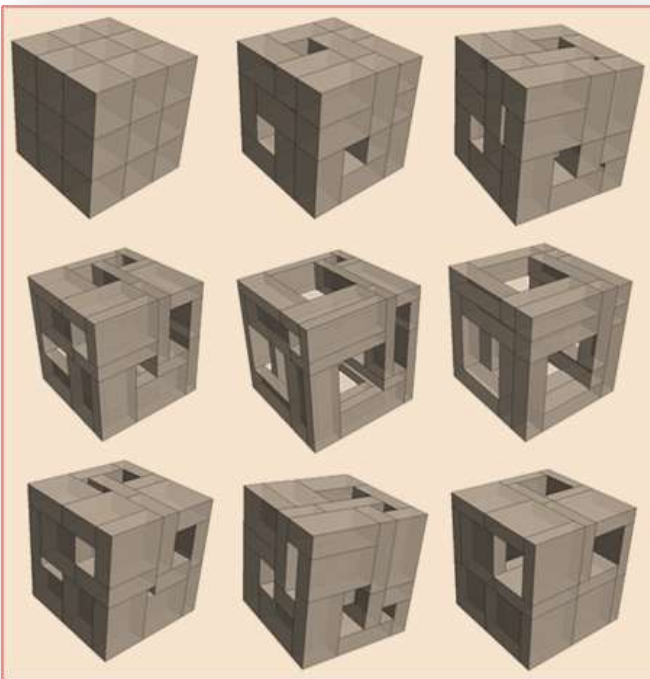# The Box Packing

As a mathematical concept interpreted architecturally
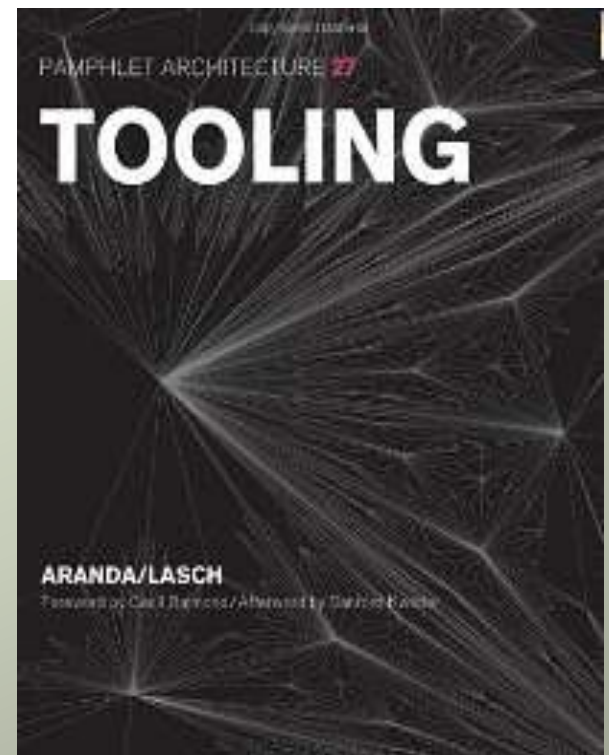
Doc. dr Mirjana Devetaković, dipl. ing. arh.

Prof. dr Ljiljana Petruševski, dipl. mat.
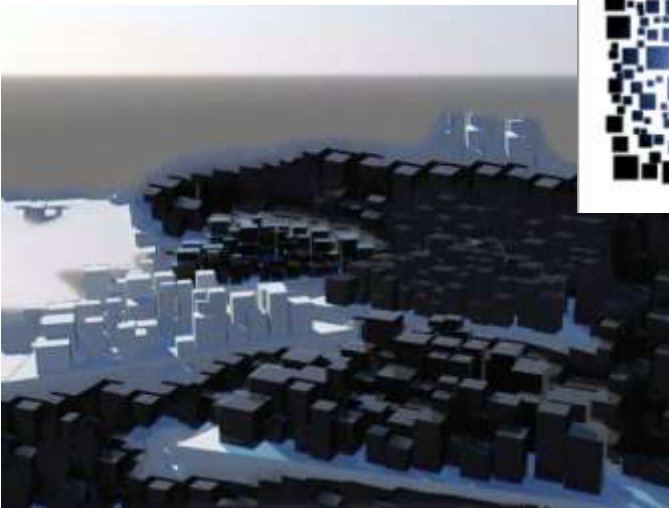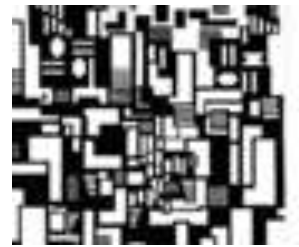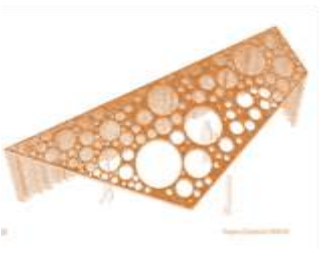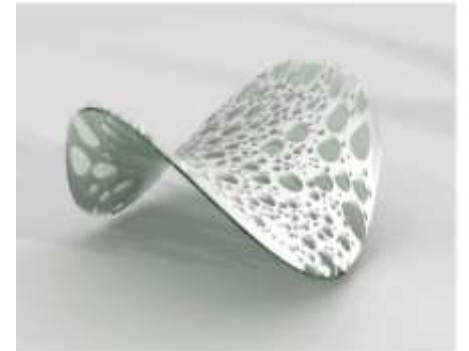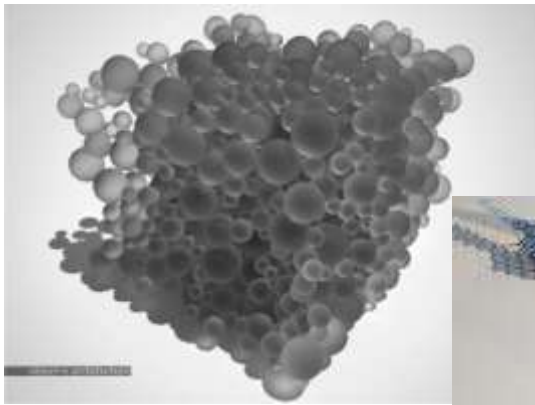
Jelena Kijanović, dipl.mat.

Exploration of Tooling,
Benjamin Aranda and Christopher Lash

Seven generative concepts:

- Spiraling
- **Packing**
- Weaving
- Blending
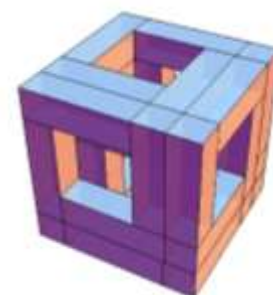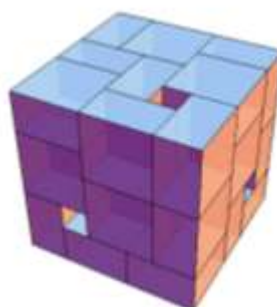- Cracking
- Flocking
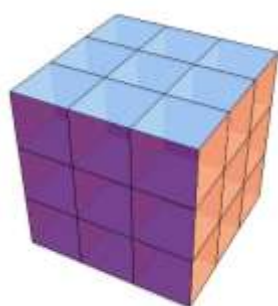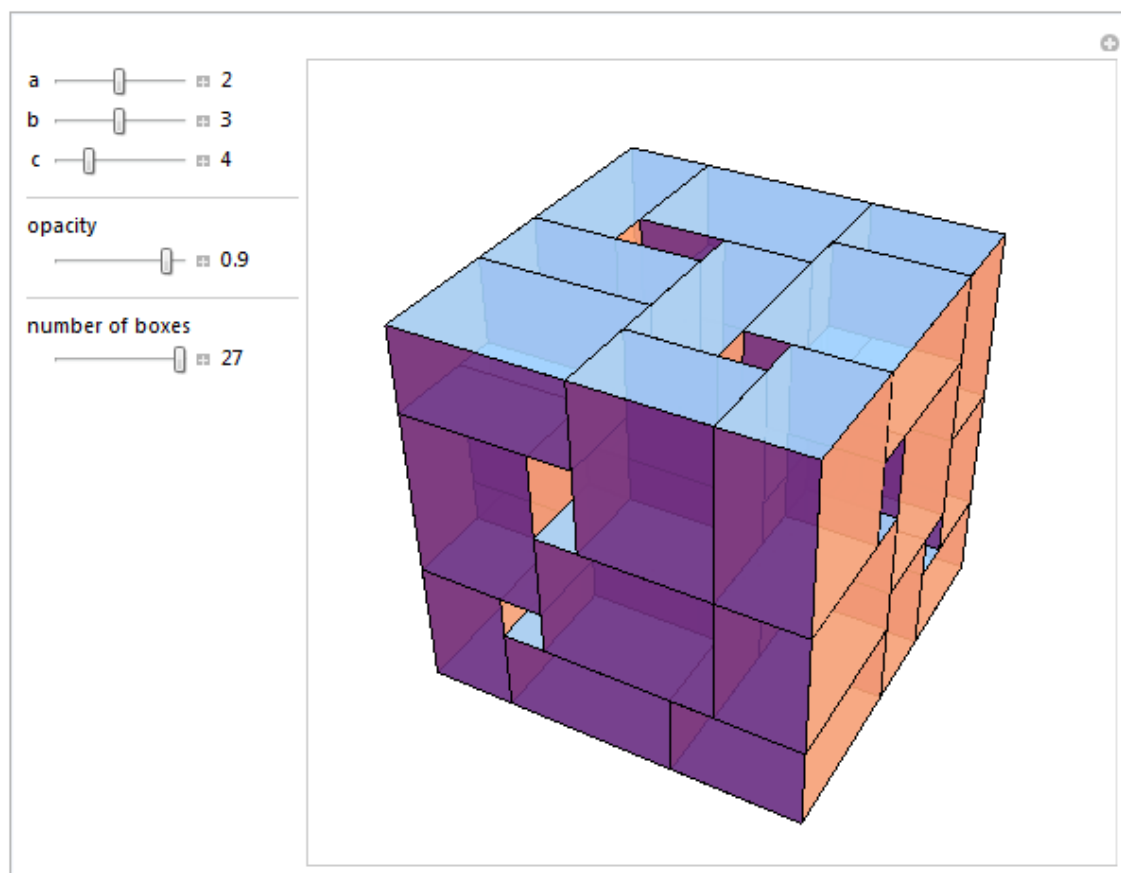- Tiling

The Packing concept

The Box Packing
within the Wolfram Demonstration projects

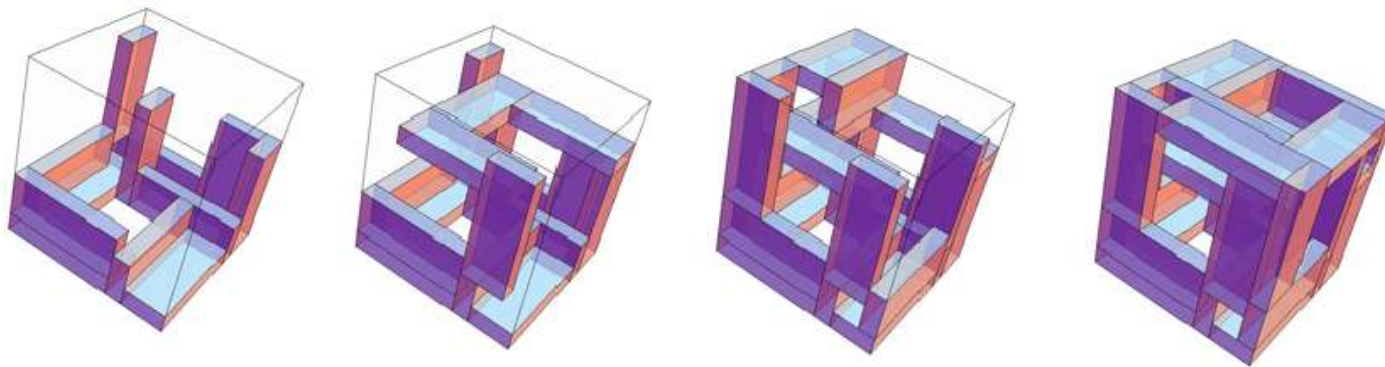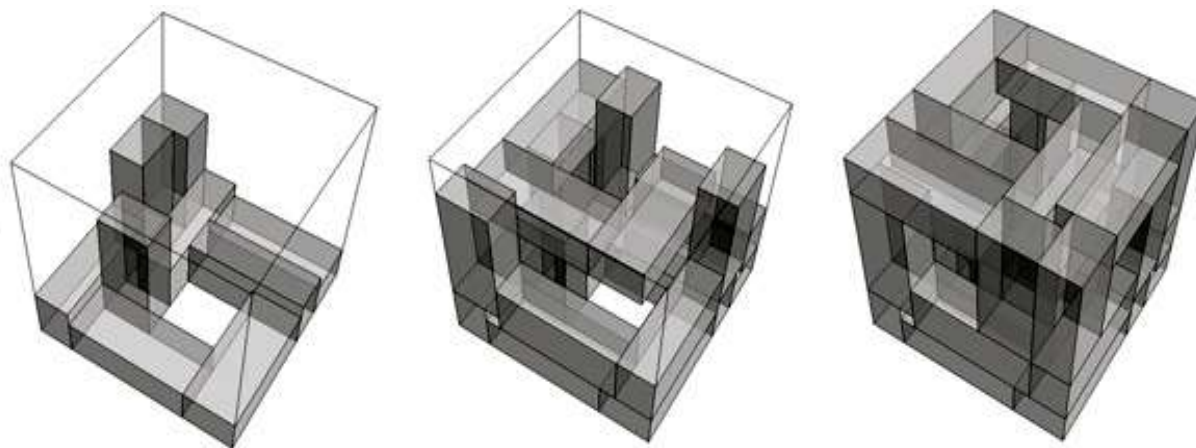# 27 identical cubic elements changing their proportions
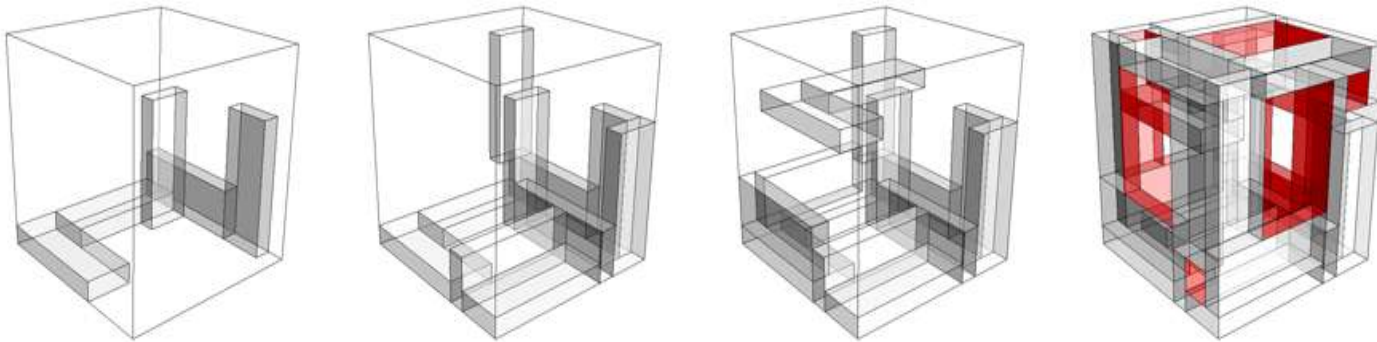
a = 1
b = 2,6
C = 7

a = 1
b = 2,5
C = 6,5

a = 1,2
b = 1,7
C = 4

Some students'results of manually packing boxes in Rhino

Grasshopper

- **Rhino plug-in**
- **Graphical editor**
- **Algorithm editor**
- **Parametric modeling in creation of 3D objects**
- **No need of scripting knowledge**
- **Building form generators**

  from the simple to awe – inspiring
- **The most common professional architectural tool for development of generative concepts**
- **Ability for expert users to extend the system with C# and Visual Basic**
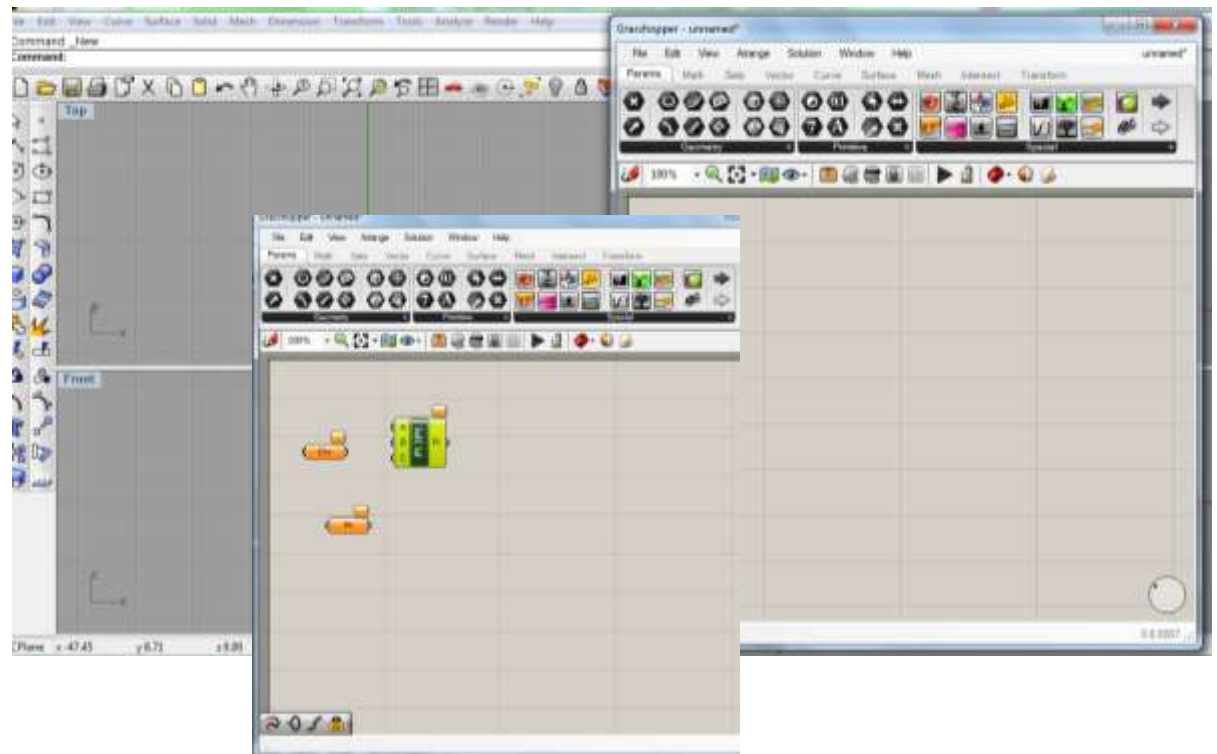
27 identical cubical elements

packing

$a + b + c$
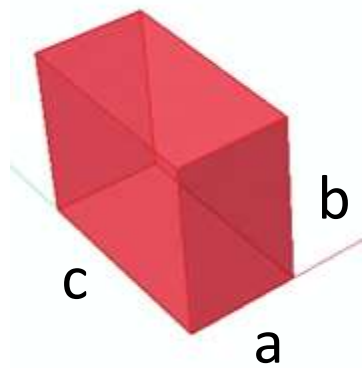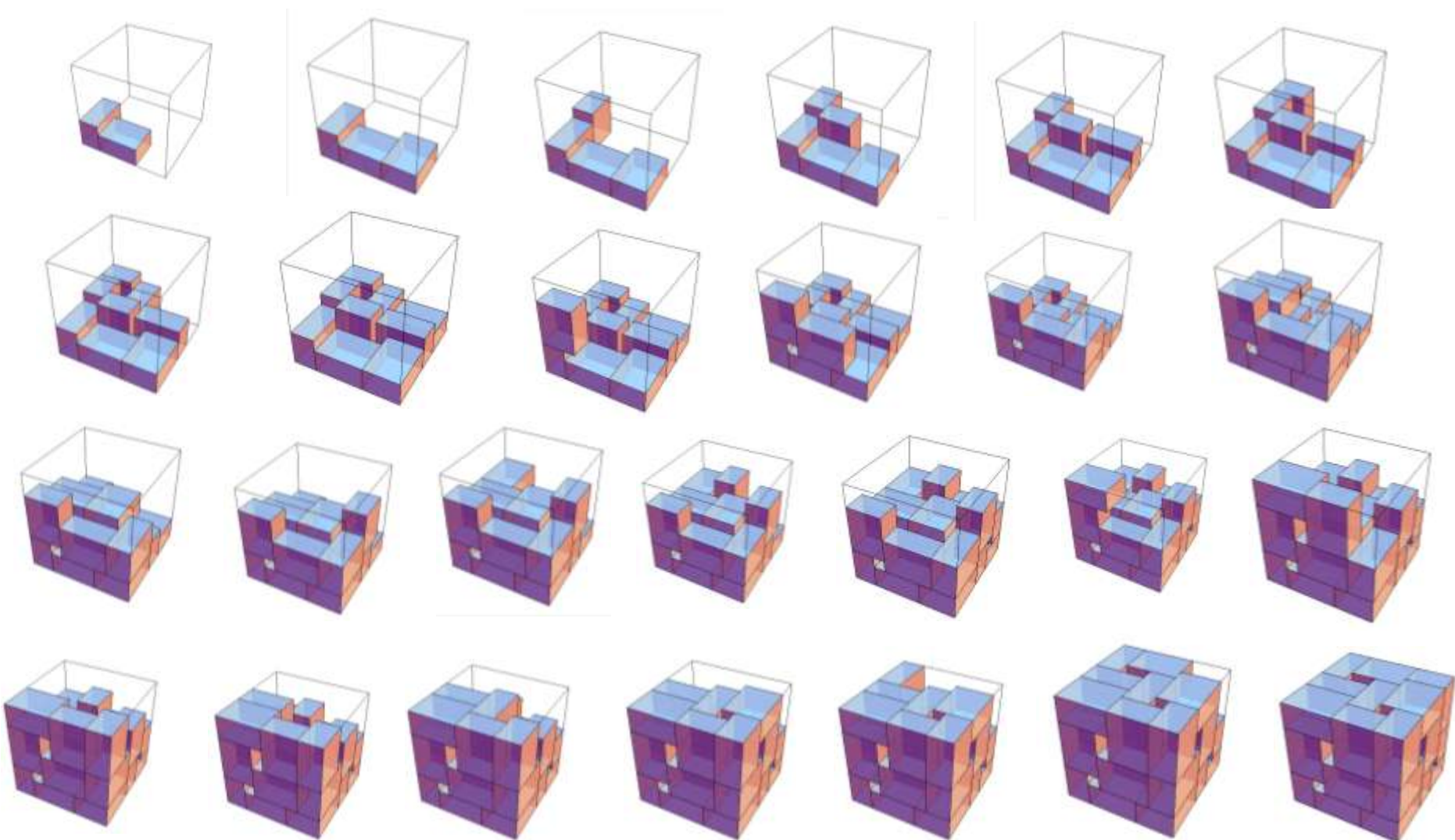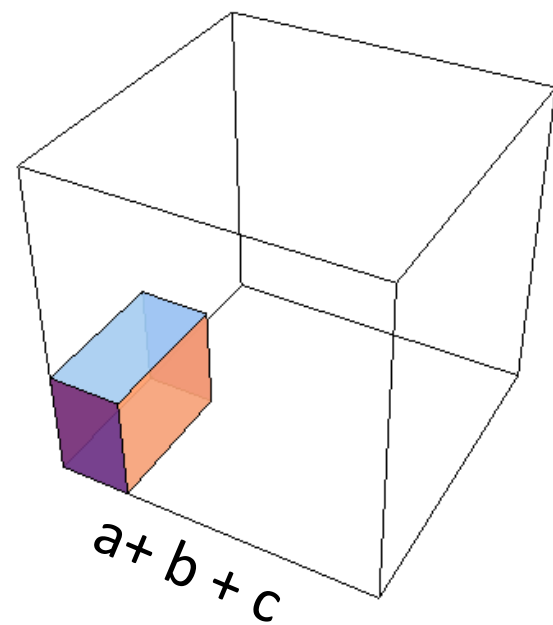
defining conditional relation

$$a < b < c$$

Realization in Grasshopper definition

Decreasing of one of the lowest parameter a

Increasing of the highest parameter c

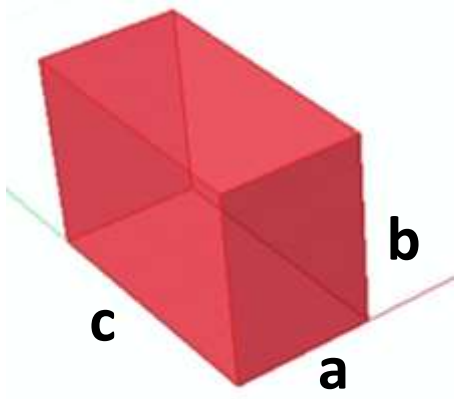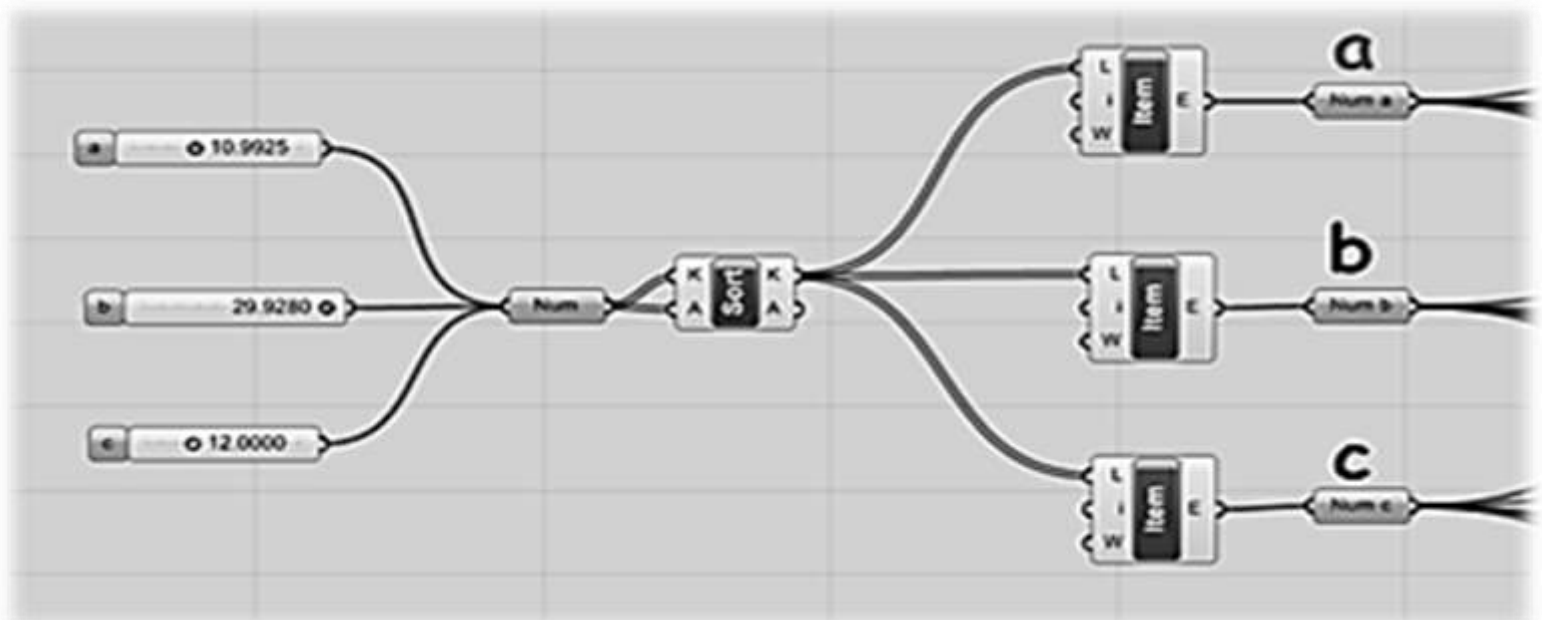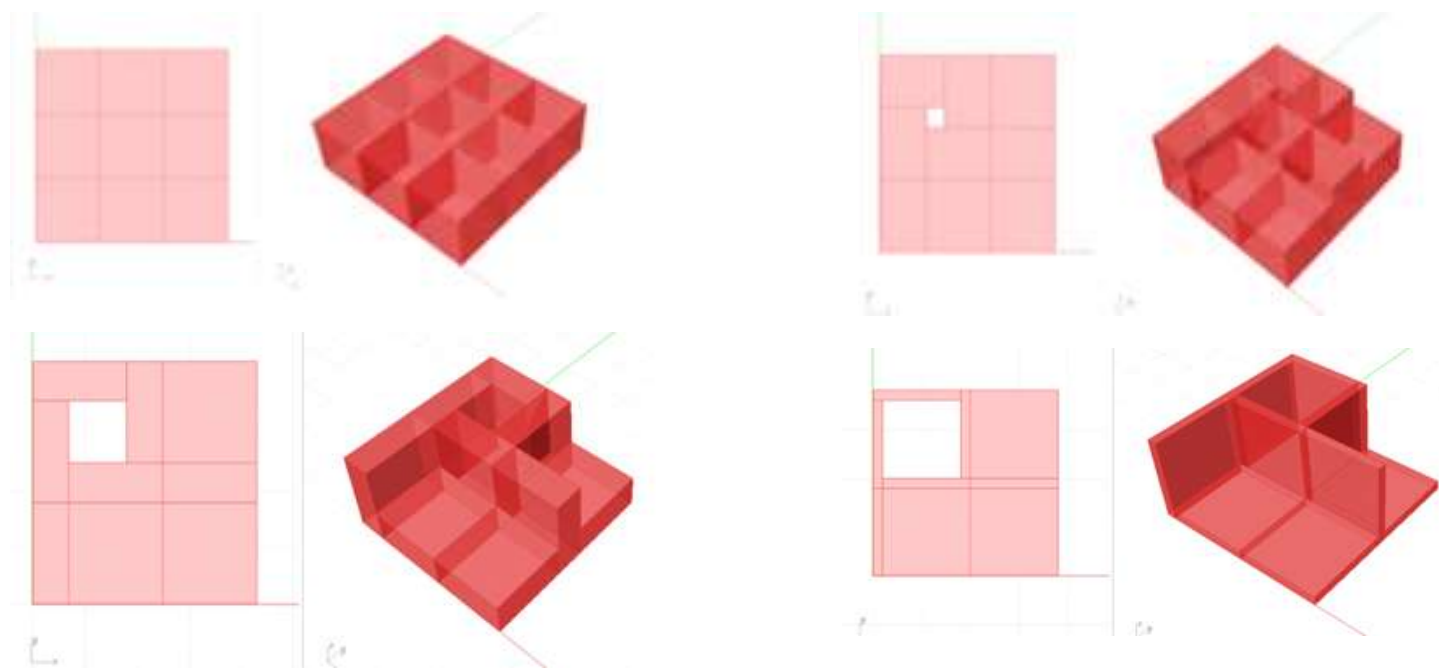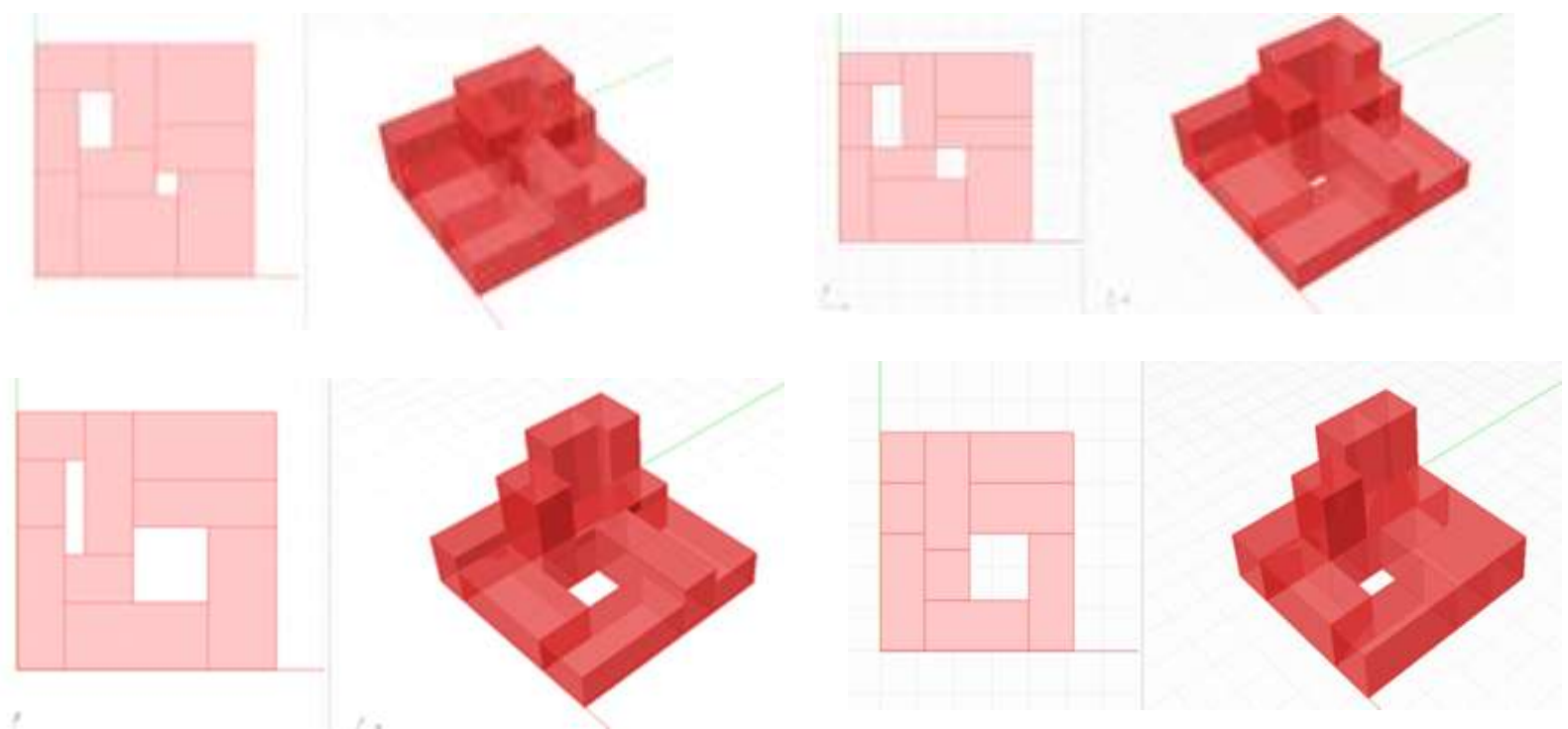| packed element	corner A (x, y, z)	corner B (x, y, z)
1	$(0, 0, 0)$	(a, c, b)
2	$(a, 0, 0)$	$(a + c, b, a)$
3	$(a + c, 0, 0)$	$(a + b + c, c, a)$
4	$(0, c, 0)$	$(a, b + c, a)$
5	$(a, b, 0)$	$(a + b, a + b, c)$
6	$(a + b, c, 0)$	$(a + b + c, a + c, b)$
7	$(0, b + c, 0)$	$(b, a + b + c, c)$
8	$(b, a + b, 0)$	$(a + b, a + b + c, b)$
9	$(a + b, a + c, 0)$	$(a + b + c, a + b + c, a)$

packed element	corner A (x, y, z)	corner B (x, y, z)
10	$(0, 0, b)$	$(b, a, b + c)$
11	$(b, 0, a)$	$(b + c, a, a + b)$
12	$(b + c, 0, a)$	$(a + b + c, c, a + b)$
13	$(0, a, c)$	$(c, a + b, a + c)$
14	(c, a, c)	$(b + c, a + c, a + c)$
15	$(b + c, c, b)$	$(a + b + c, b + c, b + c)$
16	$(0, a + b, c)$	$(b, a + b + c, a + c)$
17	$(b, a + c, b)$	$(a + b, a + b + c, b + c)$
18	$(a + b, b + c, a)$	$(a + b + c, a + b + c, a + b)$

packed element	corner A (x, y, z)	corner B (x, y, z)
19	$(0, 0, b + c)$	$(c, b, a + b + c)$
20	$(c, 0, a + b)$	$(b + c, a, a + b + c)$
21	$(b + c, 0, a + b)$	$(a + b + c, b, a + b + c)$
22	$(0, b, a + c)$	$(c, a + b, a + b + c)$
23	$(c, a, a + c)$	$(a + c, a + c, a + b + c)$
24	$(a + c, b, b + c)$	$(a + b + c, b + c, a + b + c)$
25	$(0, a + b, a + c)$	$(a, a + b + c, a + b + c)$
26	$(a, a + c, b + c)$	$(a + c, a + b + c, a + b + c)$
27	$(a + c, b + c, a + b)$	$(a + b + c, a + b + c, a + b + c)$

Grasshopper Help

Box 2Pt

Create a box defined by two points.

Input parameters:

A *(Point)*
First corner

B *(Point)*
Second corner

P *(Plane)*
Base plane

Output parameters:

B *(Box)*
Resulting box

Matching six numerical lists for packing element's corner in definition

	Ax	Ay	Az	Bx	By	Bz
1	0	0	0	a	c	b
2	a	0	0	a+c	b	a
3	a+c	0	0	a+b+c	c	a
4	0	c	0	a	b+c	a
5	a	b	0	a+b	a+b	c
6	a+b	c	0	a+b+c	a+c	b
7	0	b+c	0	b	a+b+c	c
8	b	a+b	0	a+b	a+b+c	b
9	a+b	a+c	0	a+b+c	a+b+c	a
10	0	0	b	b	a	b+c
11	b	0	a	b+c	a	a+b
12	b+c	0	a	a+b+c	c	a+b
13	0	a	c	c	a+b	a+c
14	c	a	c	b+c	a+c	a+c
15	b+c	c	b	a+b+c	b+c	b+c
16	0	a+b	c	b	a+b+c	a+c
17	b	a+c	b	a+b	a+b+c	b+c
18	a+b	b+c	a	a+b+c	a+b+c	a+b
19	0	0	b+c	c	b	a+b+c
20	c	0	a+b	b+c	a	a+b+c
21	b+c	0	a+b	a+b+c	b	a+b+c
22	0	b	a+c	c	a+b	a+b+c
23	c	a	a+c	a+c	a+c	a+b+c
24	a+c	b	b+c	a+b+c	b+c	a+b+c
25	0	a+b	a+c	a	a+b+c	a+b+c
26	a	a+c	b+c	a+c	a+b+c	a+b+c
27	a+c	b+c	a+b	a+b+c	a+b+c	a+b+c
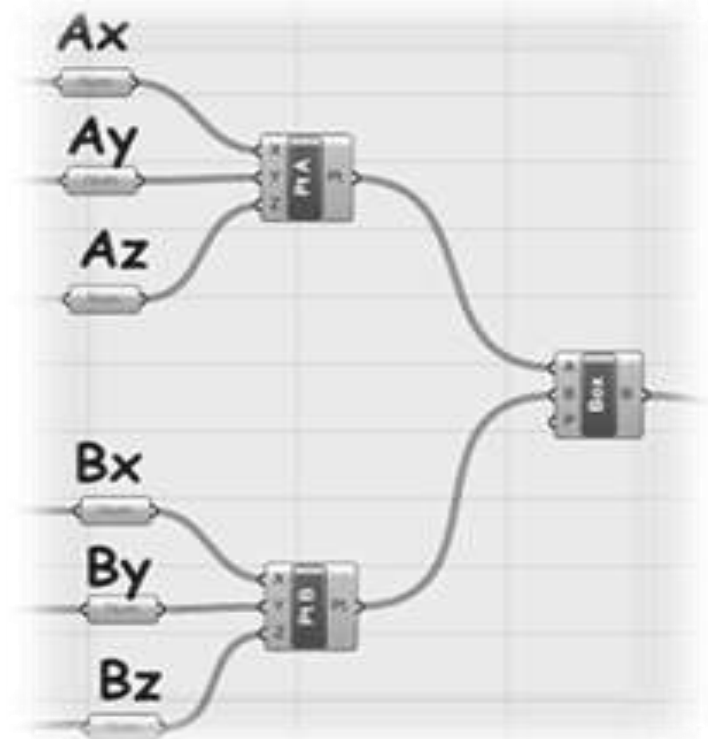
Final possible effects of initial Grasshopper definition
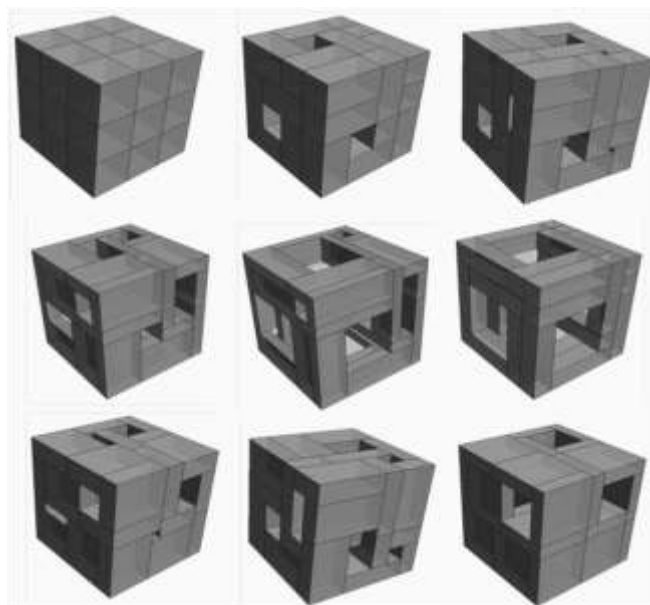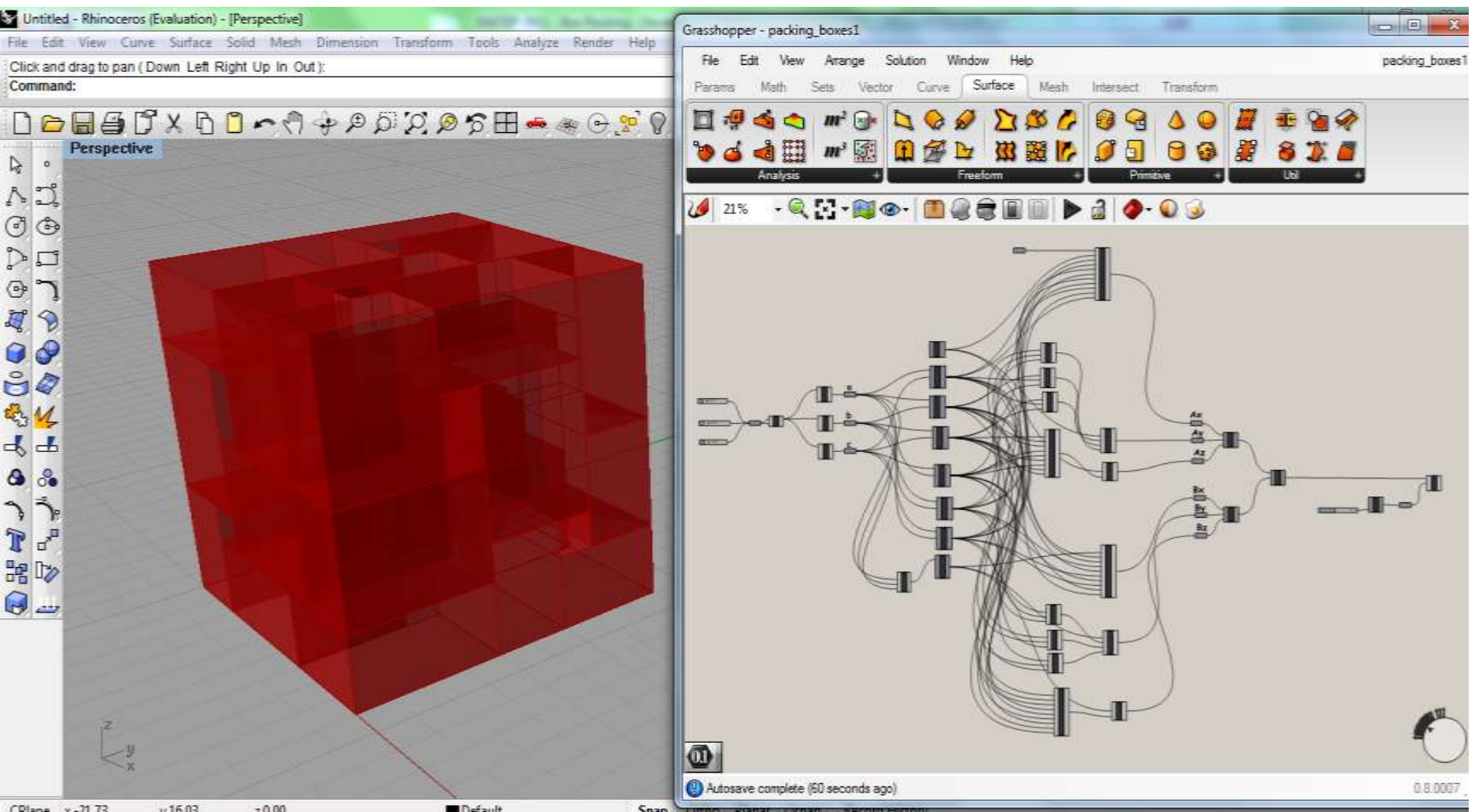
Modification and extending of initial definition

1. Varying number of backed elements
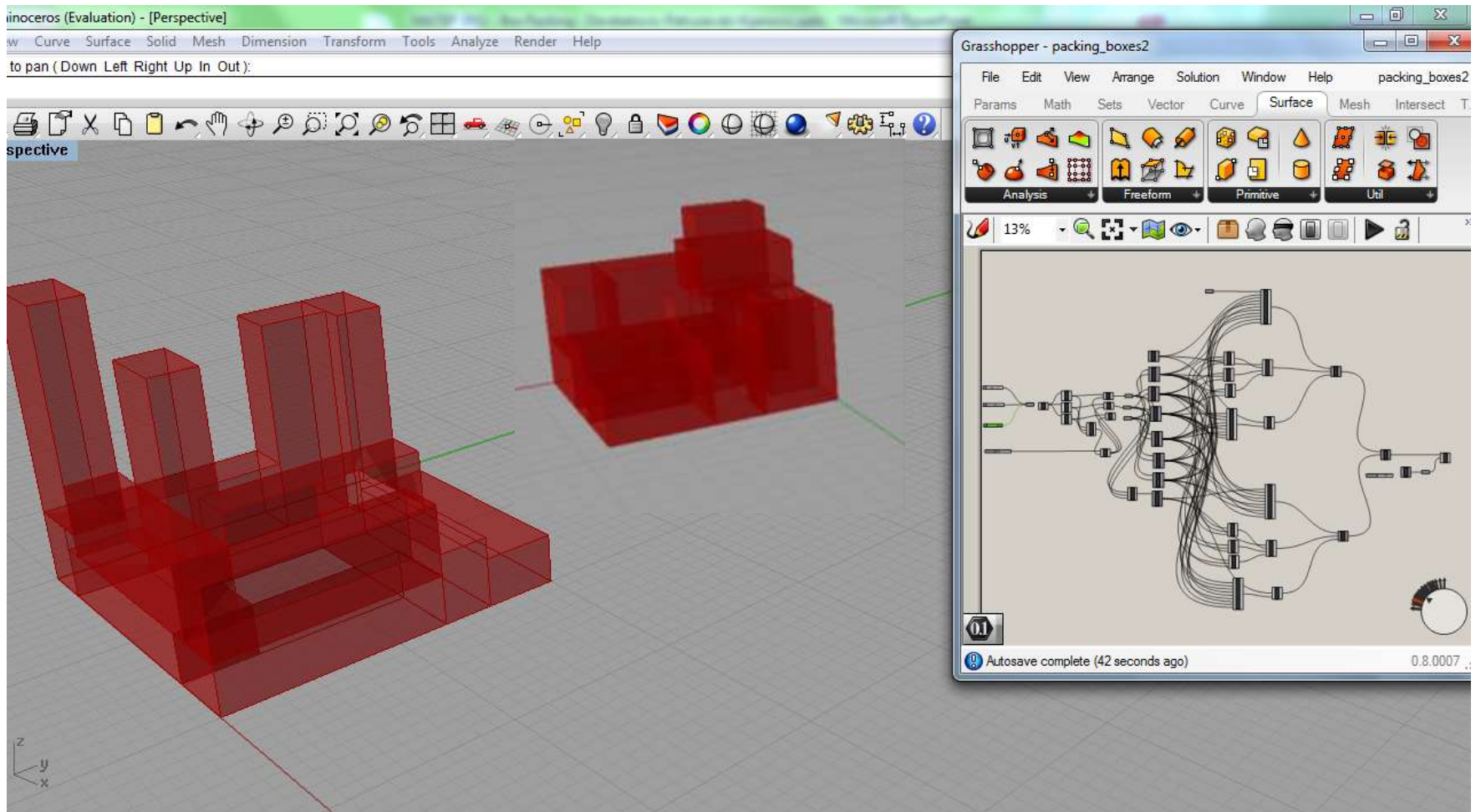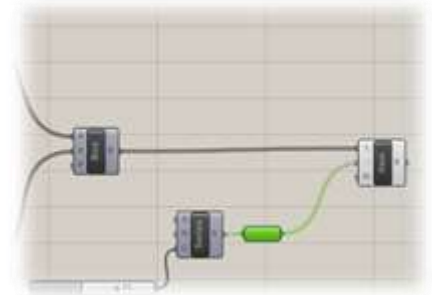
Modification and extending of initial definition

2. Varying the size of body keeping measure a+b+c
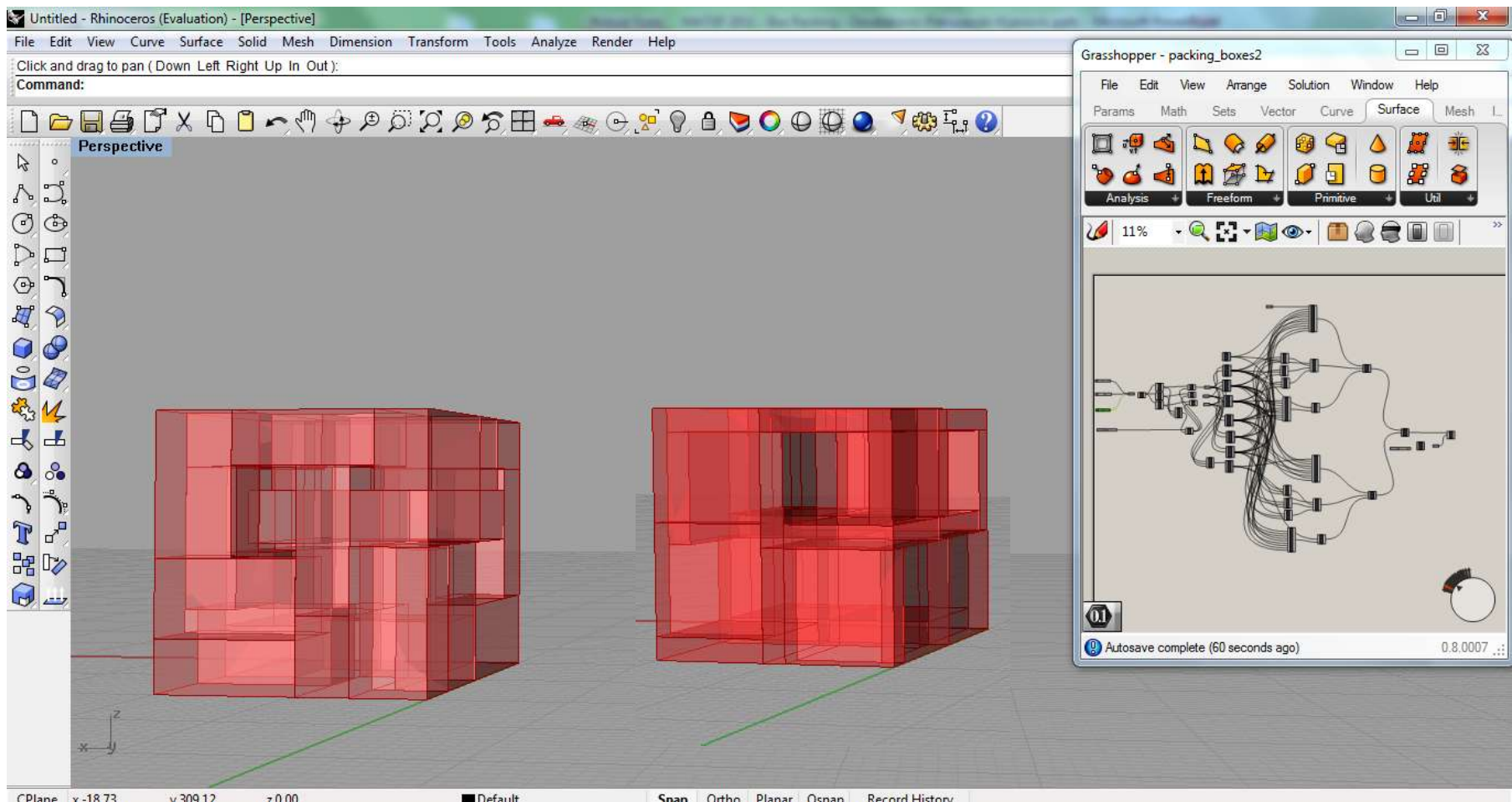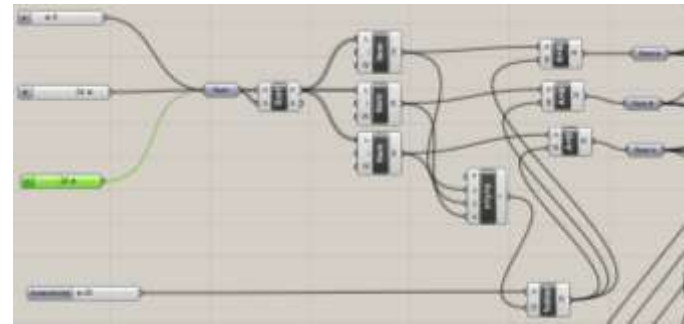
Modification and extending of initial definition

2. Multiplication, scaling and distribution along curve
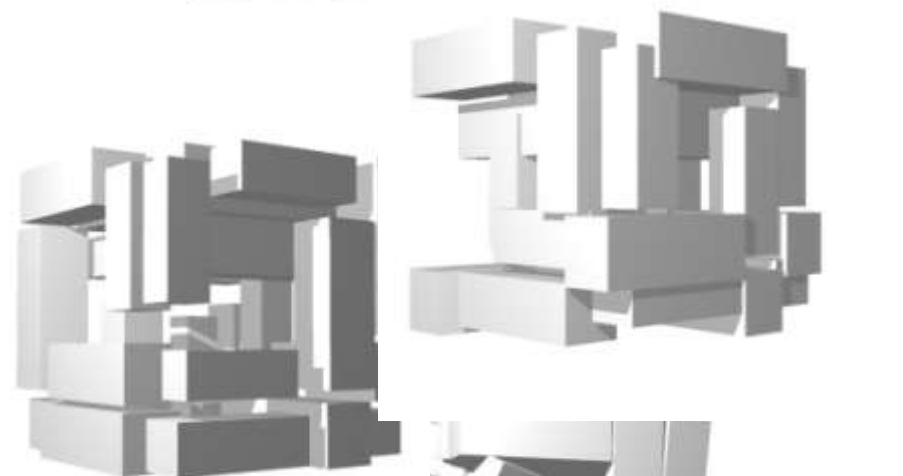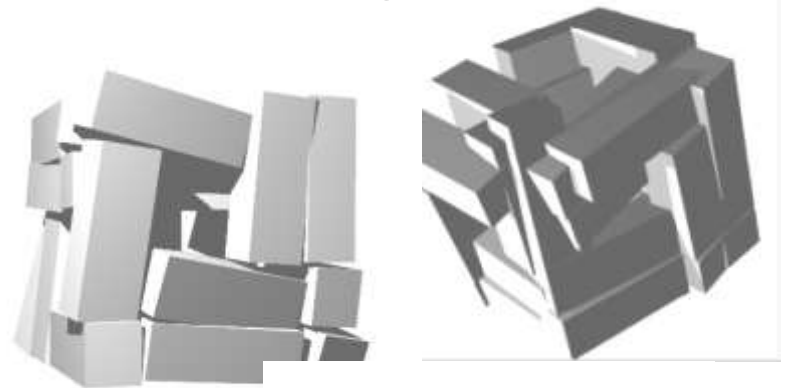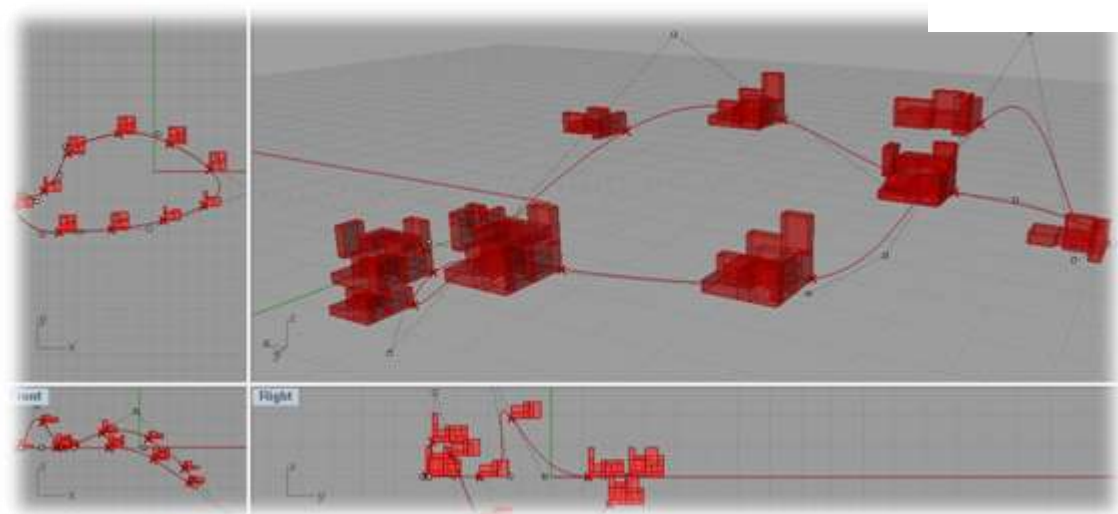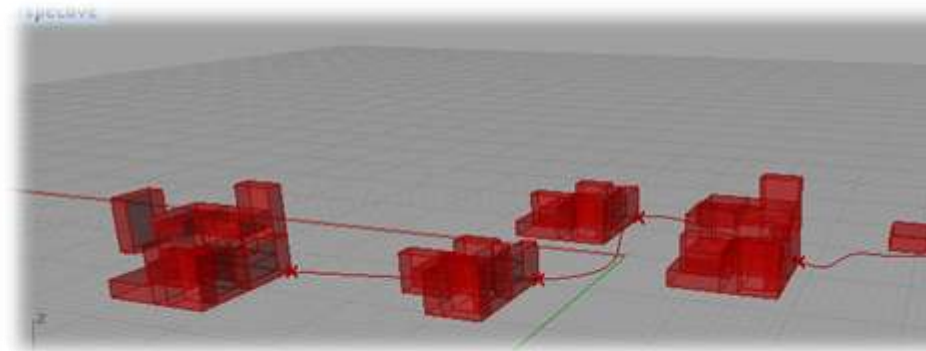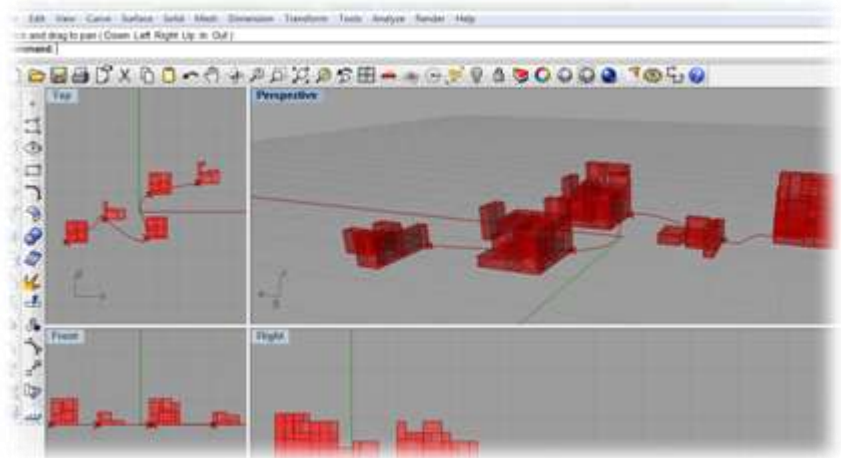
**> 3D Visual Communications:
Box Packing – Exercises**

> Box Packing: The Wolfram Demonstration

> Box Packing: Rhino Modeling exercise

> Box Packing: Analogue model 01

> Box Packing: Materialization

> Box Packing: Lighting

> Box Packing: Variations
 (using the Grasshopper definition)
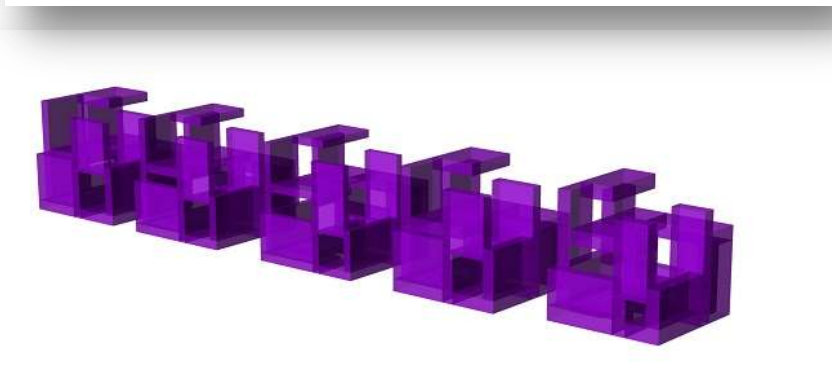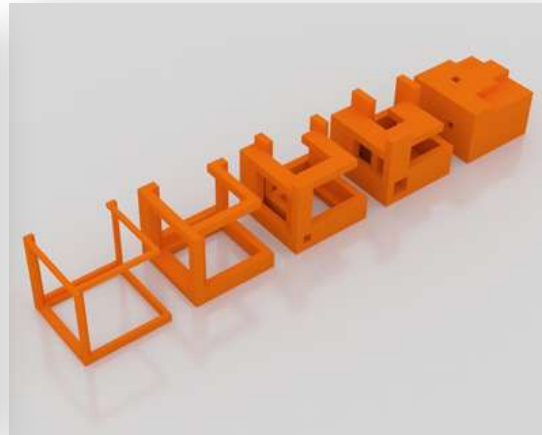
> Box Packing: Architectural object

> Box Packing: Analogue model 2
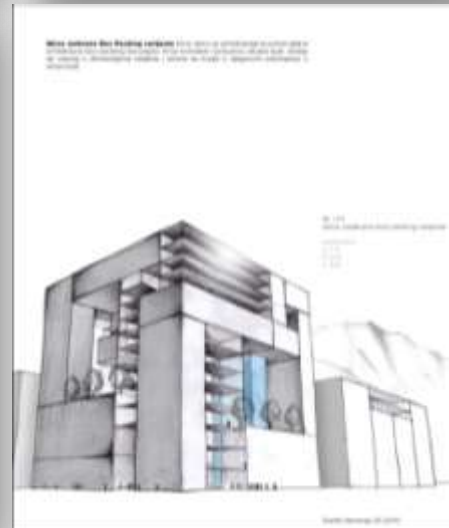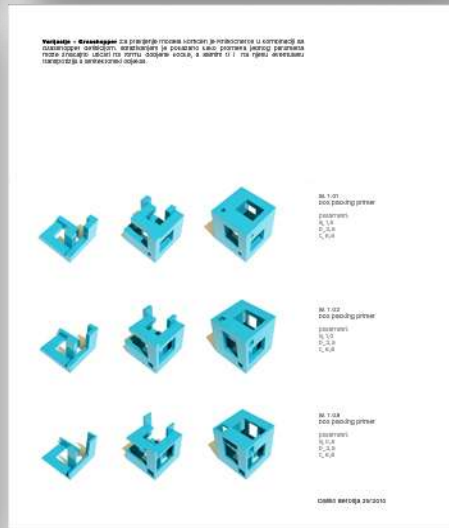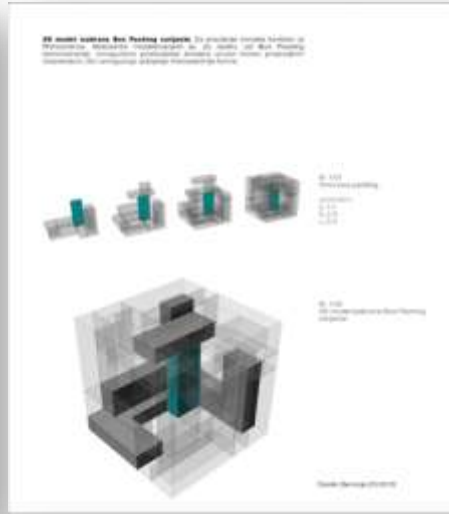
> Box Packing: Urban complex
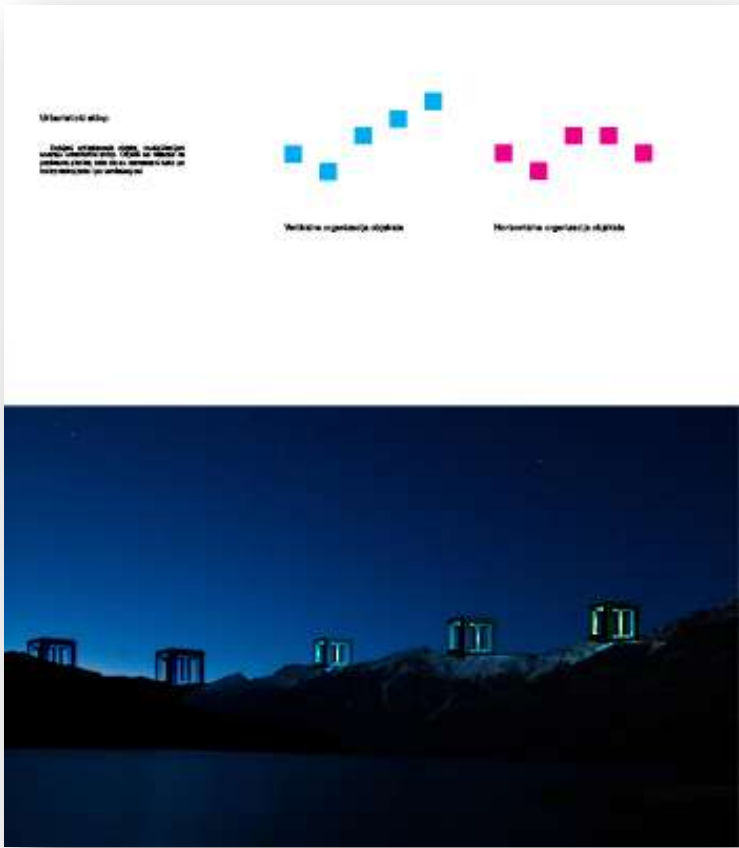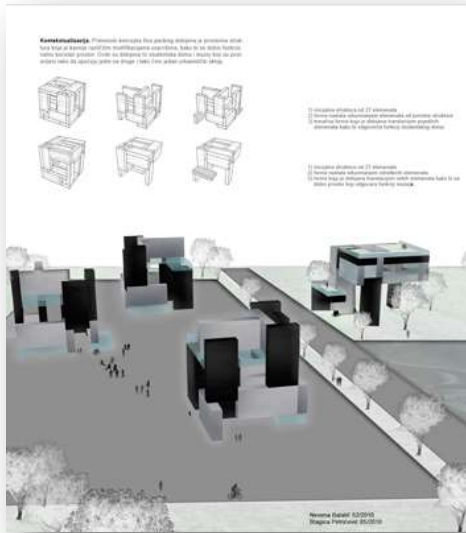
> **3D Visual Communications:**
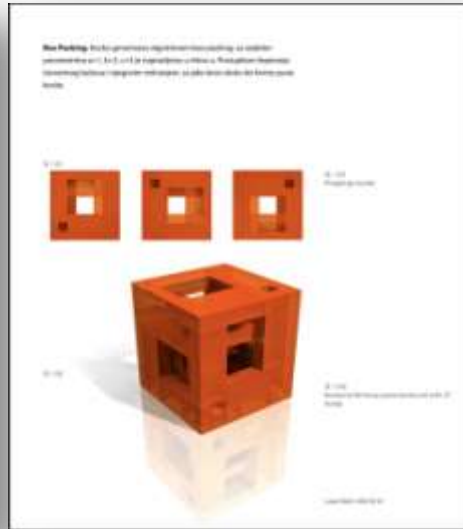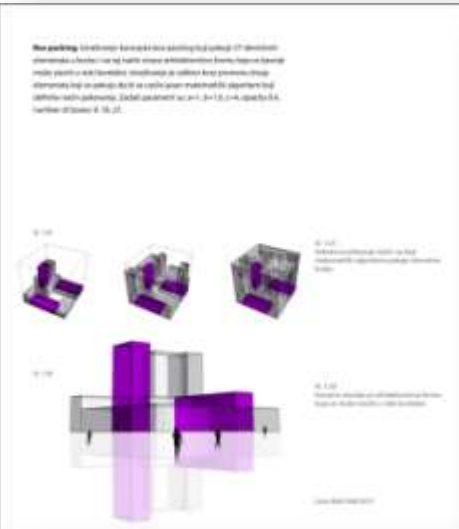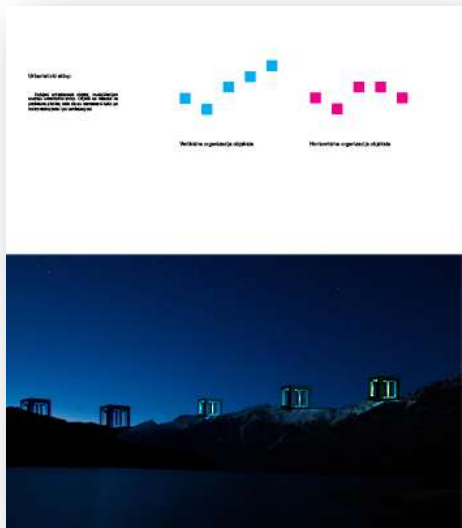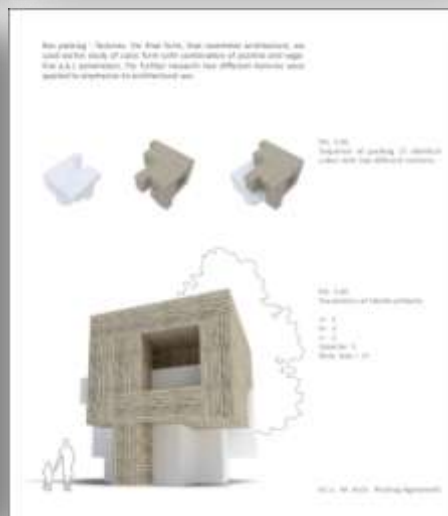 **Box Packing - Students' collections**

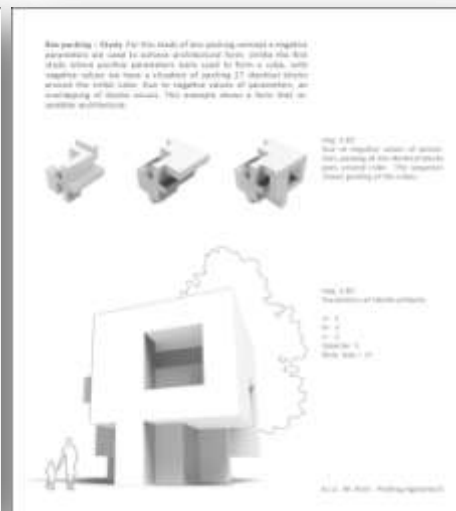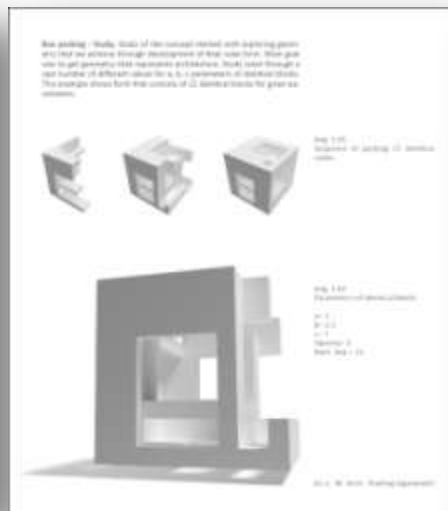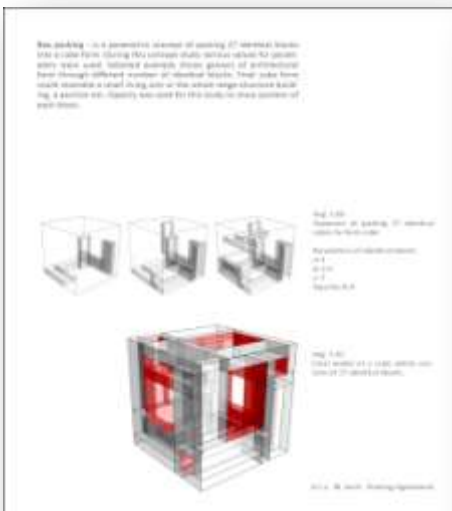> collection: student Danilo Beronja
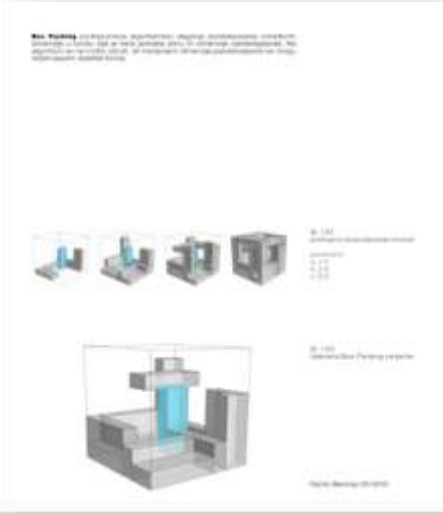
> collection: student Lazar Belic

> collection: Predrag Agatonovic, M.Arch.

**> Preparations for Spring semester 2011/12
The Szilassi Polyhedron**

> Preparation for the spring semester 2011/12
 The Szilassi polyhedron