReference('ProtoGeometry')
5 from Autodesk.DesignScript.Geometry import *
6 levelName = IN[0]
7 alllevels = IN[1]
8 levelfound = "Not Found"
9 for level in alllevels:
10     if level.Name == levelName:
11         levelfound = level
12
13 OUT = levelfound
    
```

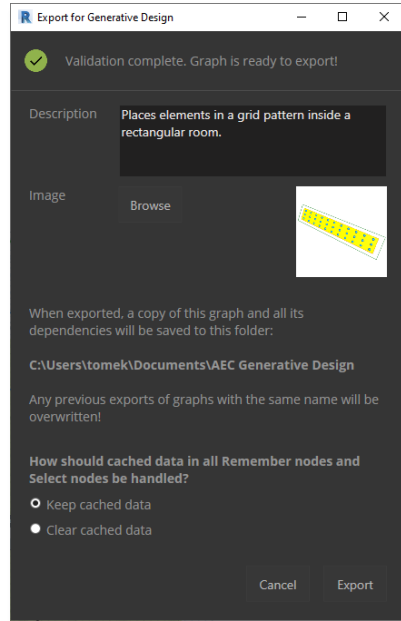
Note: The *Data.Gate* node controls the flow of data after the node. It activates the *Create Revit Elements* button on the *Explore Outcomes* dialog. You use the *Data.Gate* node to control when a branch of the graph runs. This branch creates Revit elements—i.e. it adds the desks to a room for your grid layout.

21. Finally, you will create the visualization. Connect the relevant nodes as shown to visualize and color-code elements.

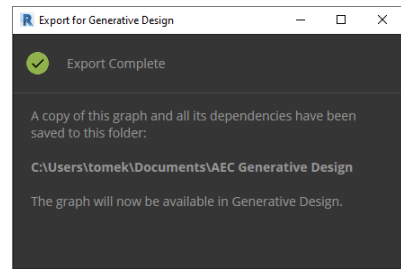


22. Once both inputs and outputs have been set up correctly and your graph is saved, it can be exported for use with the generative design toolset. In Dynamo, navigate to the toolbar and select *Generative Design > Export for Generative Design*.

GENERATIVE DESIGN IN REVIT: Using Generative Design for Workspace Layout after COVID-19

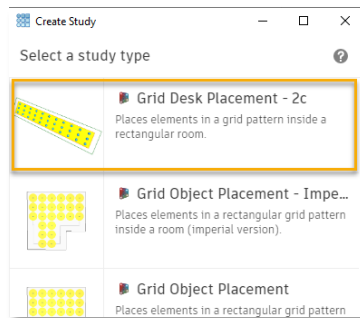


23. Click *Export*.



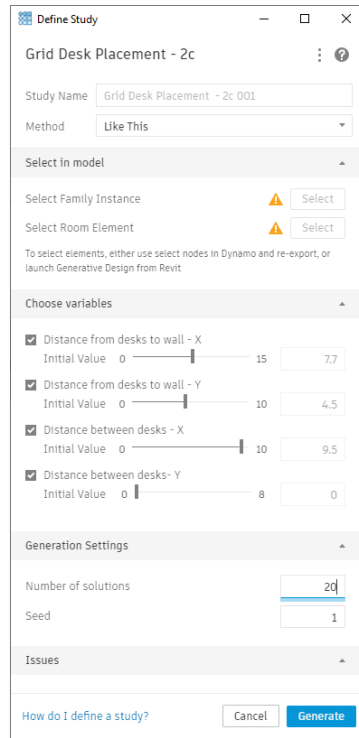
24. To launch Generative Design, navigate to the Dynamo menu and select *Generative Design > Create Study*.

25. Once the *Create Study* dialog has launched, select a study that you have just exported from Dynamo.



26. Set up the following options in the *Define Study* dialog box.

Note: You will not need to select a room and a family instance, as you selected *Keep cached data* in steps 22-23 above. Any data in the study that is specific to the Revit model you have been using with the graph will be retained.



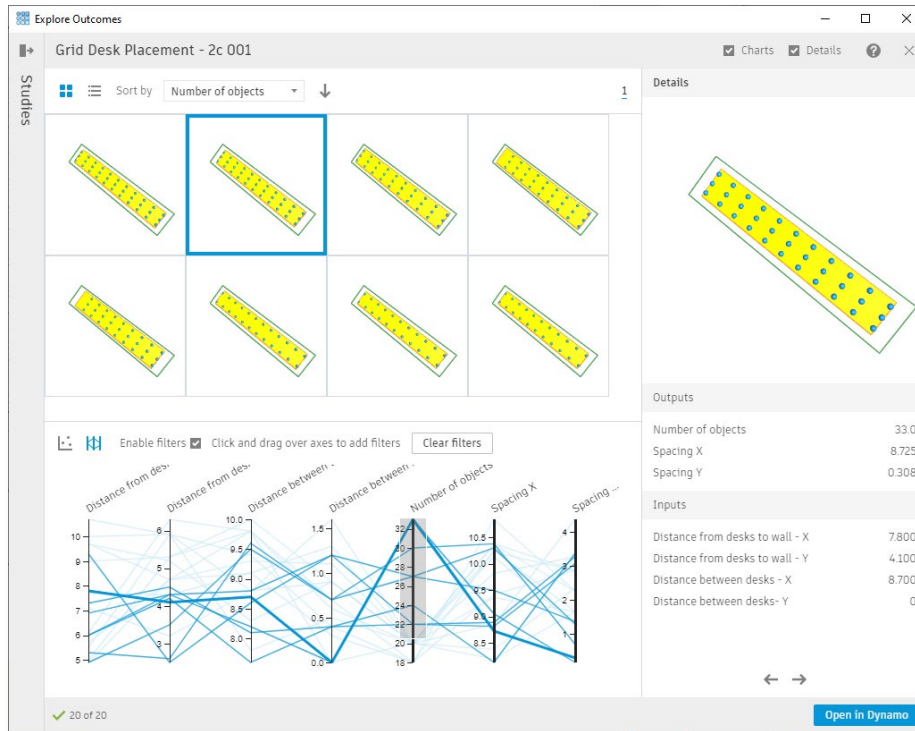
27. Click *Generate*.

28. When the generation is done, close the *Explore Outcomes* dialog and Dynamo.

29. Relaunch Dynamo for Revit and navigate to the Dynamo menu and select *Generative Design > Explore Outcomes*.

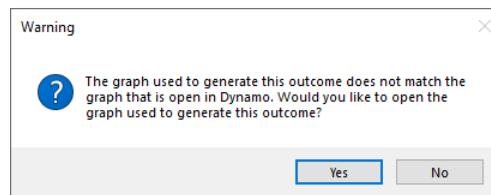
30. Filter the results as shown:

GENERATIVE DESIGN IN REVIT: Using Generative Design for Workspace Layout after COVID-19

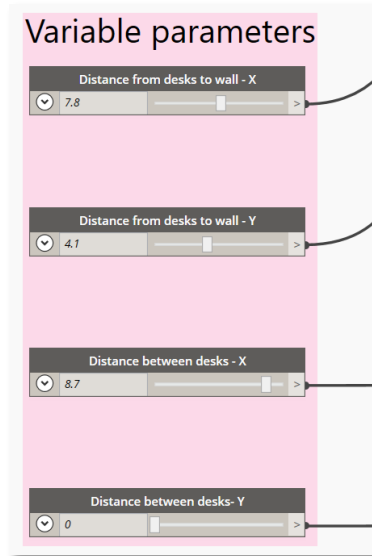


31. Click *Open in Dynamo*.

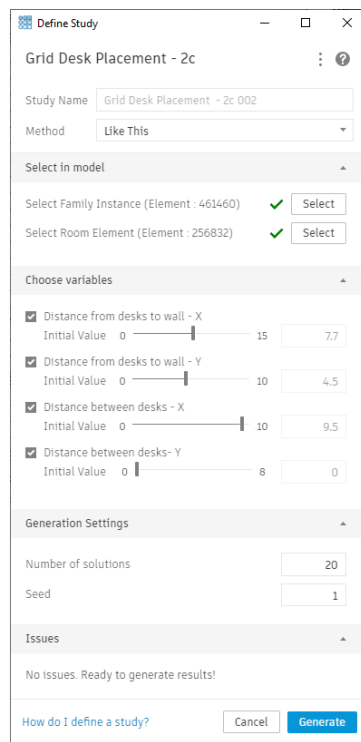
32. When you see the Warning dialog (it may be hidden under the *Explore Outcomes* dialog), click *Yes*.



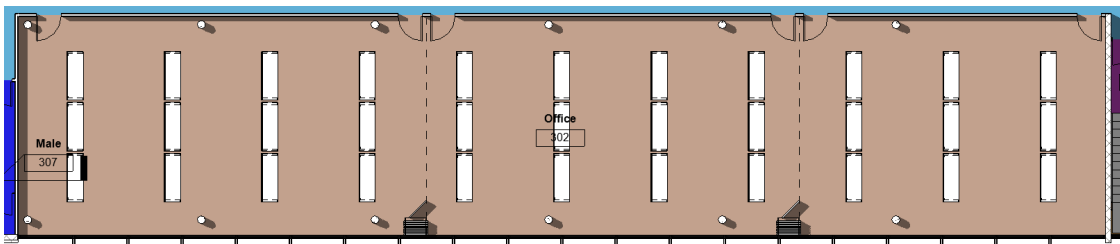
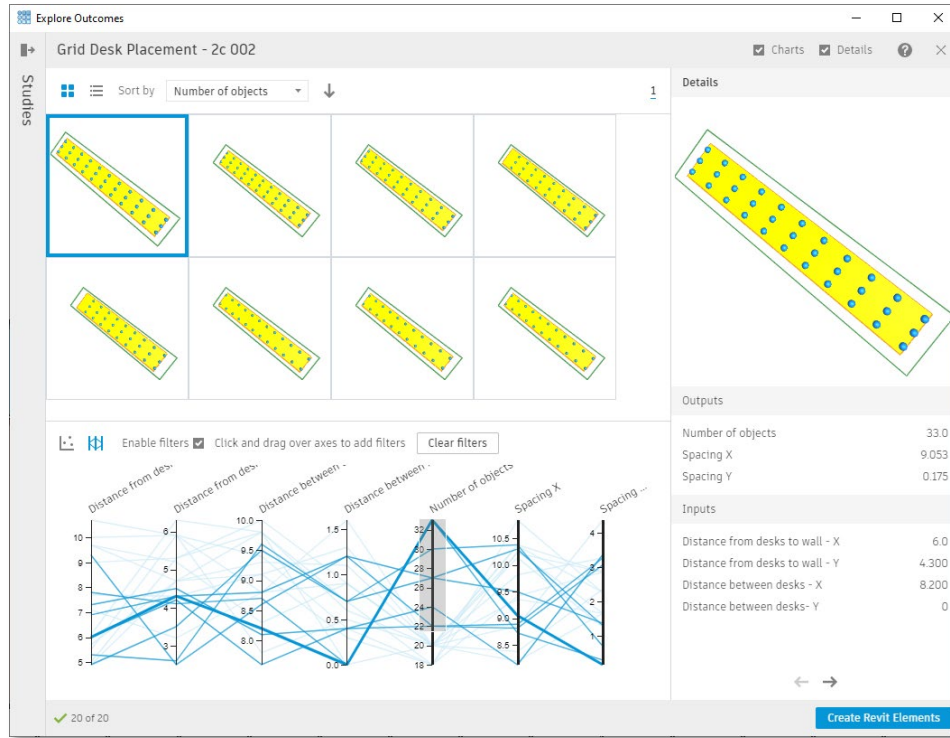
Notice that the input variables in the script have been updated based on inputs of the selected outcome.



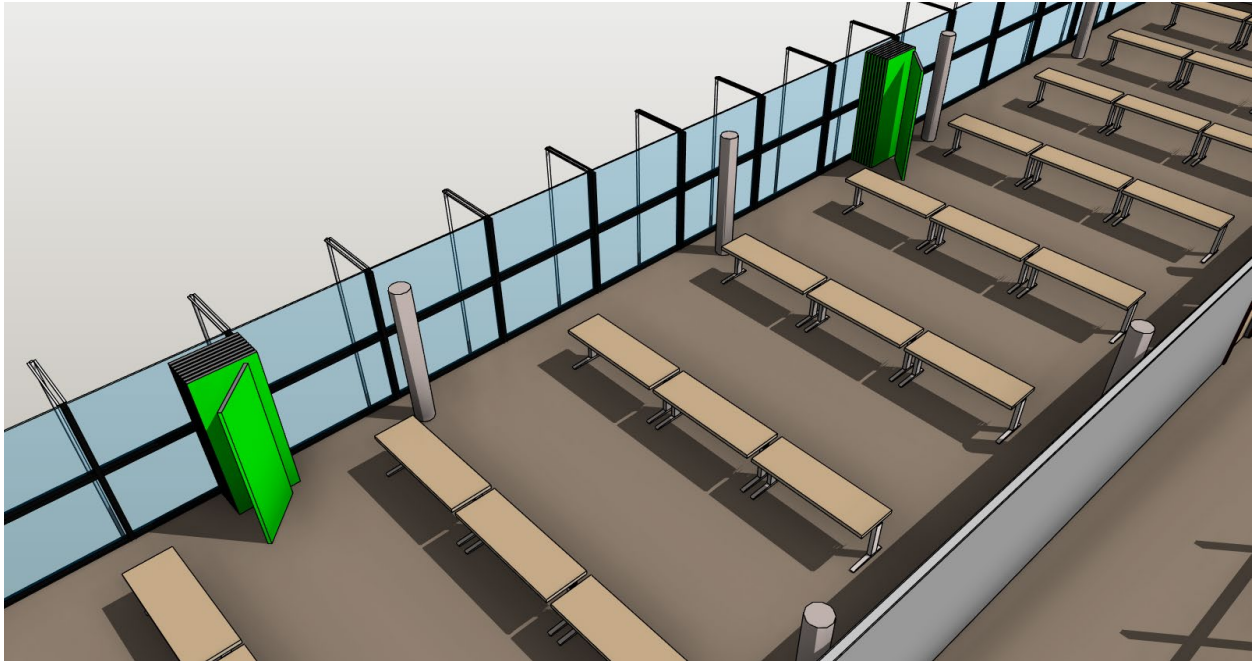
33. Export the study for Generative Design again. Select the *Clear cached data* option this time.
34. Close Dynamo.
35. On the *Manage* tab, click *Create Study*, and create a new *Grid Desk Placement - 2c* study.
36. Set up the study and click *Generate*. Notice that you need to make selections in the model.



37. Select the following outcome and click *Create Revit Elements*.



Now you are getting somewhere! In this exercise, you generated a layout that accommodates 33 employees in groups of three, and both operable partitions are functional. This outcome achieves your goals of maintaining 6' of separation between employees without installing glass panels, and every employee has a view to the outside.

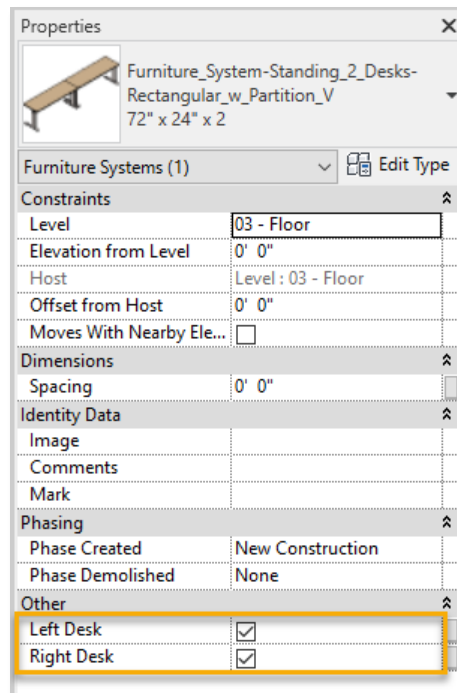
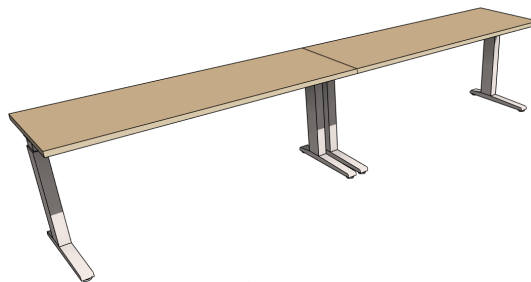


However, you still have two concerns. Your employees are still lining up directly behind one another, and you would prefer to have an even greater distance between them before removing the glass panels. Also, you would like a better circulation path between the employees' desk positions and the exits.

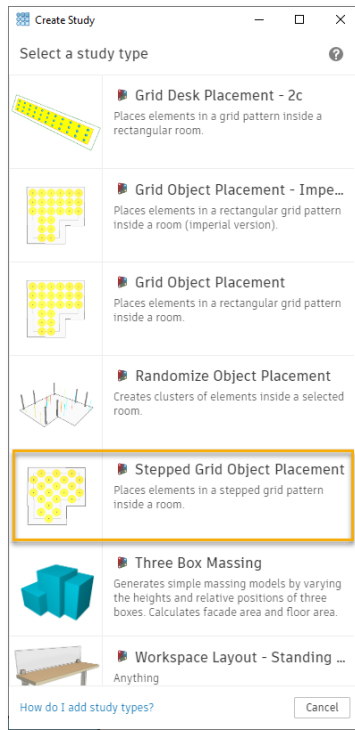
Exercise 2d – Standing Desk Layout using Customized Stepped Grid Object Placement Study

To address the remaining concerns of Exercise 2c, you will test one last approach. This time, you will use the *Stepped Grid Object Placement* study to arrange the desks with the same orientation as before.

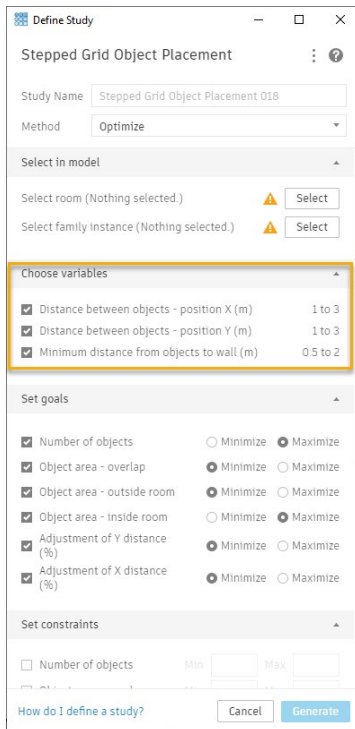
1. Begin by loading the family *Furniture_System-Standing_2_Desks-Rectangular_w_Partition_V.rfa* from the *Datasets* folder into the *Workspace Layout.rvt* project. This family is very similar to the family you used in Exercise 2c, except that it has two desks. This family has two additional parameters (*Left Desk* and *Right Desk*) that will help you better manage how this furniture system is set up. Place an instance of this family in (or near) *329 Corridor* so that it will be selectable later.



2. On the *Manage* tab, click *Create Study*. Select the *Stepped Grid Object Placement* sample study.



3. Review the settings available for this study type:

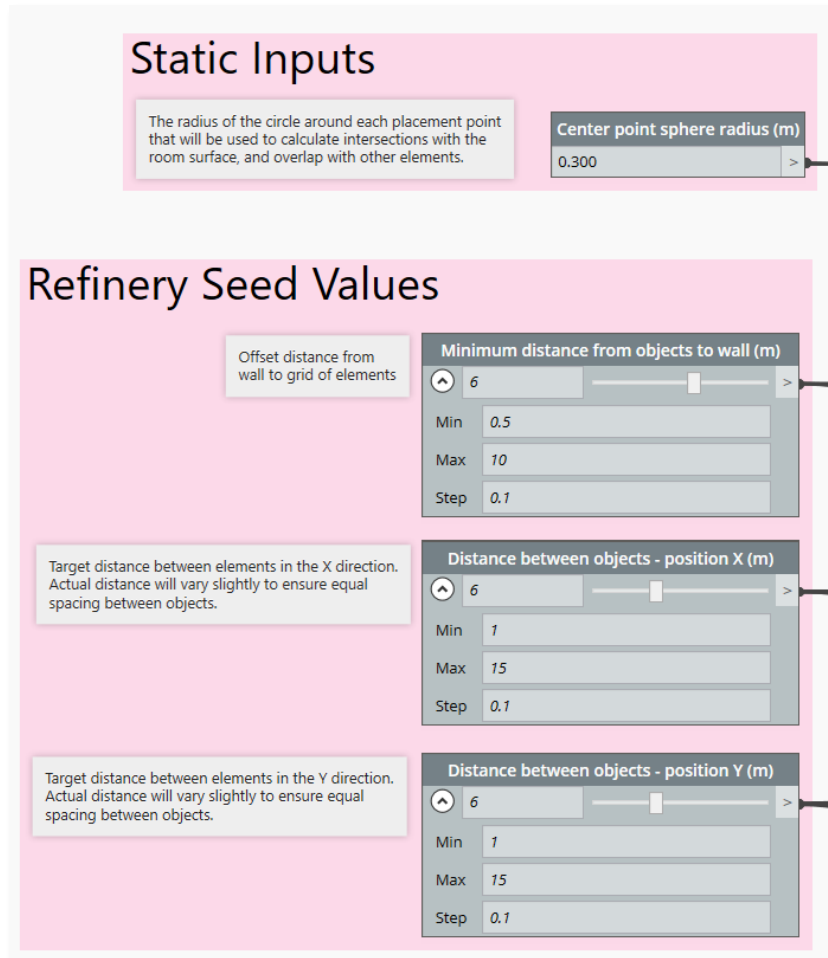


Notice that this study has variables in metric units, while your project uses imperial units. Additionally, the study measures distances between objects from their insertion points, and the ranges provided are relatively small (i.e. 1 to 3, 0.5 to 2). These are important considerations.

You faced similar issues in Exercise 2b.

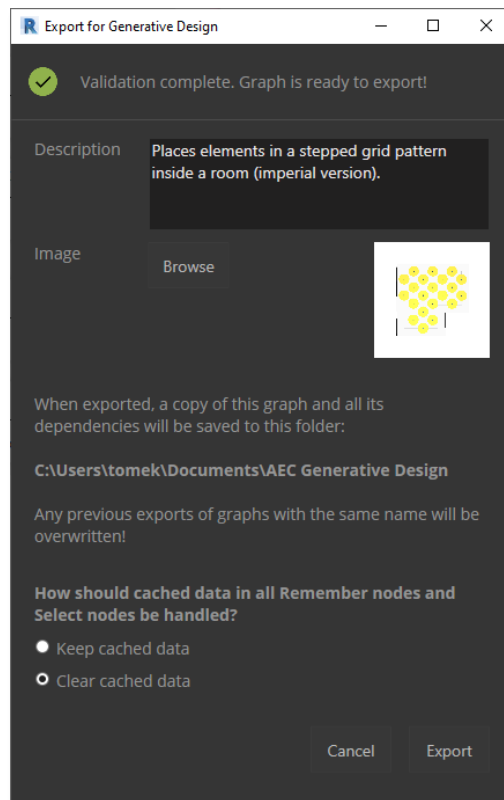
This is a situation where adjustments to the sample study need to be performed to achieve meaningful results. In the next few steps, you will update the variable ranges and their units.

4. Repeat steps 5-9 from Exercise 2b, ensuring you have set up the variables as follows:

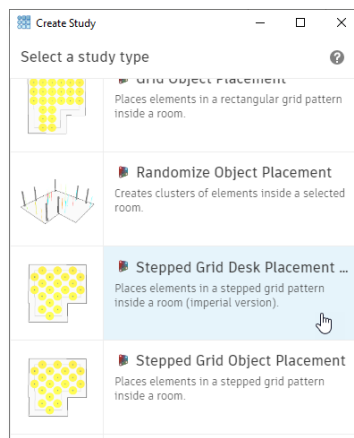


5. Use *File > Save As* to save the script with the new name *Grid Desks Placement – 2d.dyn*.

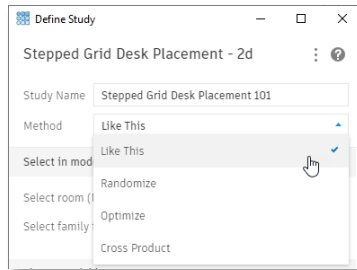
- Repeat steps 11-14 from Exercise 2b (but using the 2-desk family you loaded a few moments ago).



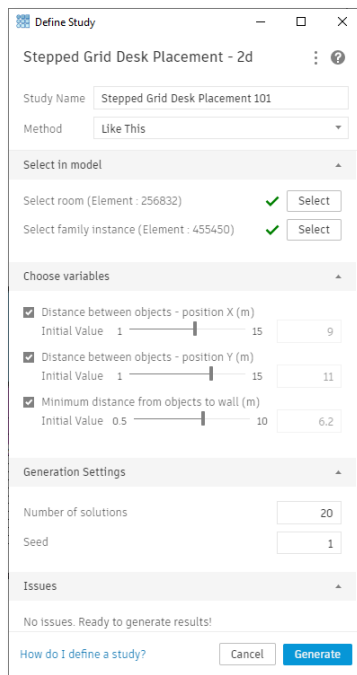
- If you opted to skip steps 4-6 in this exercise, you may simply copy the *Grid Desks Placement – 2d.dyn* file and the *Grid Desks Placement – 2d.Dependencies* folder from the *Datasets* folder to *C:\Users\\Documents\AEC Generative Design*.
- Close Dynamo for Revit and click *Create Study*. You will see the new study that you have just created (or loaded):



9. Create a new *Grid Desk Placement – 2d* study. Choose the *Like This* method. This method will make Generative Design apply slight adjustments to your current input configuration, enabling you to explore variations of a design that you already like.



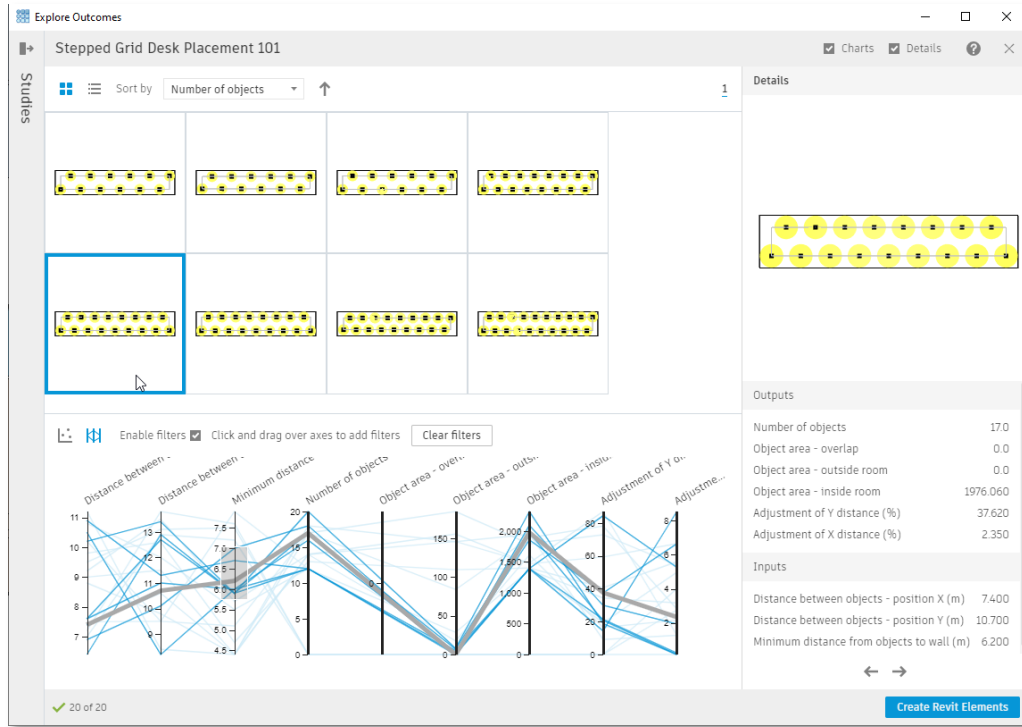
10. Select room *302 Office* and the 2-desk family instance, together with the following variables and Generation Settings:



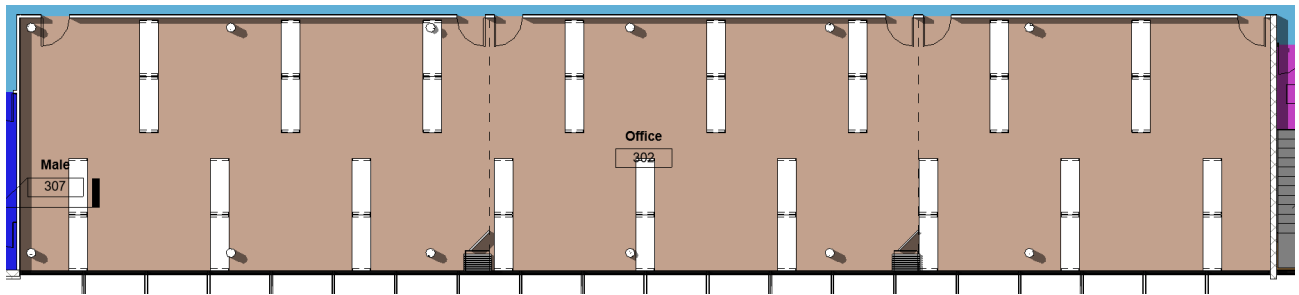
11. Click *Generate*.

12. Filter the results as shown:

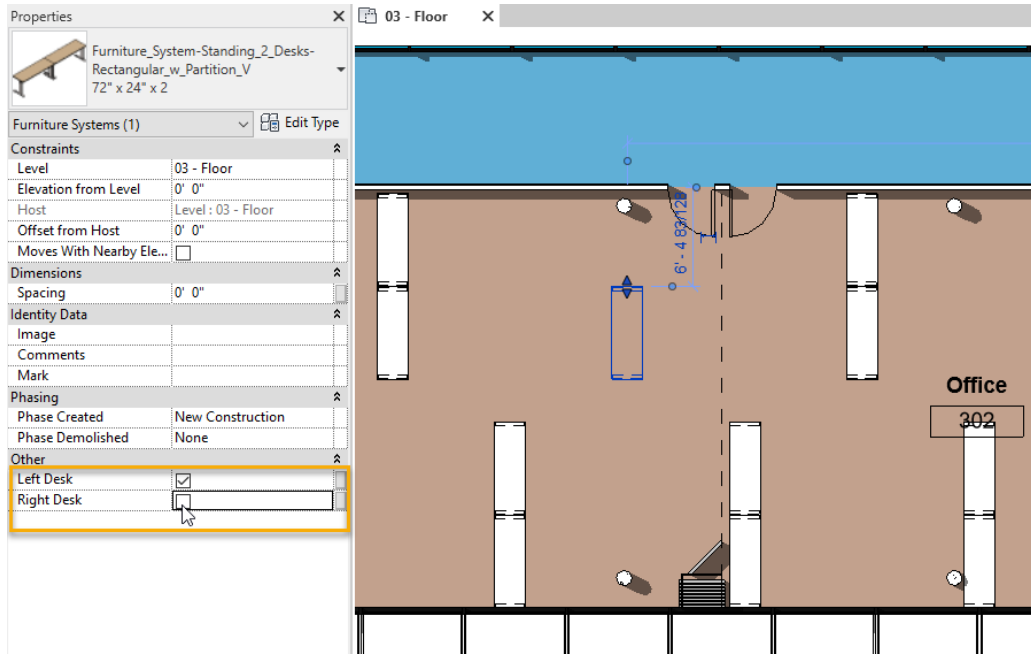
GENERATIVE DESIGN IN REVIT: Using Generative Design for Workspace Layout after COVID-19



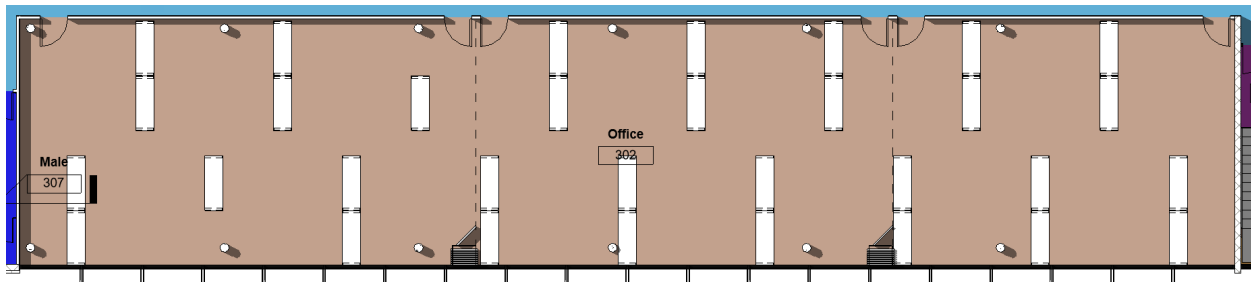
13. Select one of the outcomes yielding 17 groups of desks (see above) and click *Create Revit Elements*.

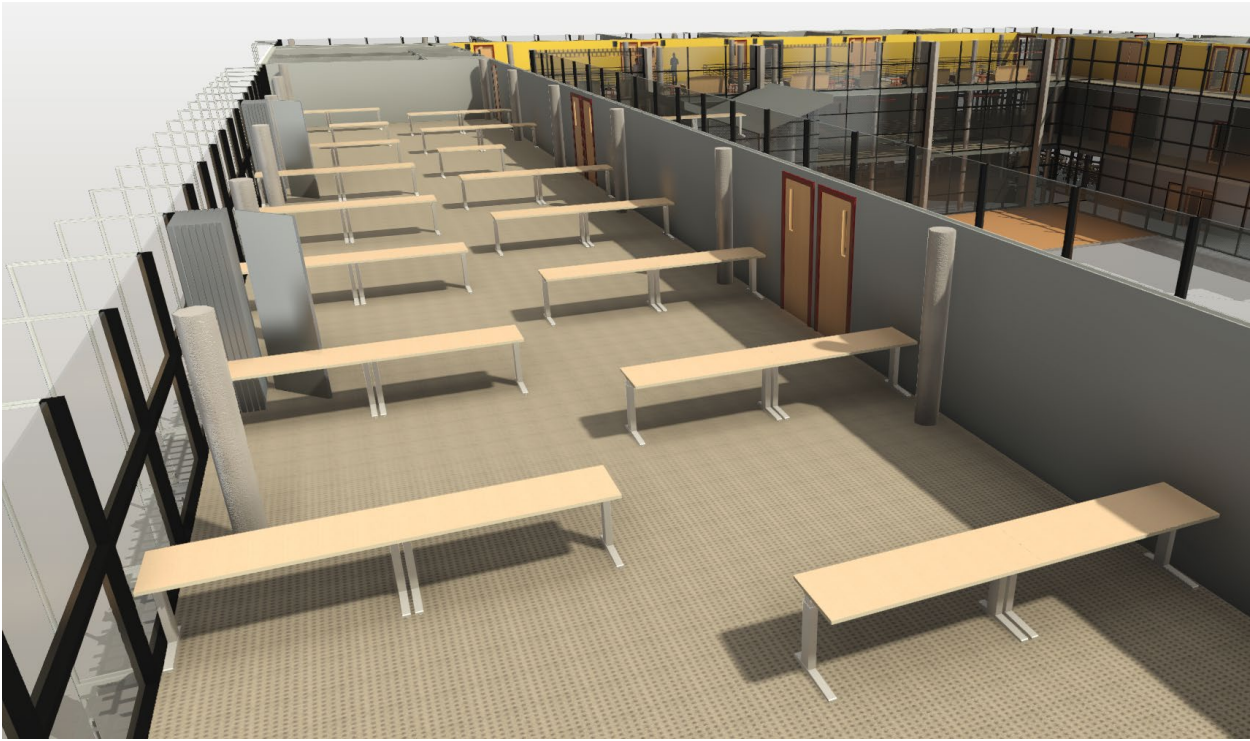
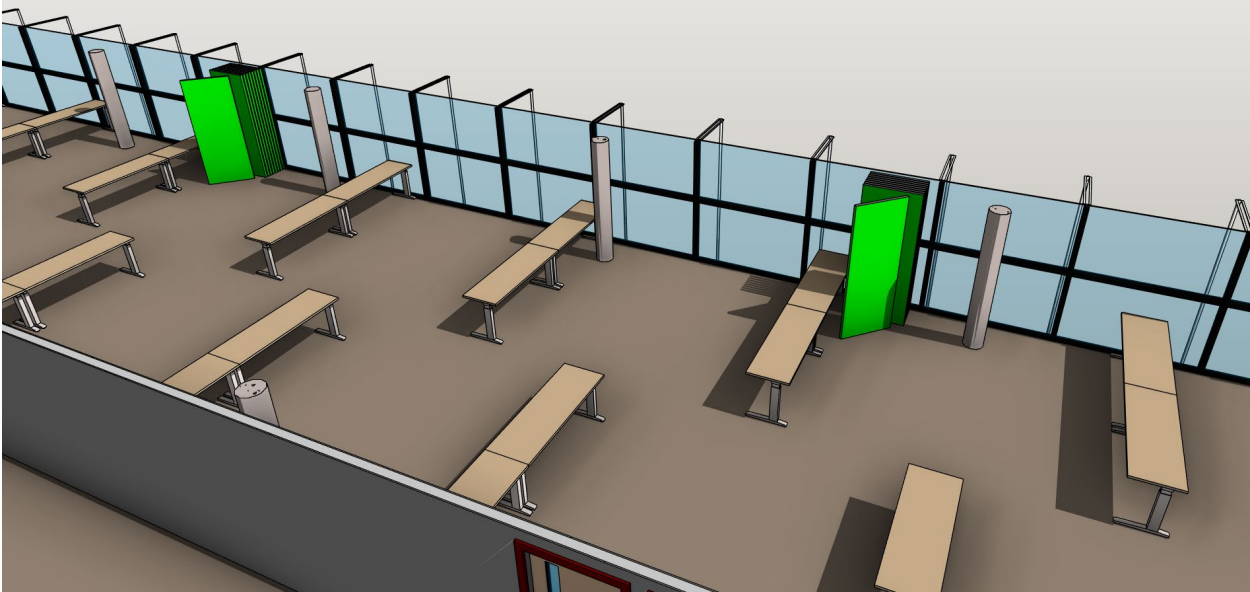


14. Using the *Left Desk* and *Right Desk* parameters, exclude desks that conflict with columns:



You have found an optimal solution for your 32 employees in groups of two. This layout ensures maximum spacing between employees, and both of the operable partitions in the office space are functional.





GENERATIVE DESIGN IN REVIT: Using Generative Design for Workspace Layout after COVID-19

Congratulations! Without manually moving a single desk, you have discovered the optimal open office layout to safely accommodate your employees using Generative Design in Revit. Best of all, these customized studies are ready to be utilized on all of your office layouts.

