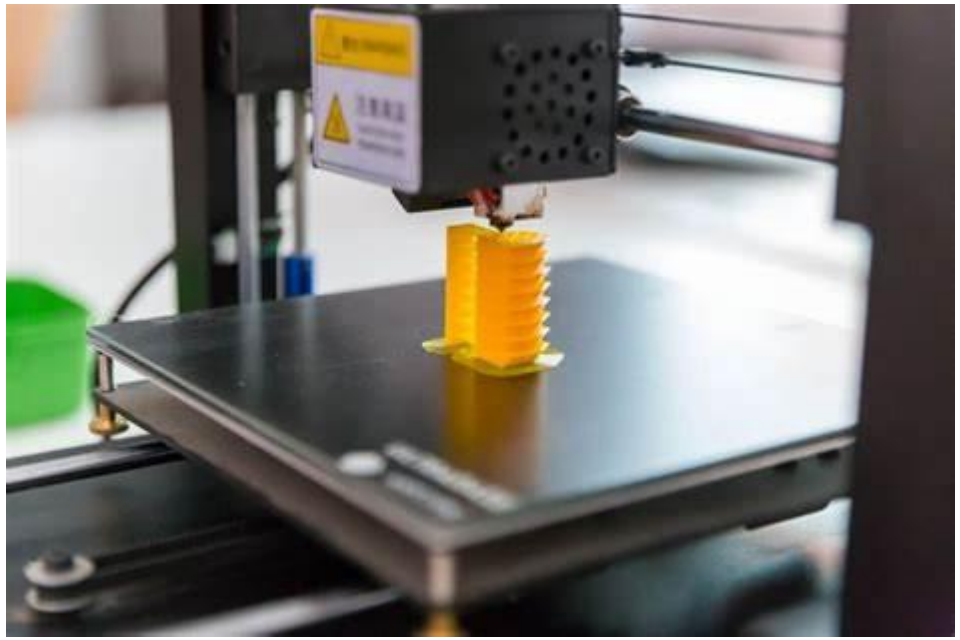
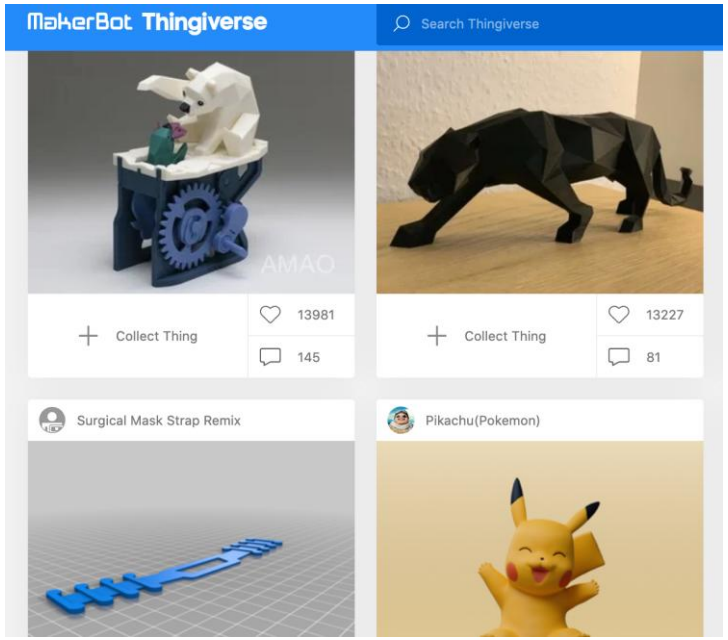
ConTextural: A Toolpath-Based Texture Editing Tool for Extrusion 3D Printers

Daphna Kaplan, *Mirela Ben-Chen*, *Yoav Sterman*

Technion Institute of Technology

Modeling




MakerBot Thingiverse
Search Thingiverse
Collect Thing
13981
145
Collect Thing
13227
81
Surgical Mask Strap Remix
Pikachu(Pokemon)

Textures

- Textures are crucial in **design**
- Textures can alter **physical** properties
- **Functional** properties

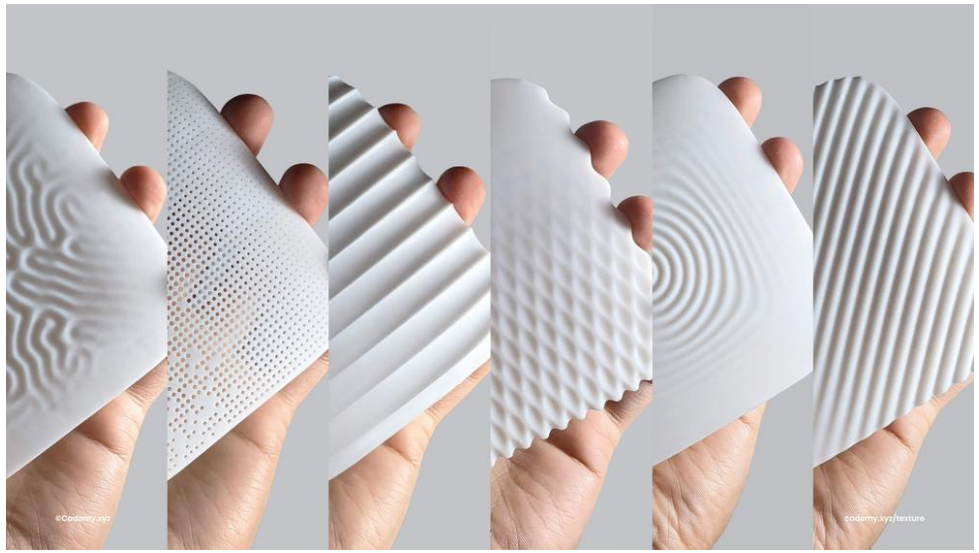
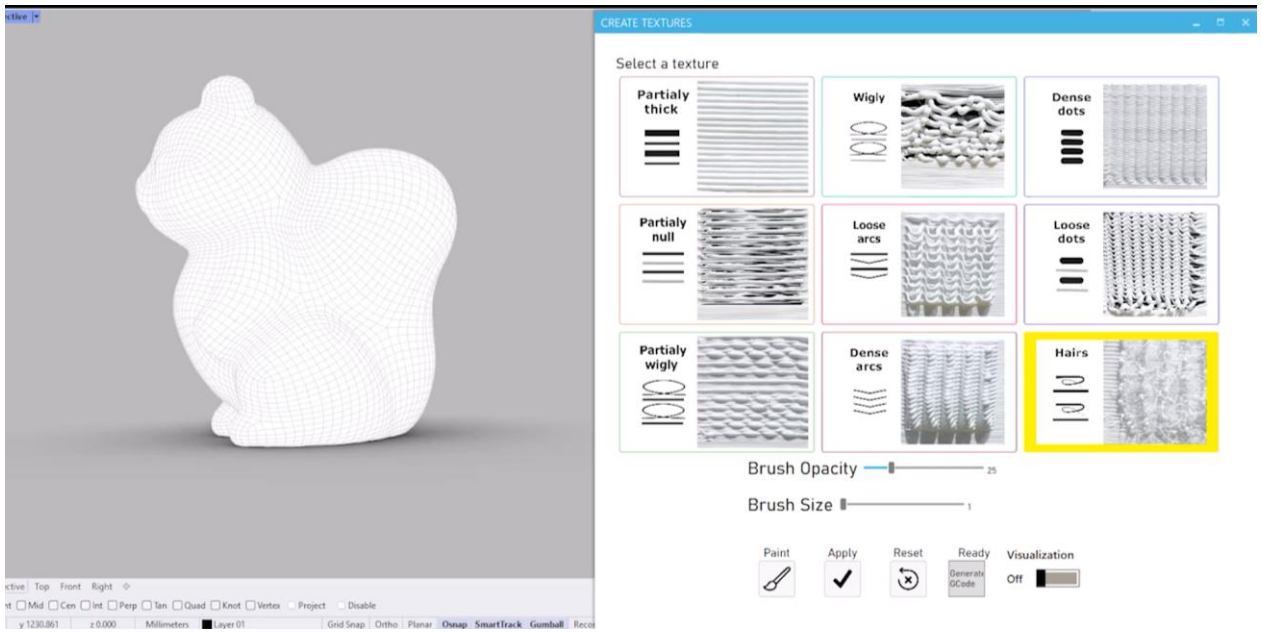
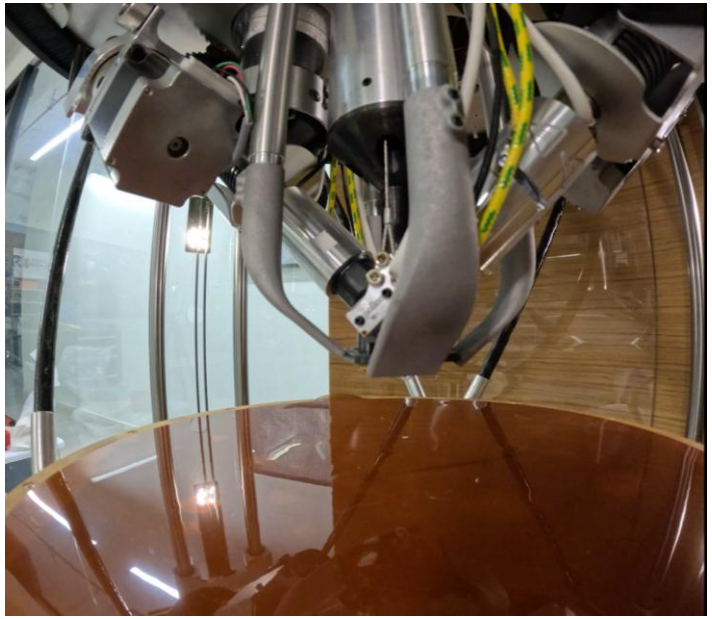


Image source: https://www.cademy.xyz/learn/why-grasshopper-3d-is-essential-for-industrial-designers

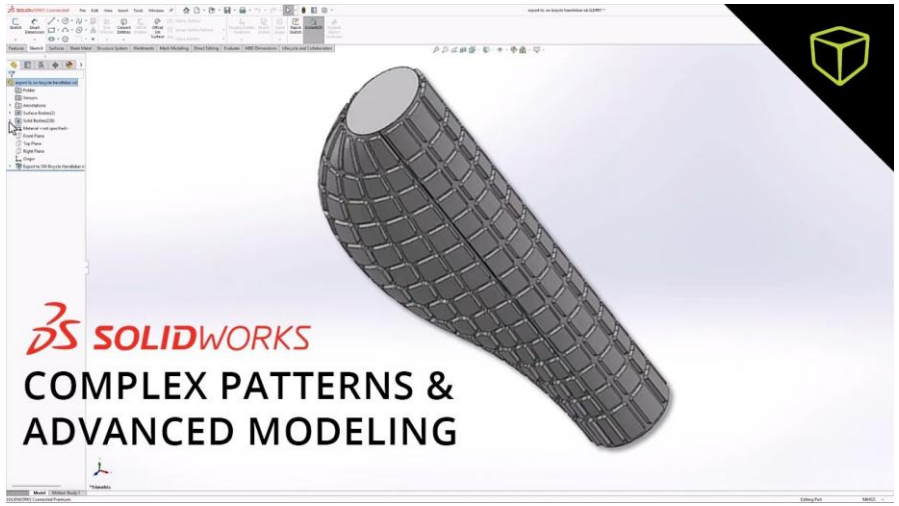
ConTextural



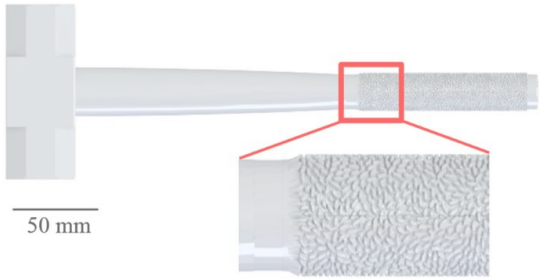


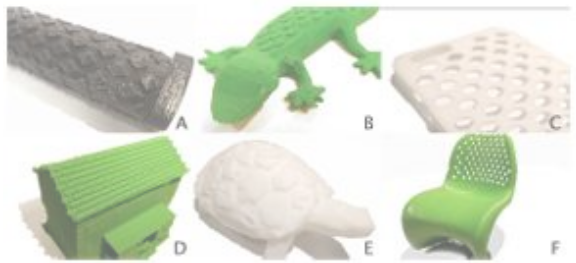
Textures using CAD

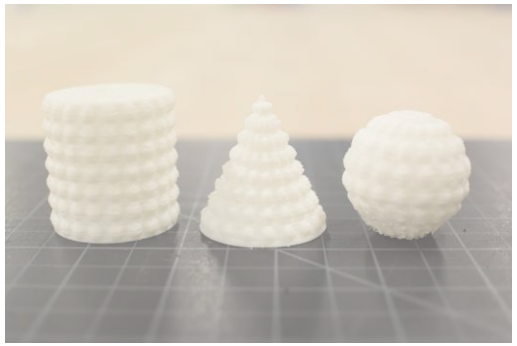
CAD software



2D Input

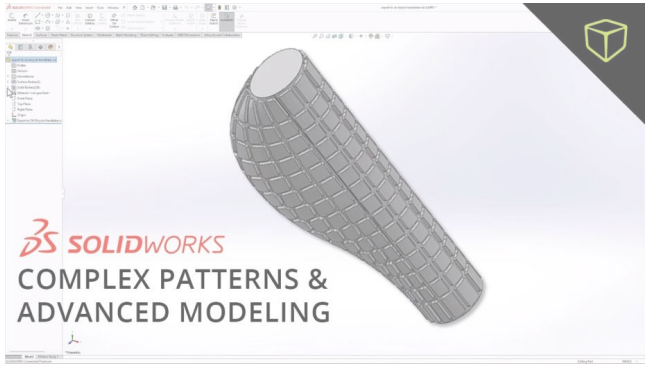




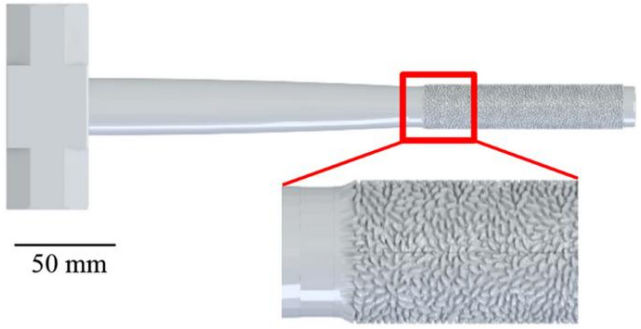


Textures using CAD

CAD software



2D Input



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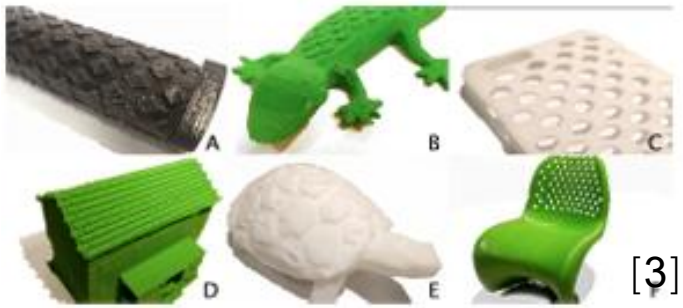

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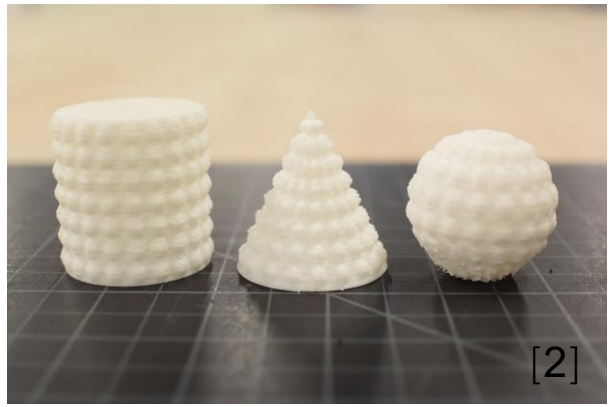


[2]

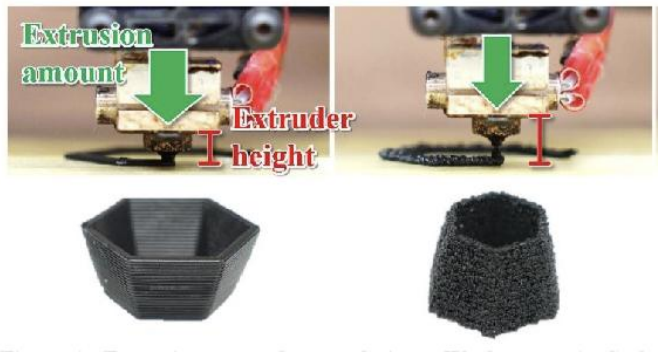
[1] Bhupesh Verma, Omid Zarei, Song Zhang, and Johannes Henrich Schleifenbaum. 2022. Development of texture mapping approaches for additively manufacturable surfaces. Chinese Journal of Mechanical Engineering 35, 1 (2022).
[2] Cesar Torres, Tim Campbell, Neil Kumar, and Eric Paulos. 2015. Hapticprint: Designing feel aesthetics for 3D printing. In UIST 2015 - Proceedings of the 28th Annual ACM Symposium on User Interface Software and Technology.
[3] Ryo Suzuki, Koji Yatani, Mark D. Gross, and Tom Yeh. 2018. Tabby: Explorable Design for 3D Printing Textures.

CAD vs CAM

Lipton and Lipson, 2016, 3D Printing Variable Stiffness Foams Using Viscous Thread Instability

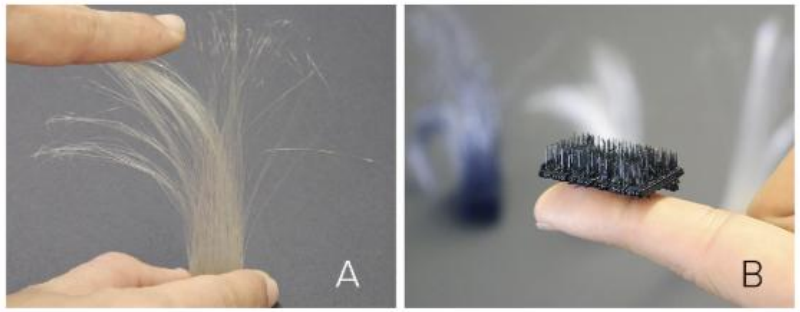
Textures using CAM

Techniques



Takahashi, Haruki, and Homei Miyashita. "Expressive fused deposition modeling by controlling extruder height and extrusion amount."

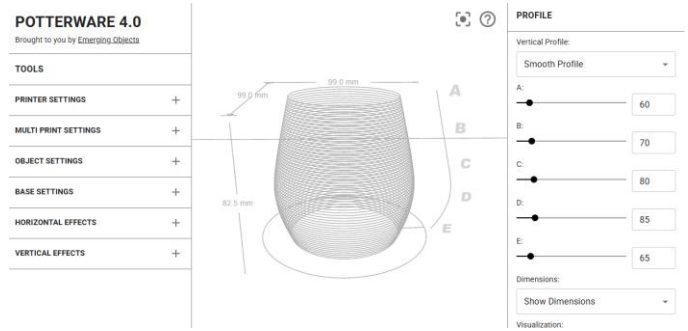
Paul O'Dowd, Stephen Hoskins, Peter Walters, Adrian Geisow, "Modulated Extrusion for Textured 3D Printing"



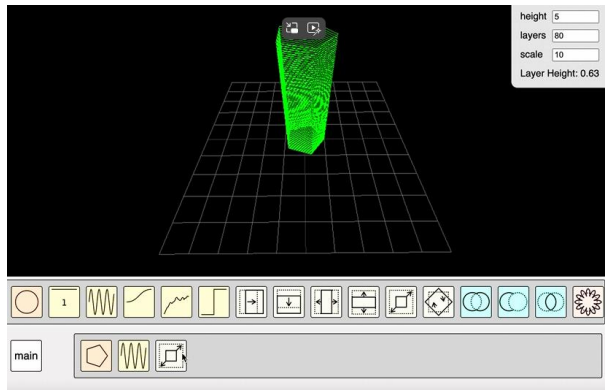
Laput, Gierad, Xiang'Anthony Chen, and Chris Harrison. "3D printed hair: Fused deposition modeling of soft strands, fibers, and bristles."

Textures using CAM

Layout

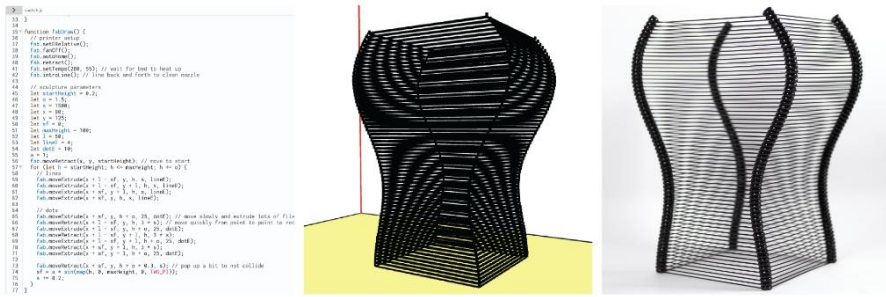


Ronald Rael. 2020. PotterWare by Emerging Objects

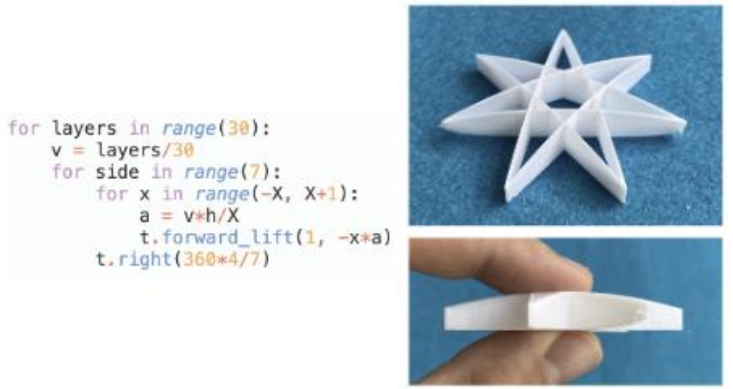


Leo McElroy and Lingdong Huang. 2023. PotScript: a visual grammar for sculpting with functions.

Coding



Blair Subbaraman and Nadya Peek. 2022. p5.fab: Direct Control of Digital Fabrication Machines from a Creative Coding Environment



Franklin Pezutti-Dyer and Leah Buechley. 2022. Extruder-Turtle: A Library for 3D Printing Delicate, Textured, and Flexible Objects.

Gap

Toolpath editing is **hard** to do,

even for users with experience in 3D printing and coding

Gap

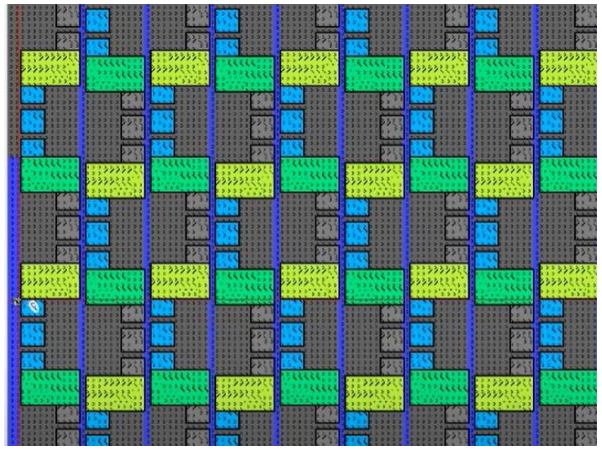
- Working with existing models
- Accessing local features
- Modifying the Toolpath requires knowledge

Solution

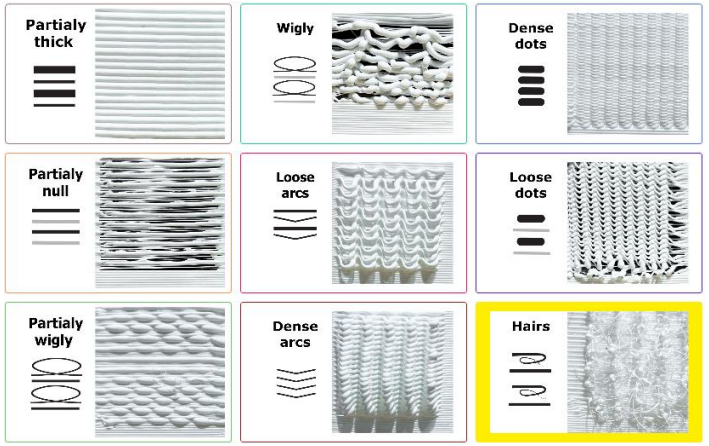
- A simple **interface** for toolpath manipulation
- **Modular framework** with access to numerous textures
- Give **visual** feedback

Solution

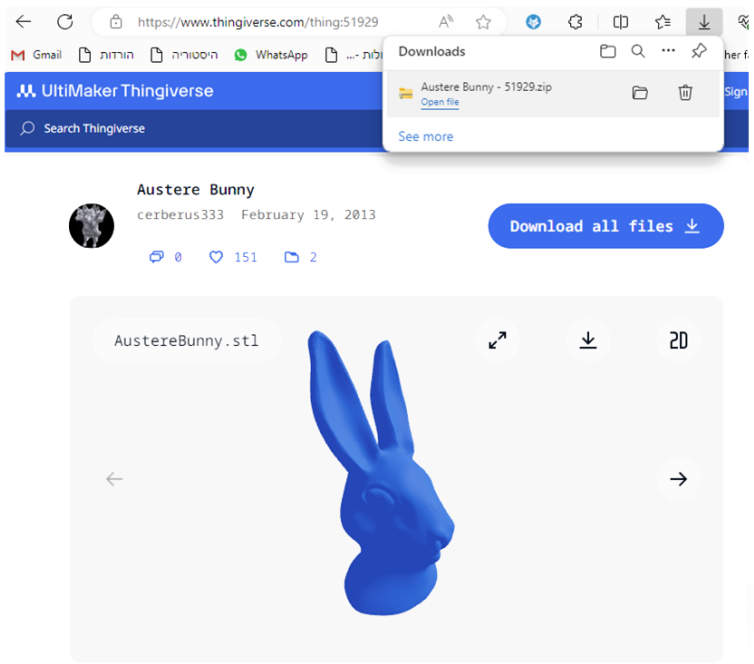
Digital Knitting Yarn



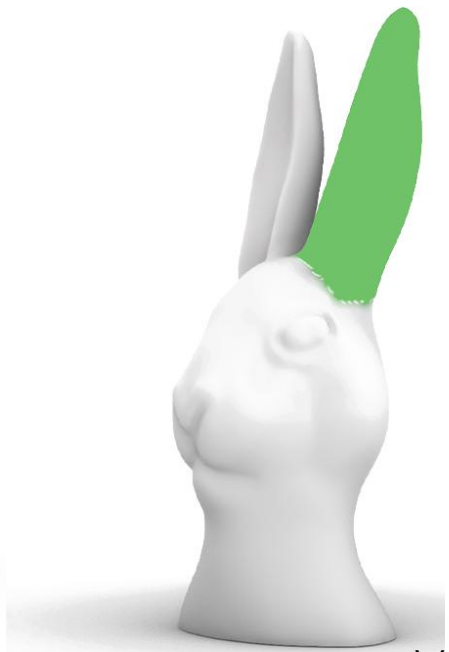
3D Printing Filament



Workflow



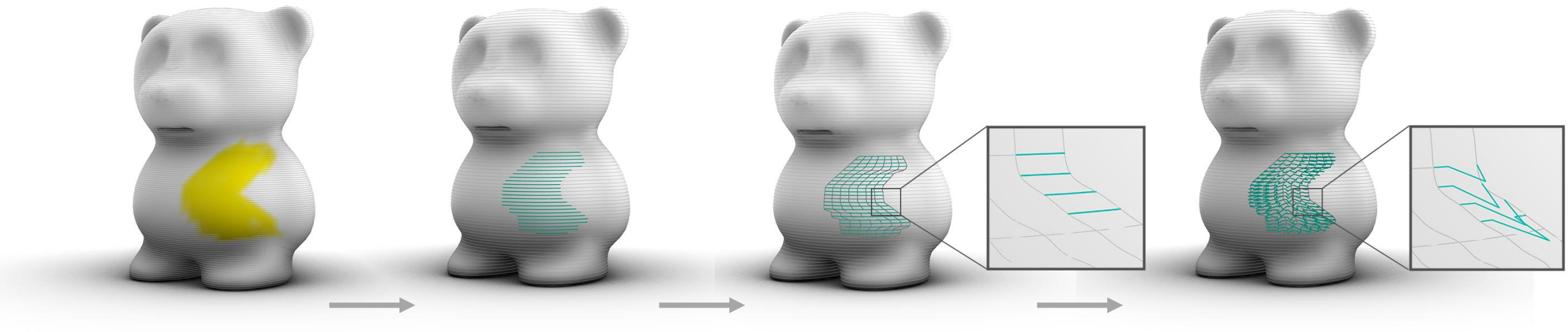
Get Model



Color

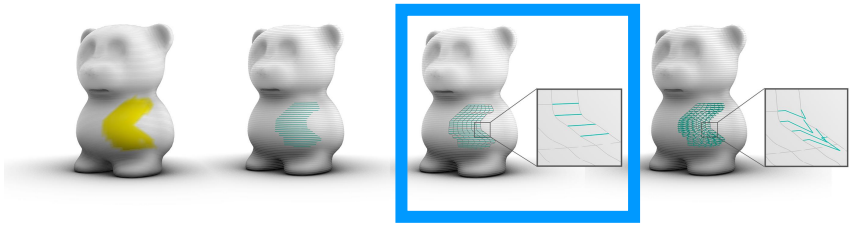
V

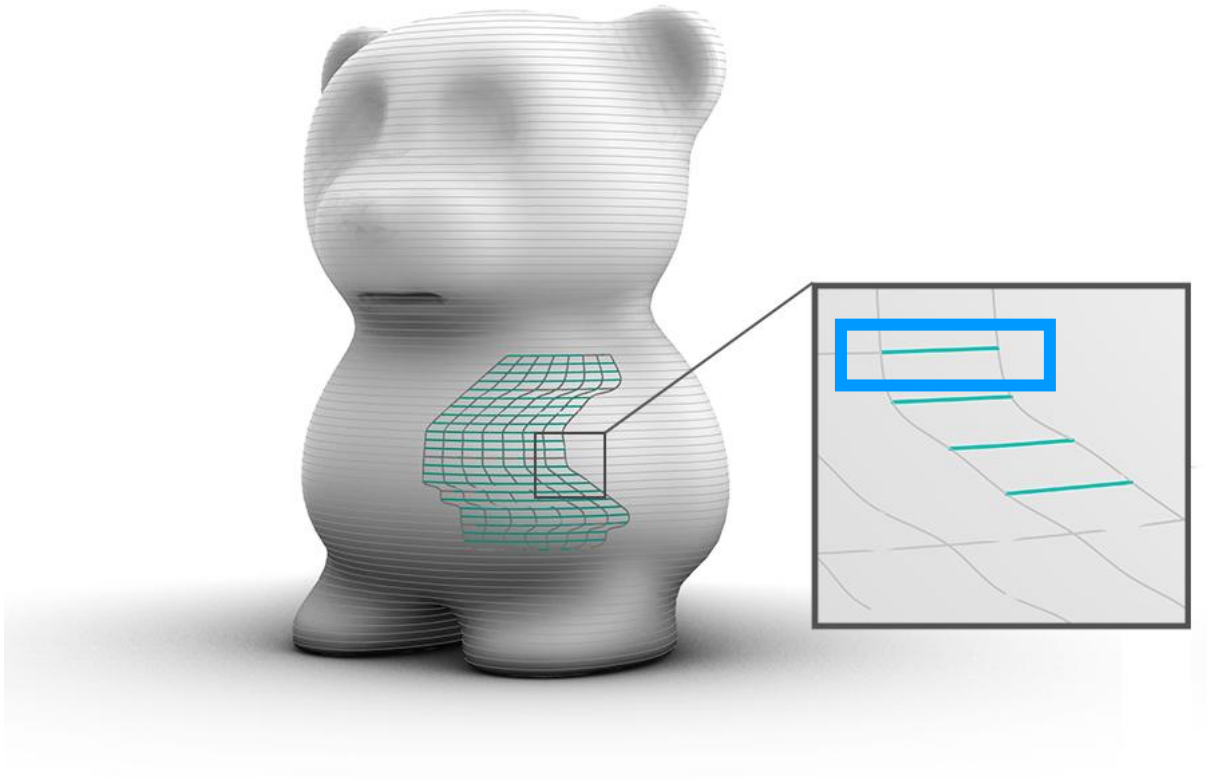
Workflow



Segment

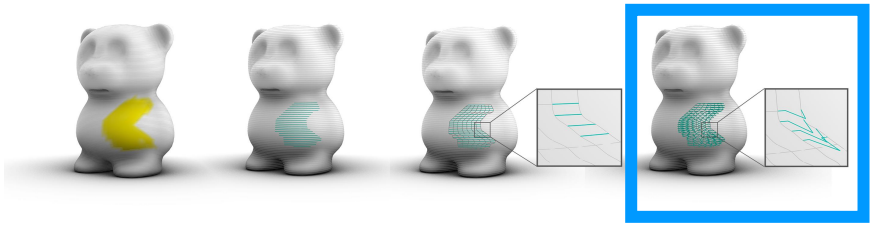
A single curve in a structure, which is a small sub-curve of an original iso-z curve of the model.

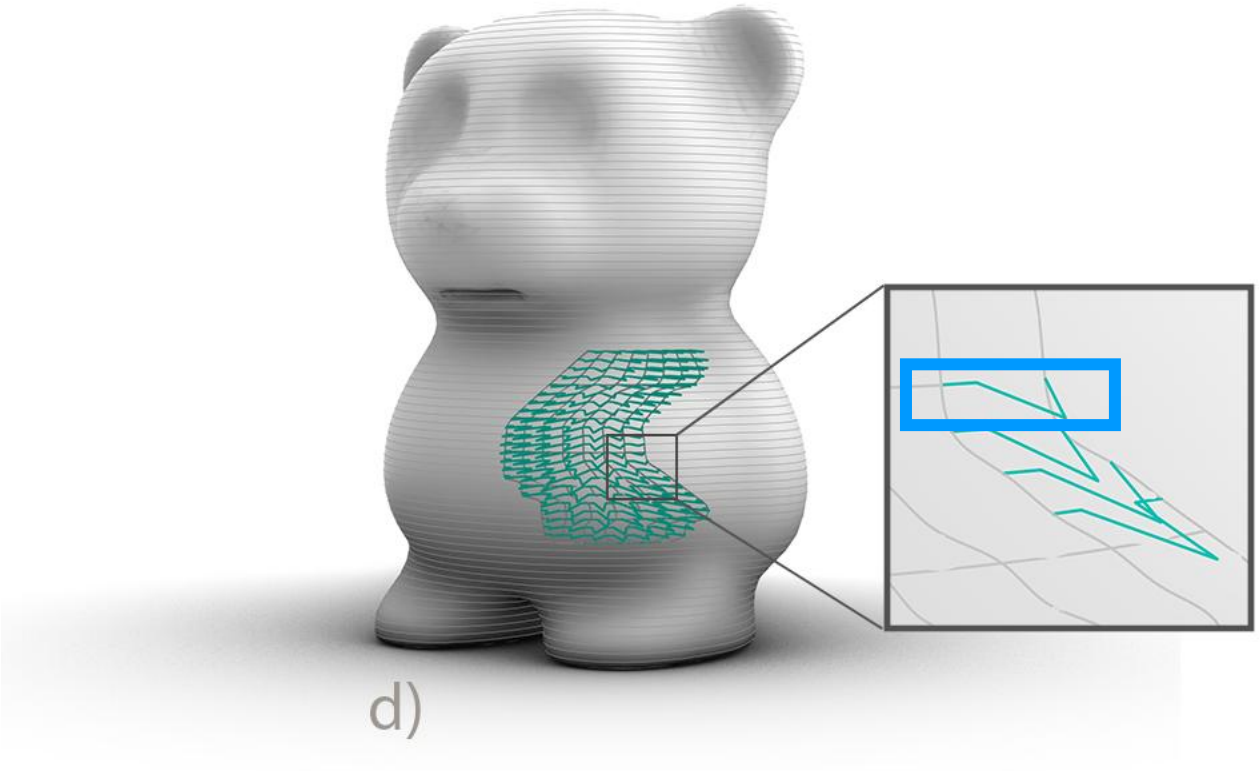




Primitive

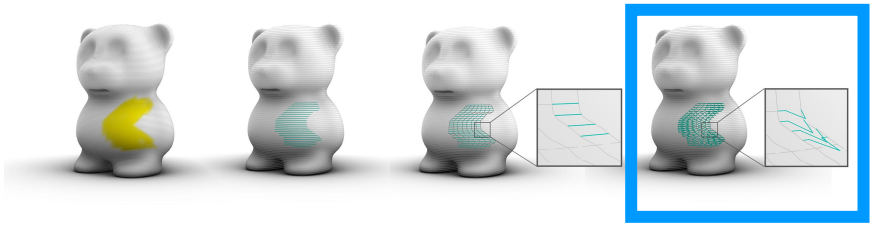
A geometric and printing parameter manipulation on a segment.

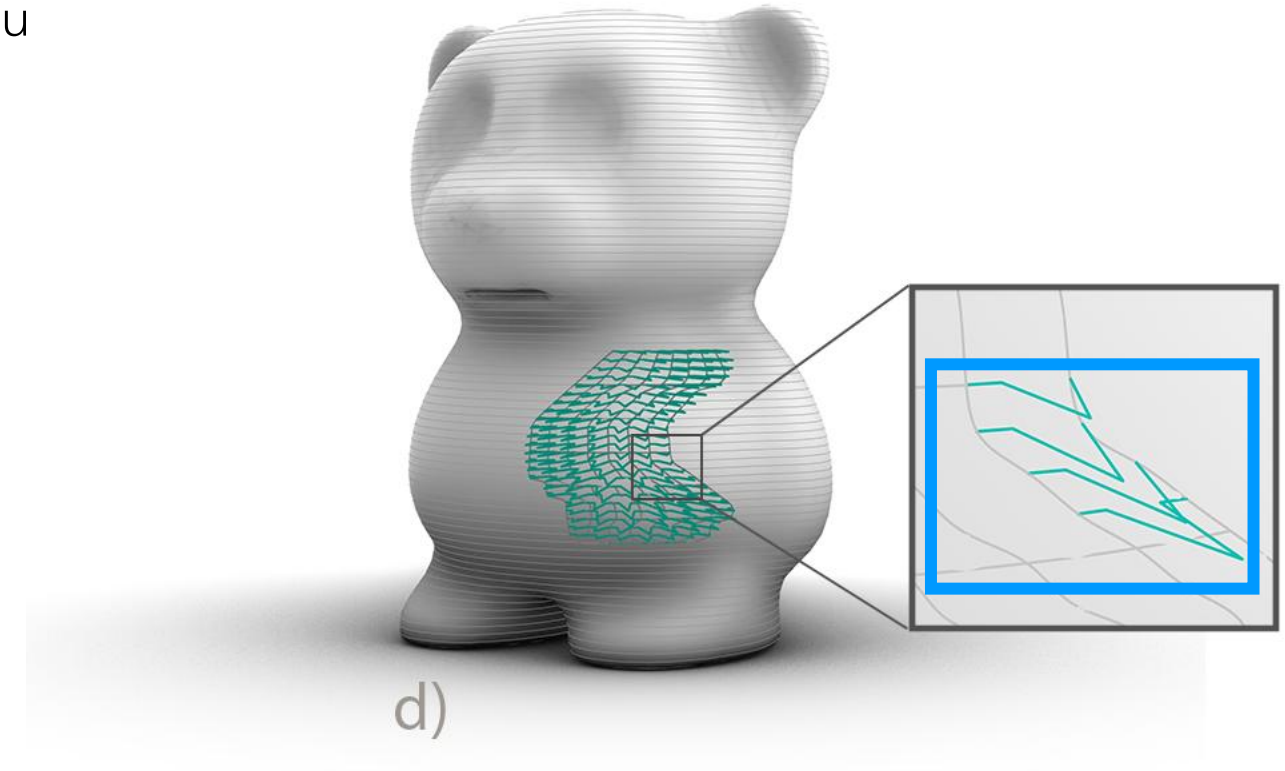




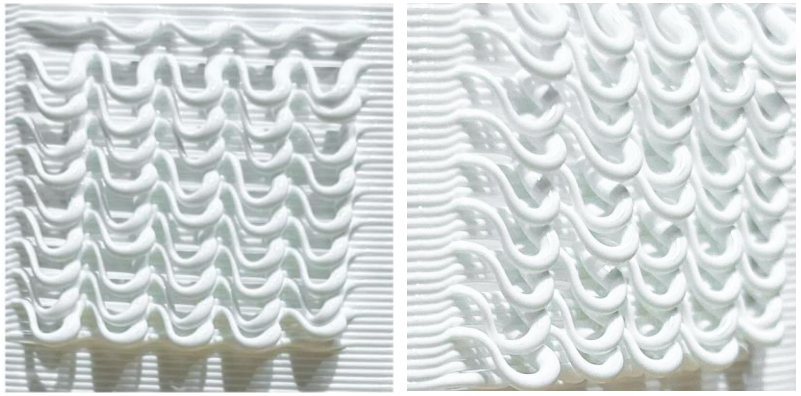
Structure

An ordered list of paired segments an primitives that together form the textu

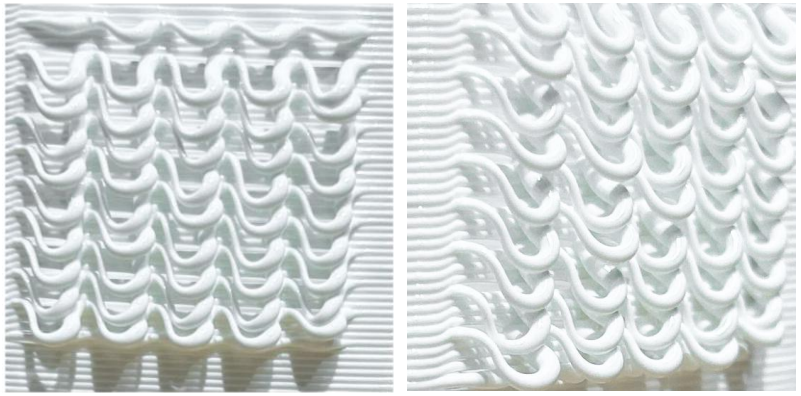




Structure Example: Loose Arcs

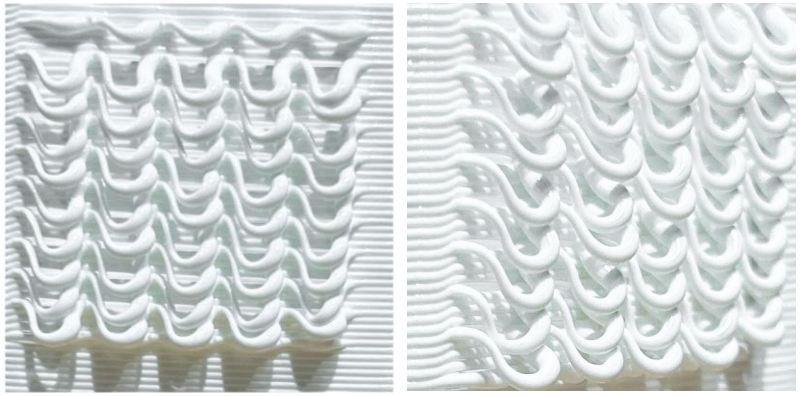


Structure Example: Loose Arcs



4 Segments

Structure Example: Loose Arcs

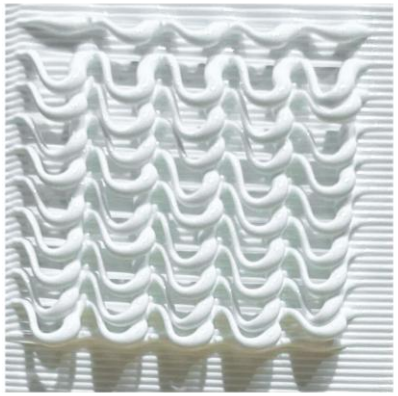


4 Segments

Primitives:

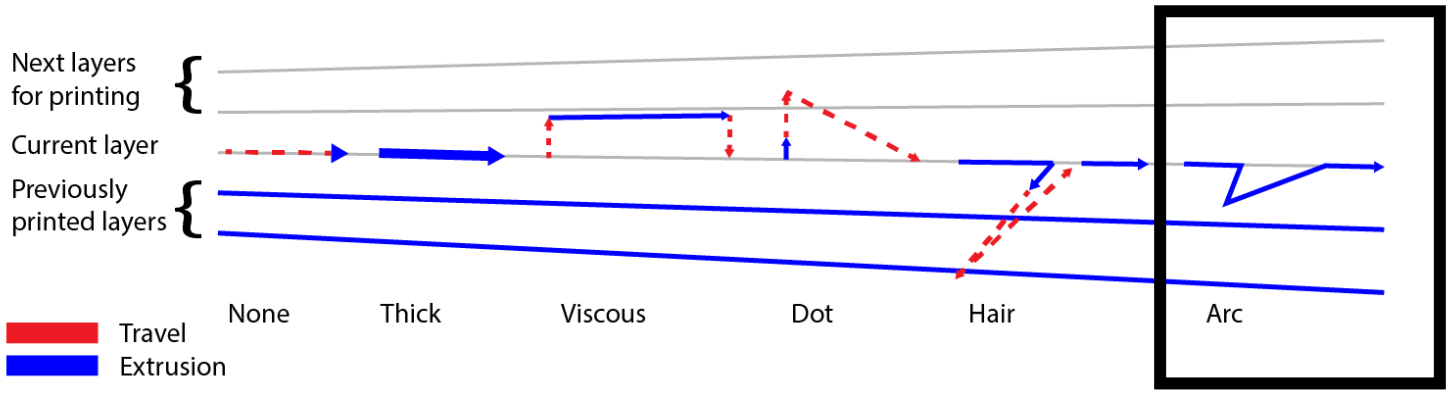
Regular
Arc
Regular
Arc

Structure Example: Loose Arcs

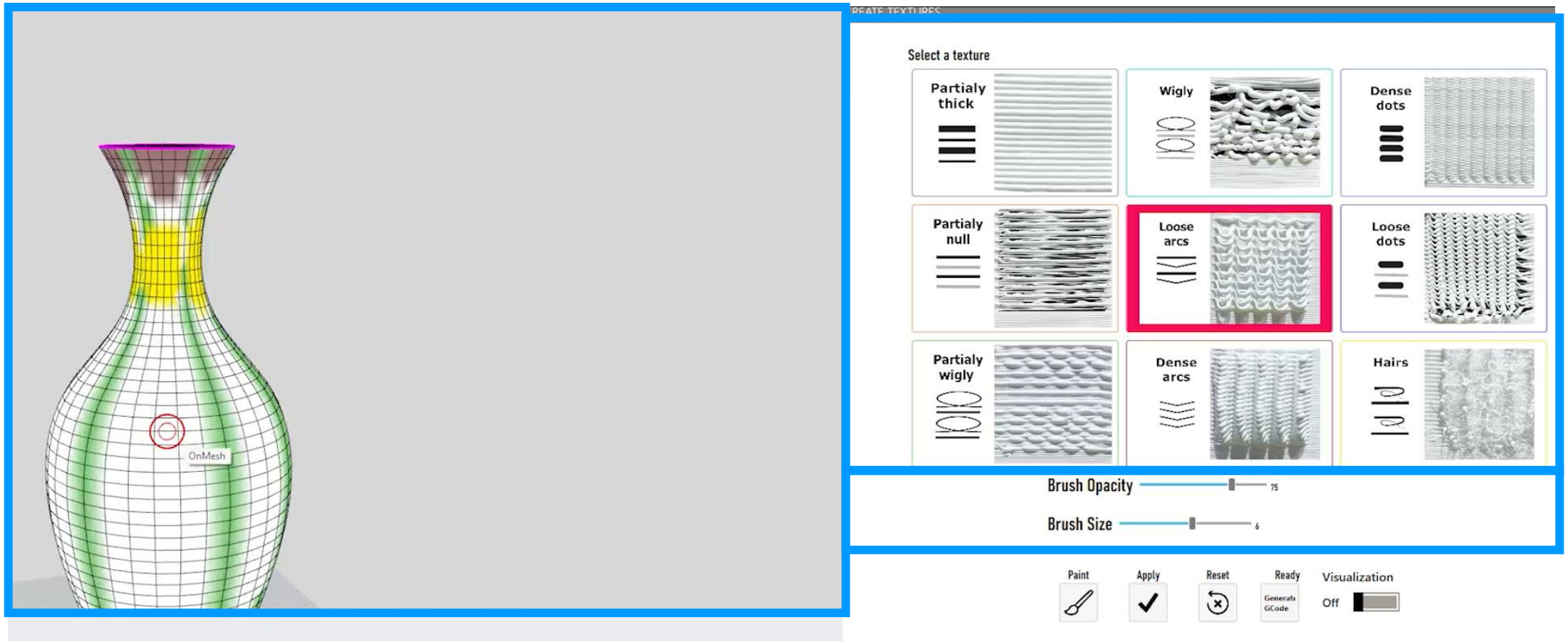


4 Segments

Primitives:
Regular
Arc
Regular
Arc

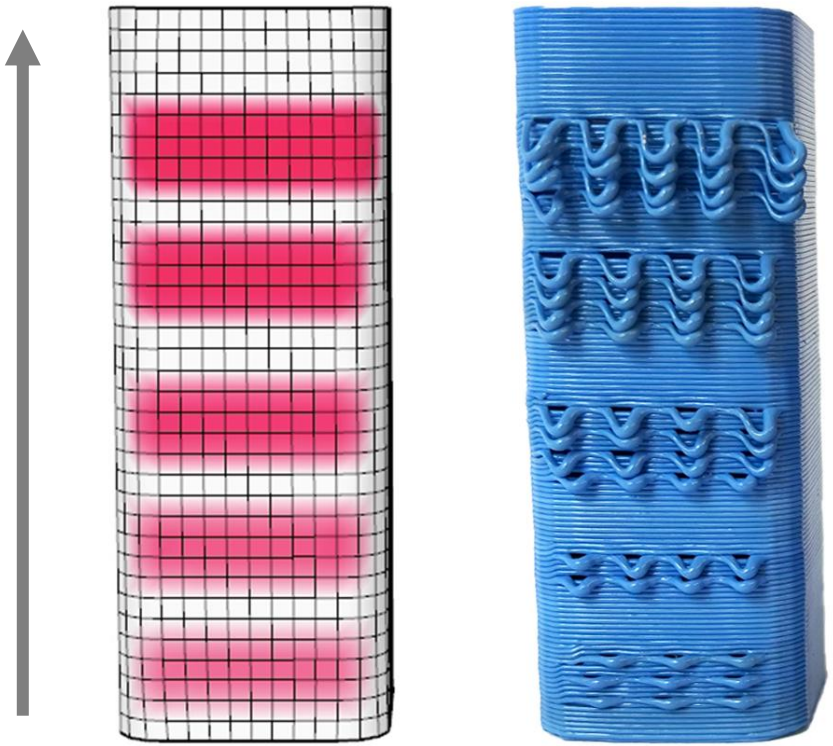


Interface

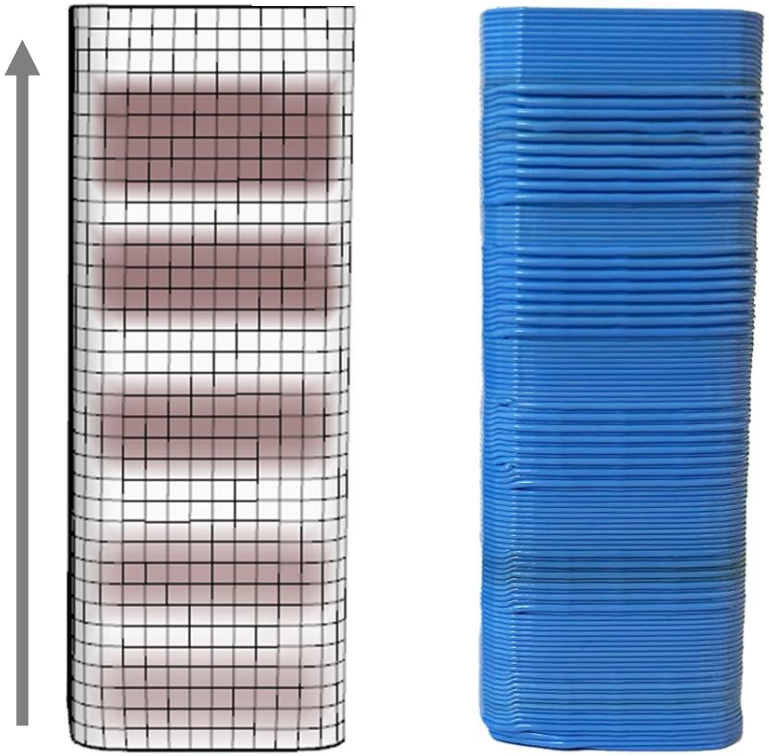

OnMesh
Select a texture
Partialy thick
Wigly
Dense dots
Partialy null
Loose arcs
Loose dots
Partialy wigly
Dense arcs
Hairs
Brush Opacity
75
Brush Size
6
Paint
Apply
Reset
Ready
Visualization
Off

Intensity

Loose arcs

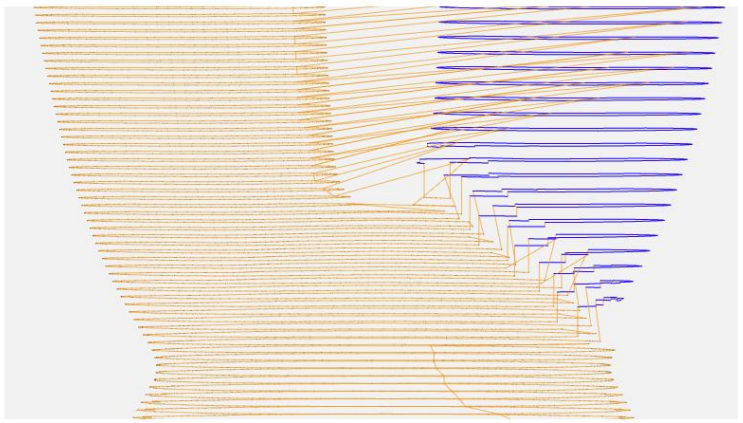


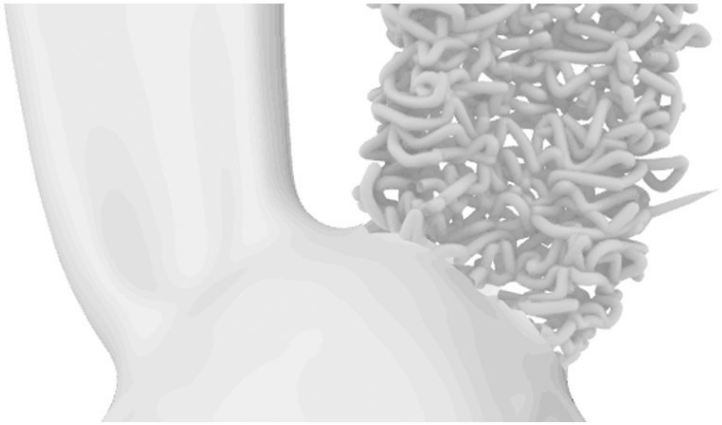
Partially thick

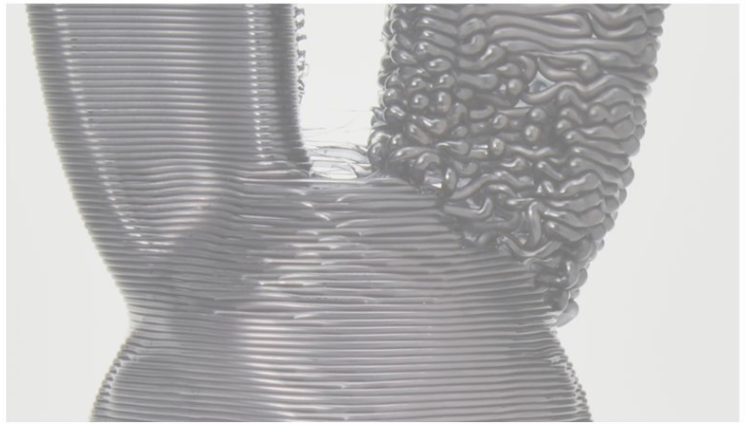


Visualization

Gcode Viewer

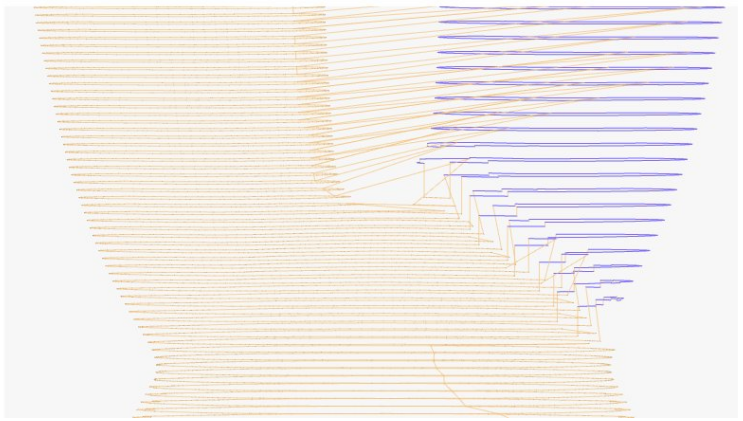


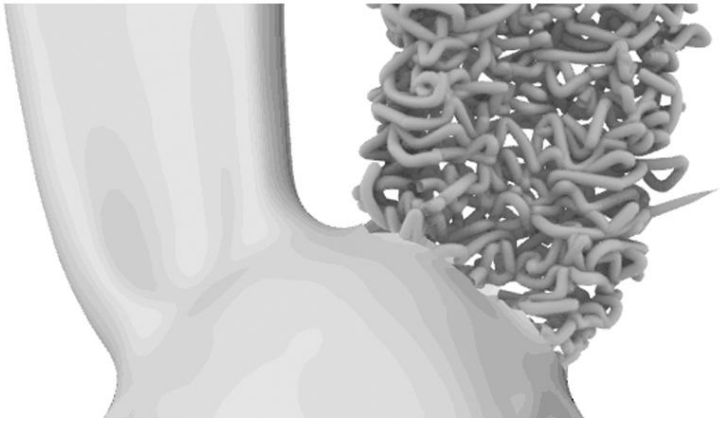




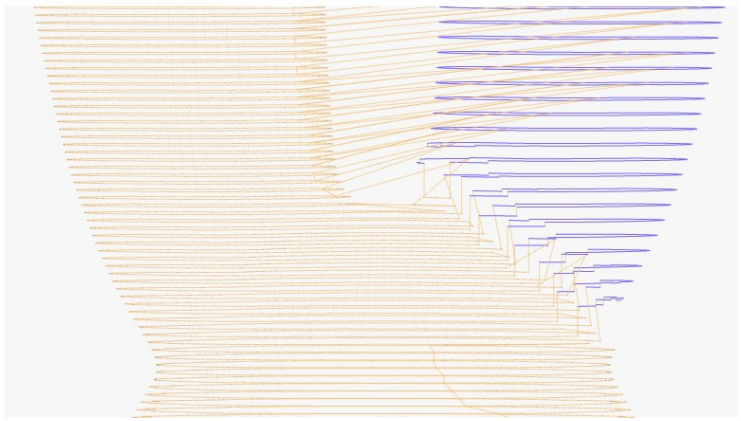
Visualization

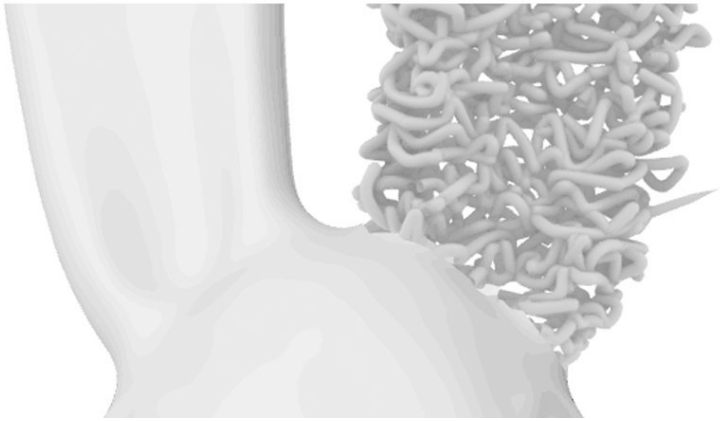
Our Visualization





Visualization

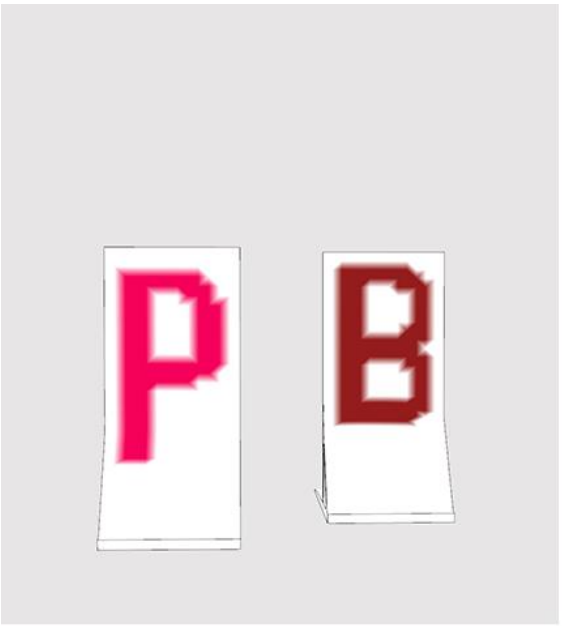


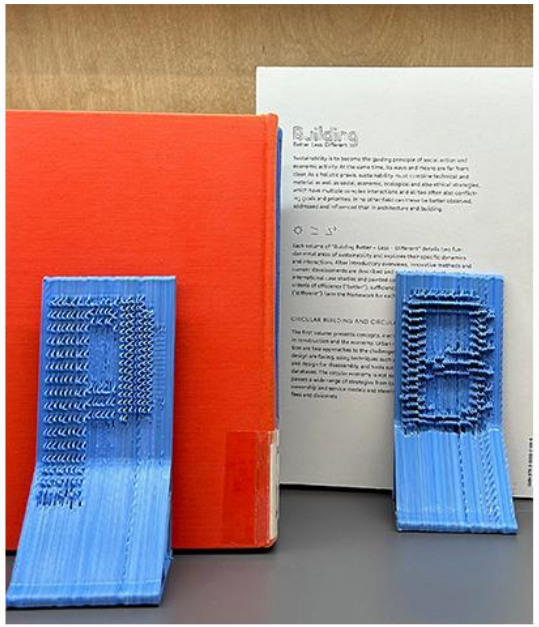


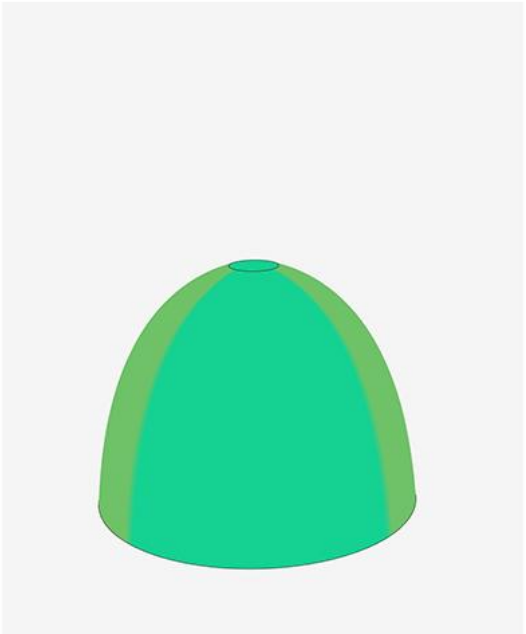
Real Results

Design Examples

Design Examples

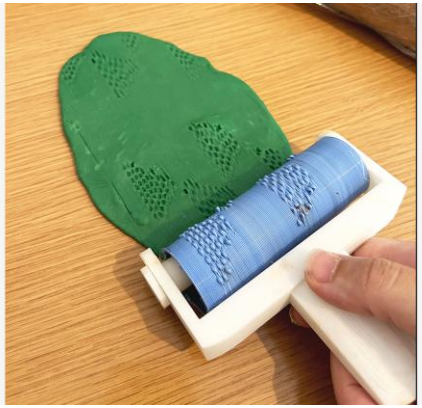






Design Examples



Design Examples

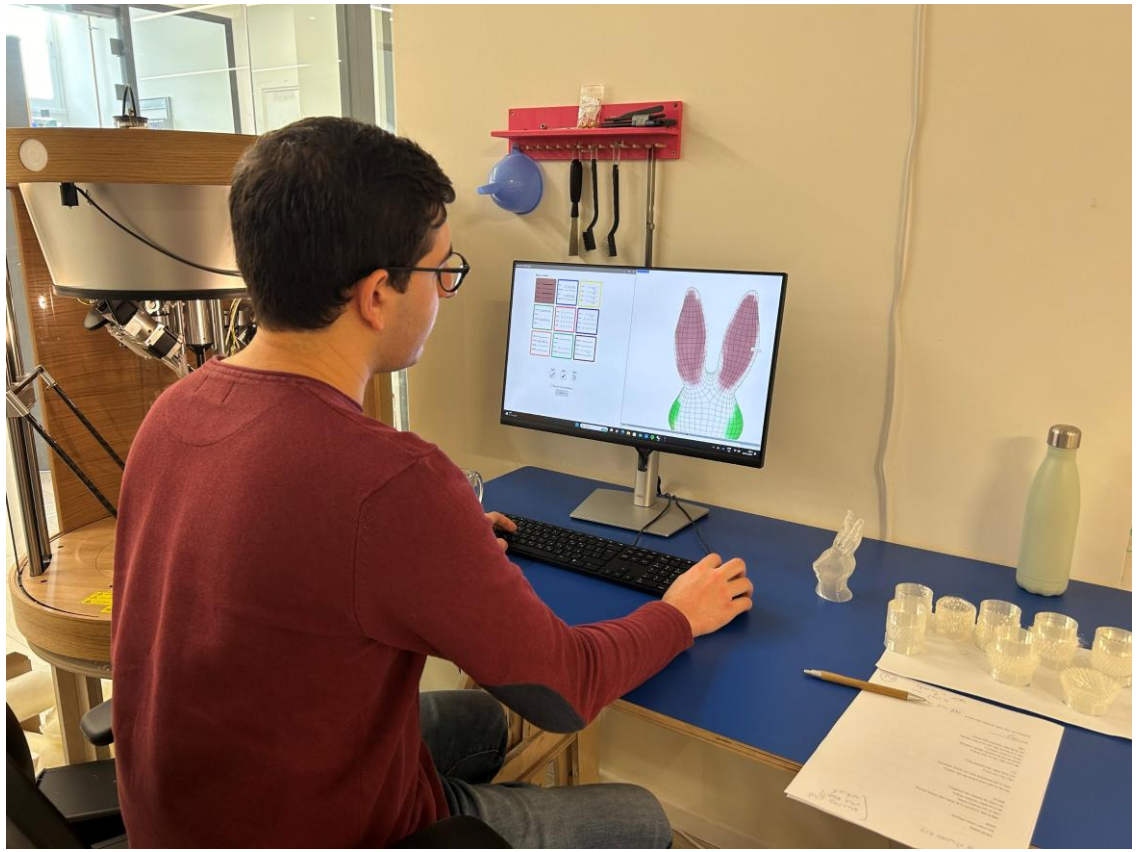



User Study

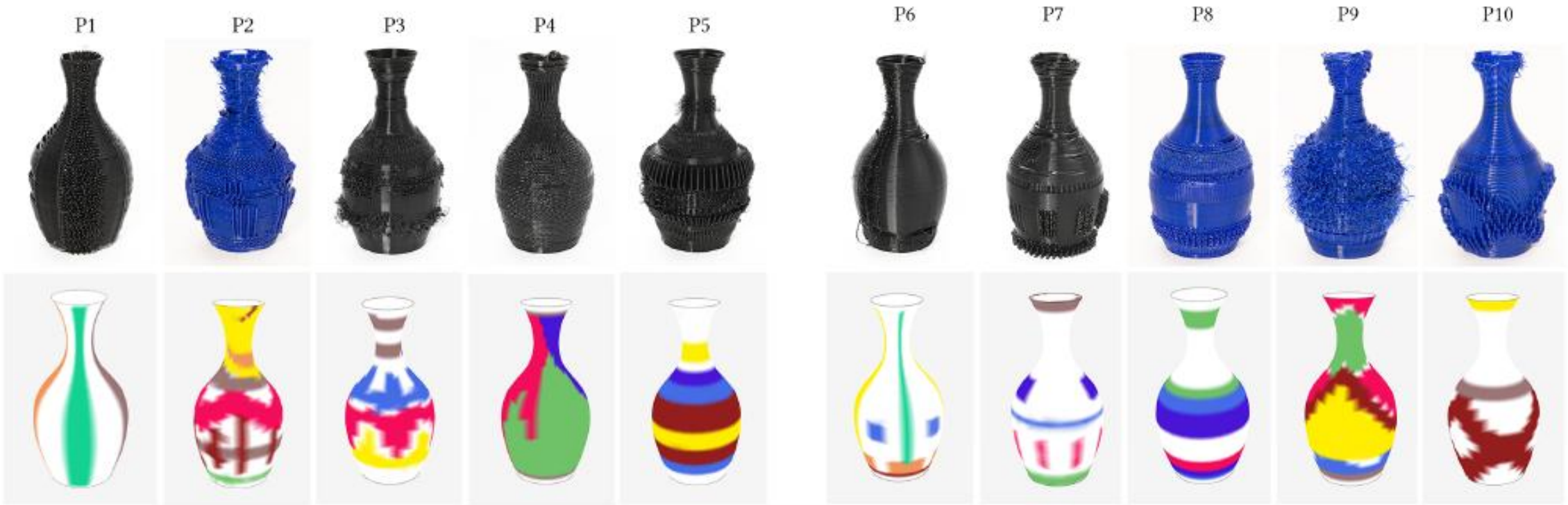
10 Users

Hands-on Workshop

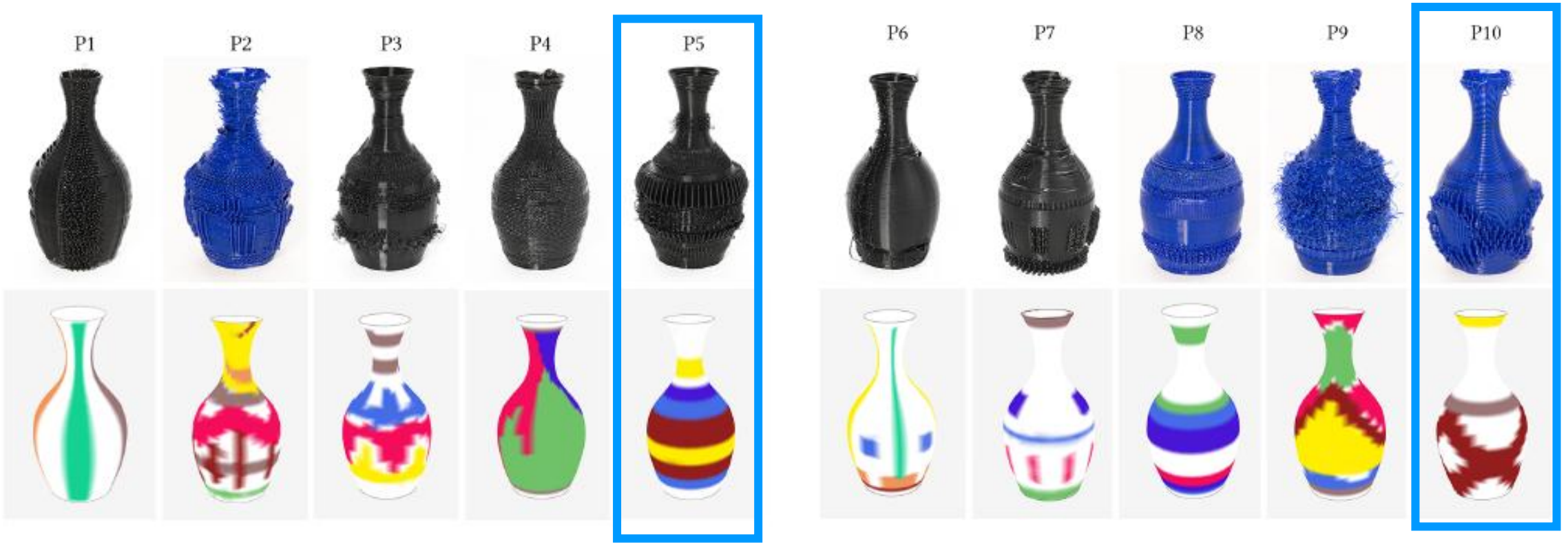
Questionnaire



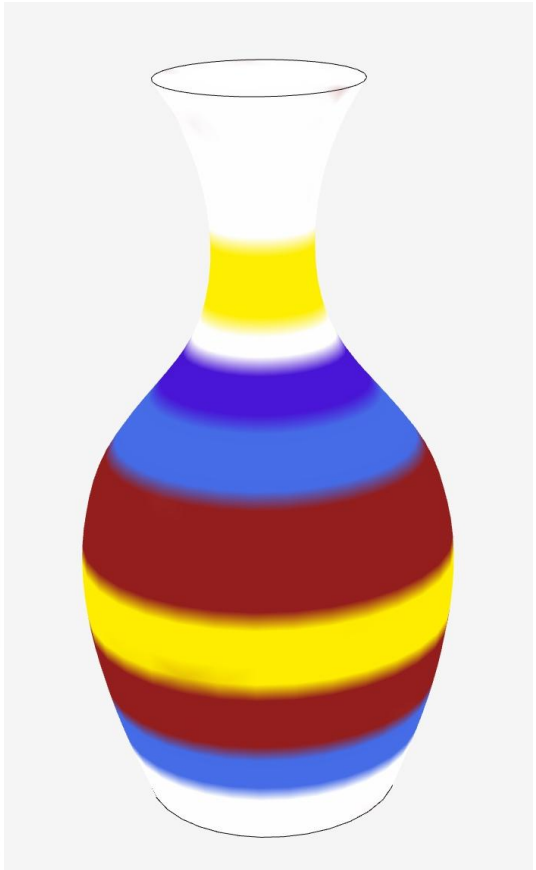
User Study



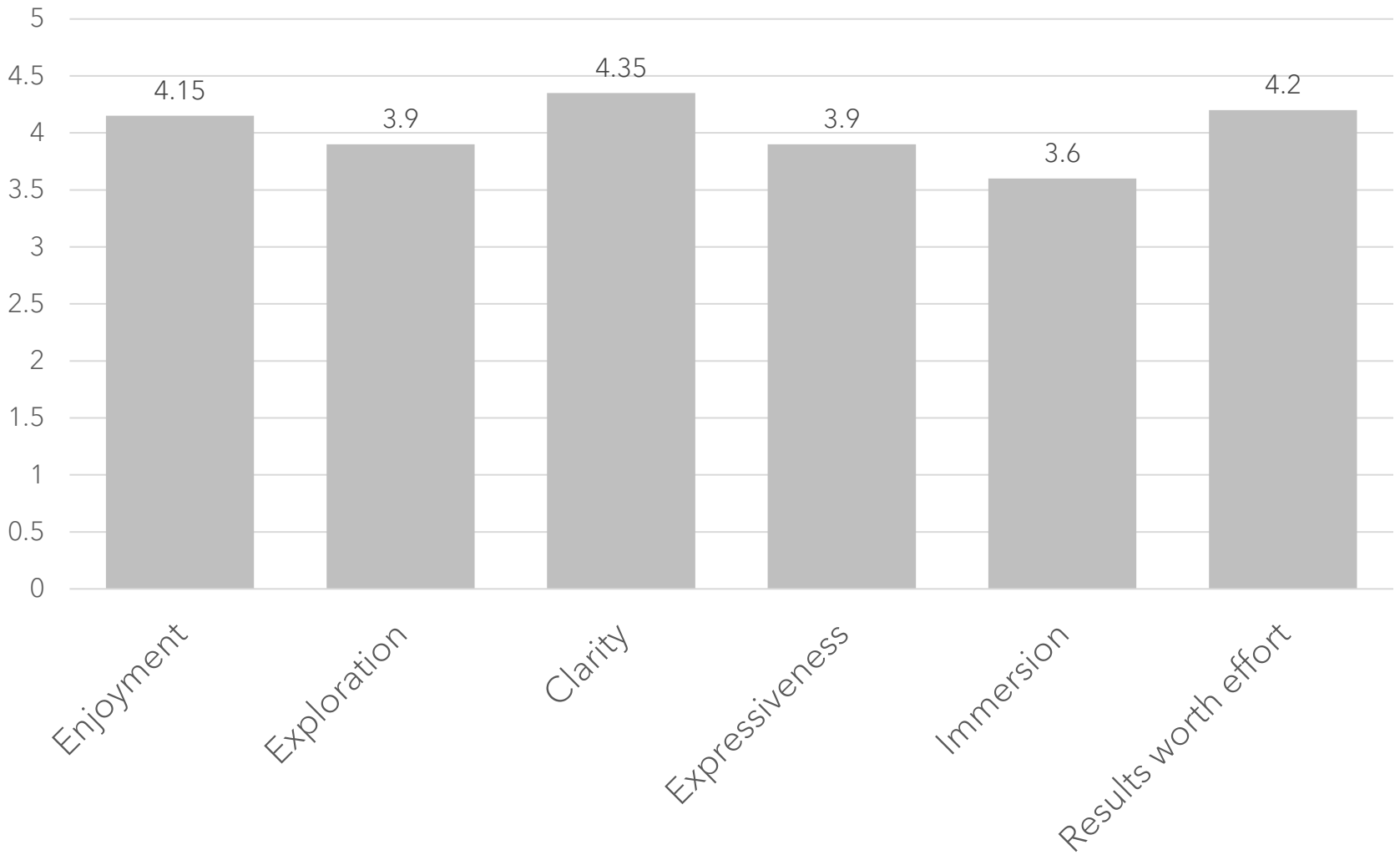
User Study



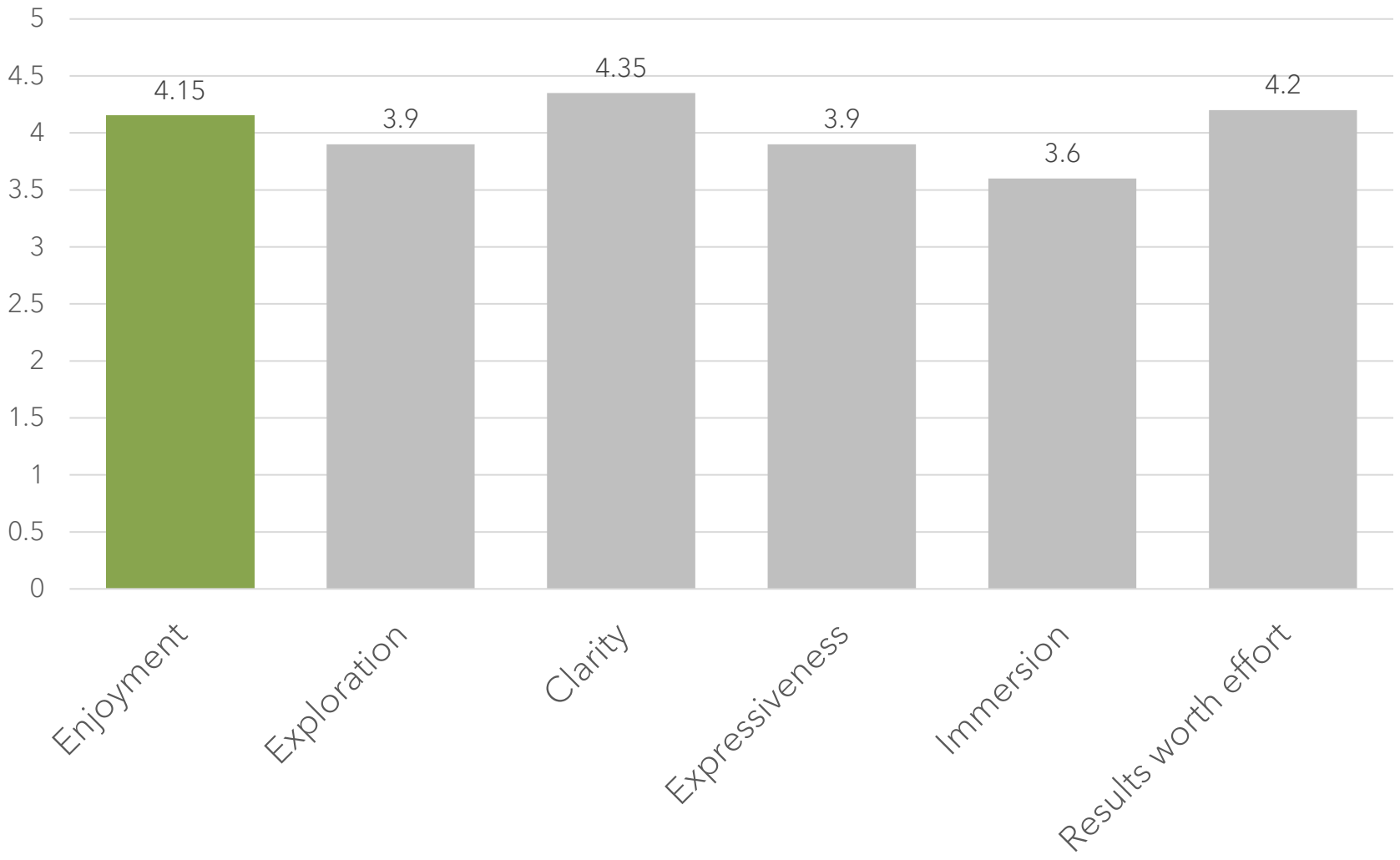
User Study



Results


5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
4.15
3.9
4.35
3.9
3.6
4.2
Enjoyment
Exploration
Clarity
Expressiveness
Immersion
Results worth effort

Results


5
4.5
4
3.5
3
2.5
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1.5
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0.5
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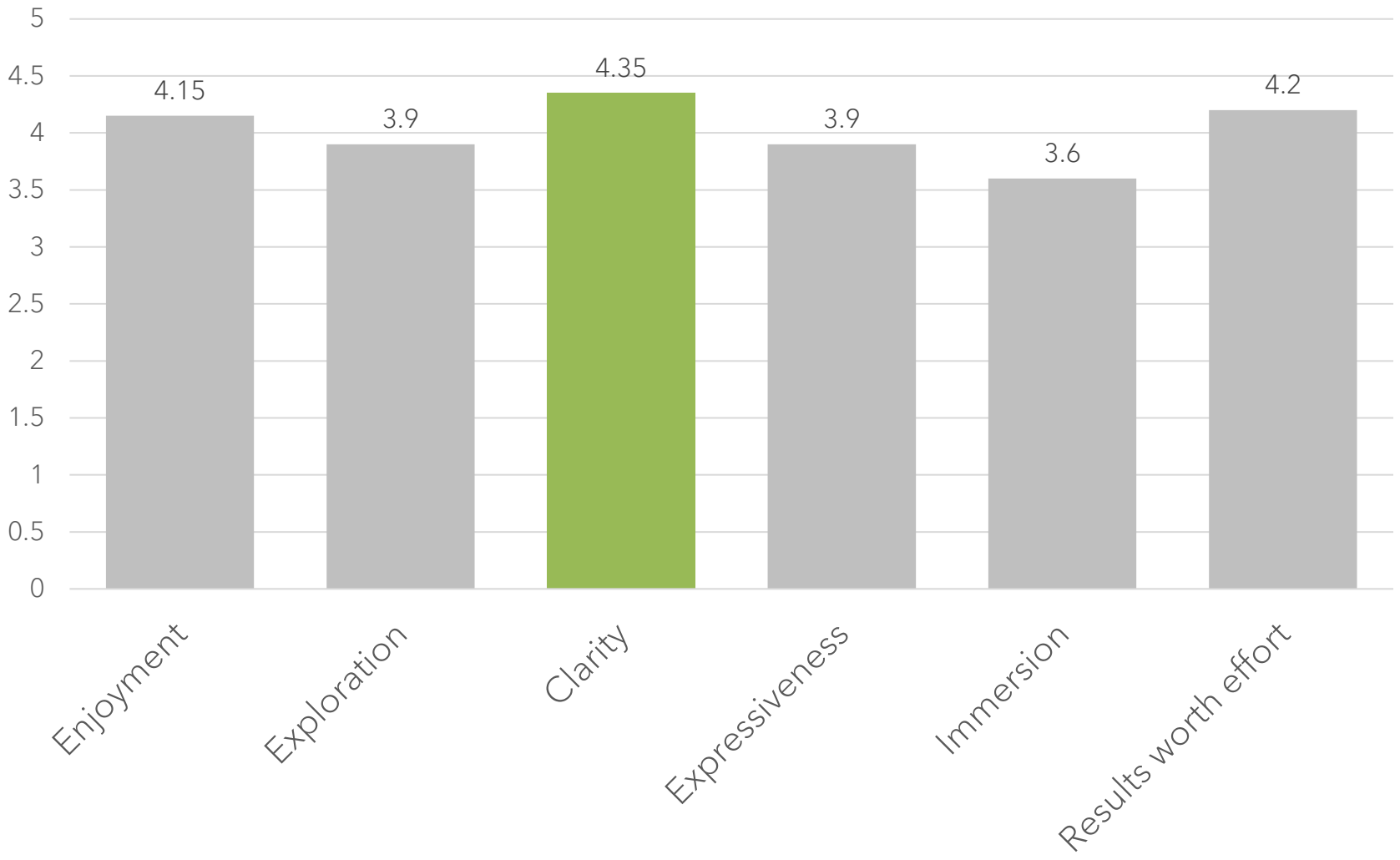
4.15
3.9
4.35
3.9
3.6
4.2
Enjoyment
Exploration
Clarity
Expressiveness
Immersion
Results worth effort

Results


5
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3
2.5
2
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1
0.5
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4.15
3.9
4.35
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3.6
4.2
Enjoyment
Exploration
Clarity
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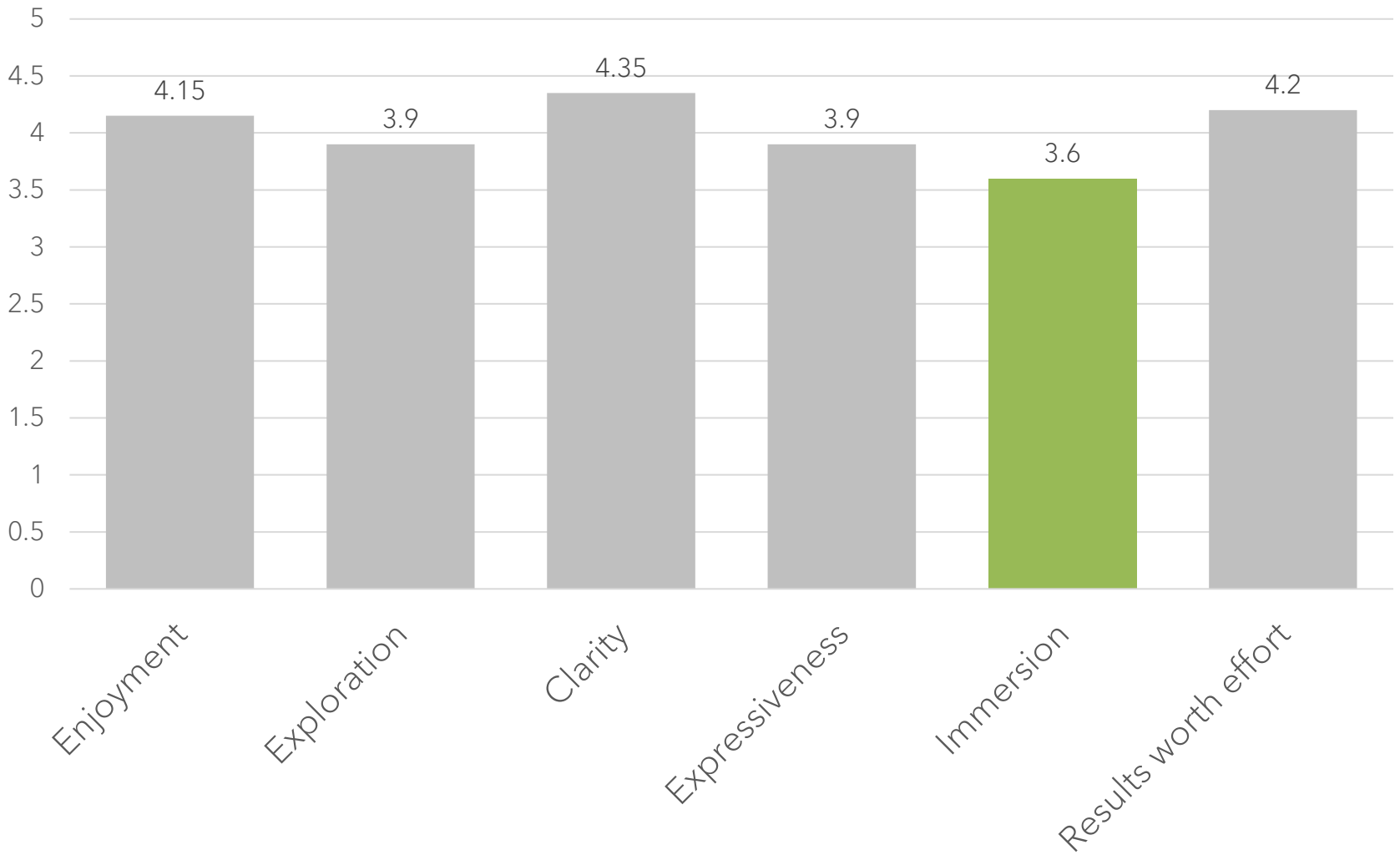
Results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4.35
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Limitations

- Restricted library
- Fabrication limitations

Future

- Create a texture editor and importer
- Generalize for other setups

Summary

- A modular system
- A coloring-based tool
- A Textures Library

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Questions?

daphnakaplan@campus.technion.ac.il