

from fragments to futures

scalable hybrid system that transforms high-fired ceramic waste into durable surfaces by combining craft knowledge with digital design and robotic assistance

Christoph Zellweger
Robert Bossart

HSLU Hochschule
Luzern

Anastasiia Dubinkina
Master Design 2026

from fragments to futures

scalable hybrid system turning ceramic waste into architectural surfaces using craft, digital tools and robotics

Christoph Zellweger
Robert Bossart

HSLU Hochschule
Luzern

Anastasiia Dubinkina
Master Design 2026

Switzerland generates large volumes of construction sector waste.

Municipal solid waste in 2020: 6.1 million tonnes
≈ 700 kg per person per year

High fired ceramic waste (tiles, sanitary ceramics, tableware) appears within these material streams and becomes difficult to recover once combined with similar materials.

A precise annual quantity of high-fired ceramic waste is difficult to quantify separately.

*Federal Office for the Environment FOEN

high-fired ceramics
are durable — but
treated as waste





high-fired ceramics
(stoneware/porcelain)

fired at $\sim 1200 - 1400^{\circ}\text{C}$,
covered with glazes,
creating a strong,
waterproof,
long-lasting material

as a ceramic artist...

- > I observe a wide range of ceramic waste generated in ceramic studios.
- > with my expertise, I can identify, sort, and evaluate material properties to enable future reuse and redesign.



**what if broken ceramics are not the end of a
product...**

...but the beginning of a new system?

material sources

industrial level

recycling stations

second hands

local level

ceramic studios

local artists

individuals



research and inspiration

existing techniques with broken ceramics



terrazzo



trencadís



kintsugi



focus on recycling as reusing

trencadís





Hundertwasser Haus, <https://www.kunsthauswien.com/> 11



Parc Güell — Barcelona, Spain

limits of handwork



- >slow production speed
- >intensive process
- >limited ability to generate complex design variations





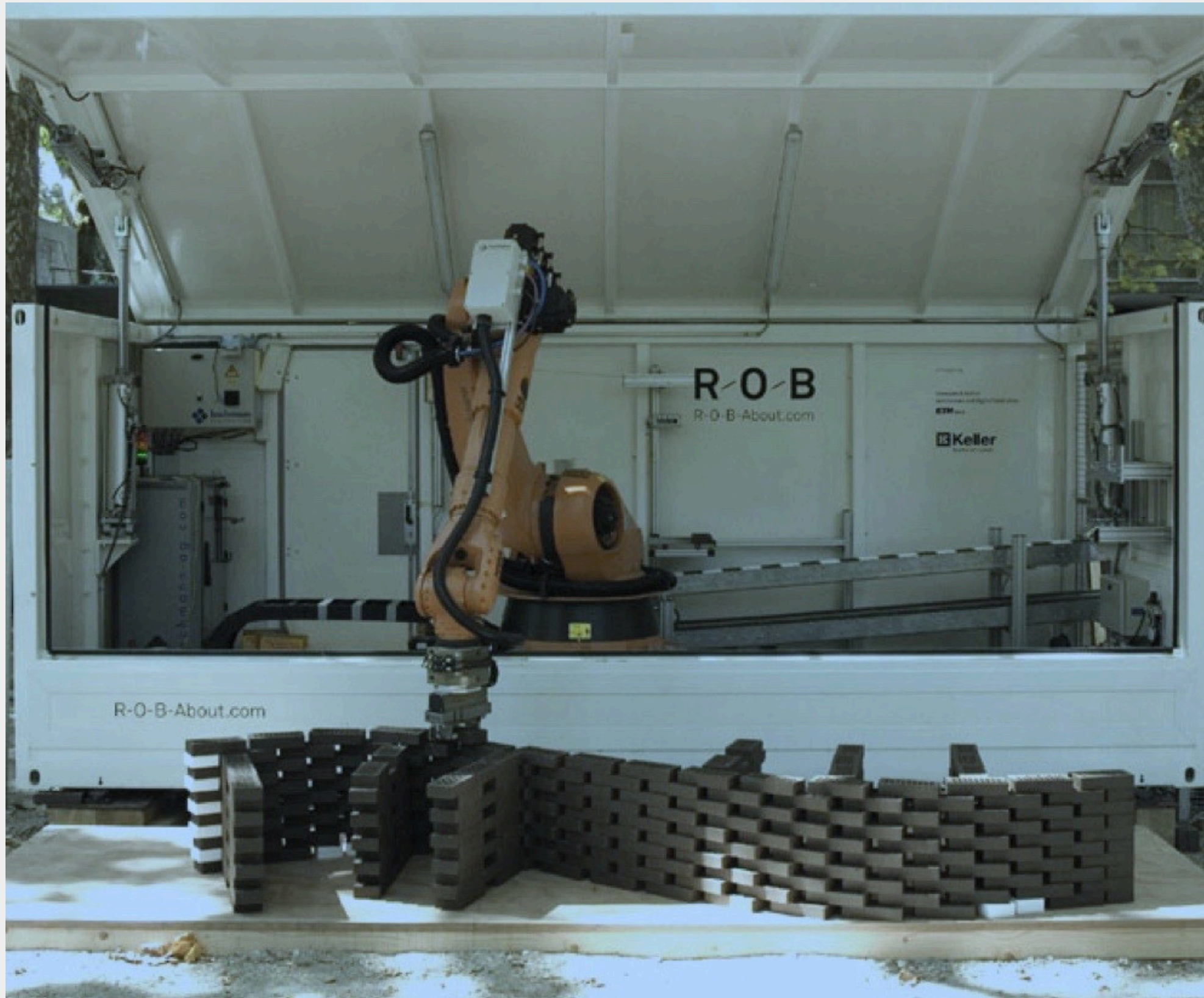
AI generated image

from fragments to large-scale surfaces

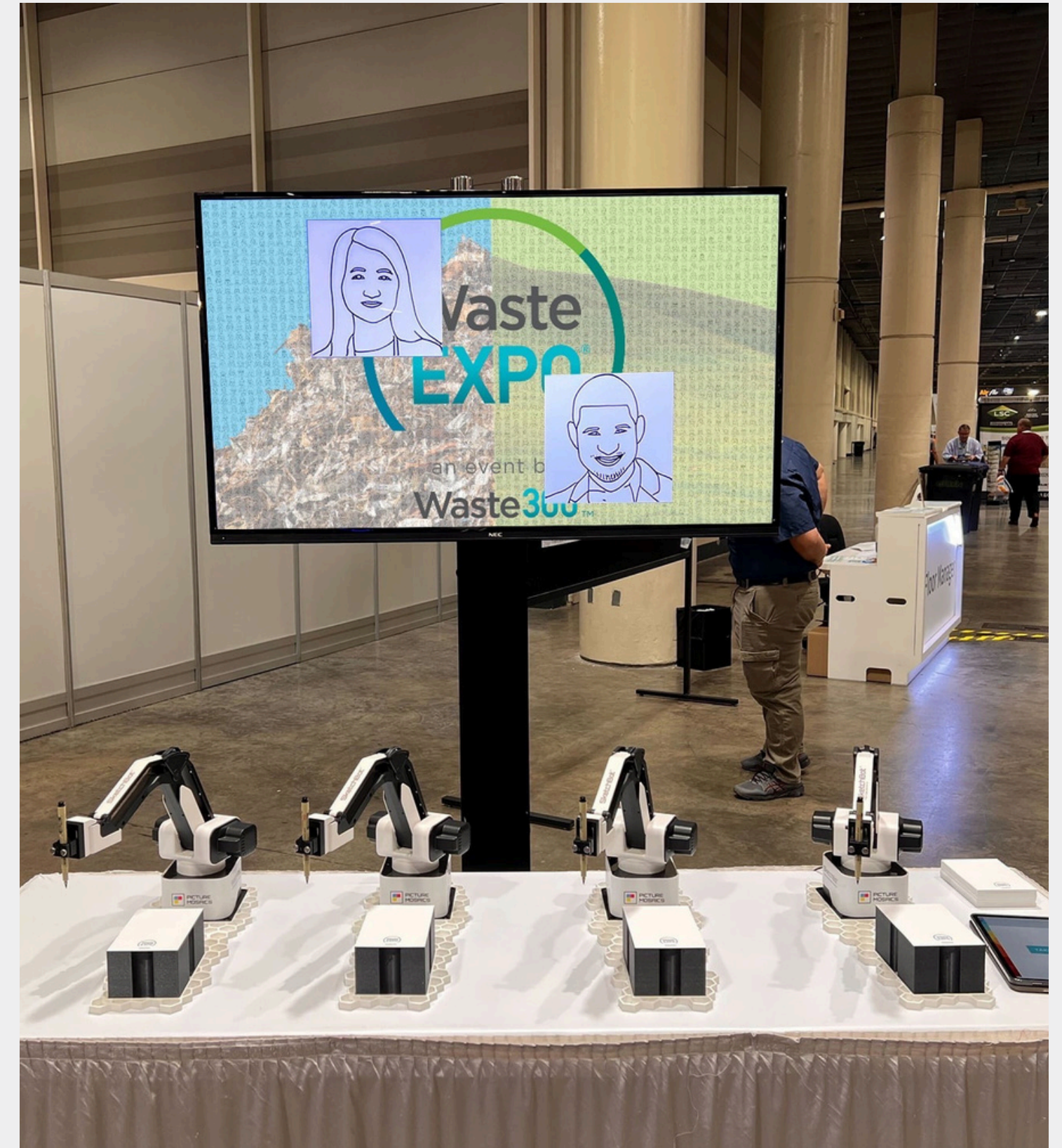


large-scale surfaces must be divided into sections, making manual production more complex and time-consuming

Scale: 1:5



Tobias Bonwetsch, Robotic Assembly Processes in Architectural Design, 2012



Digital SketchBot Mosaic, WasteExpo 2023

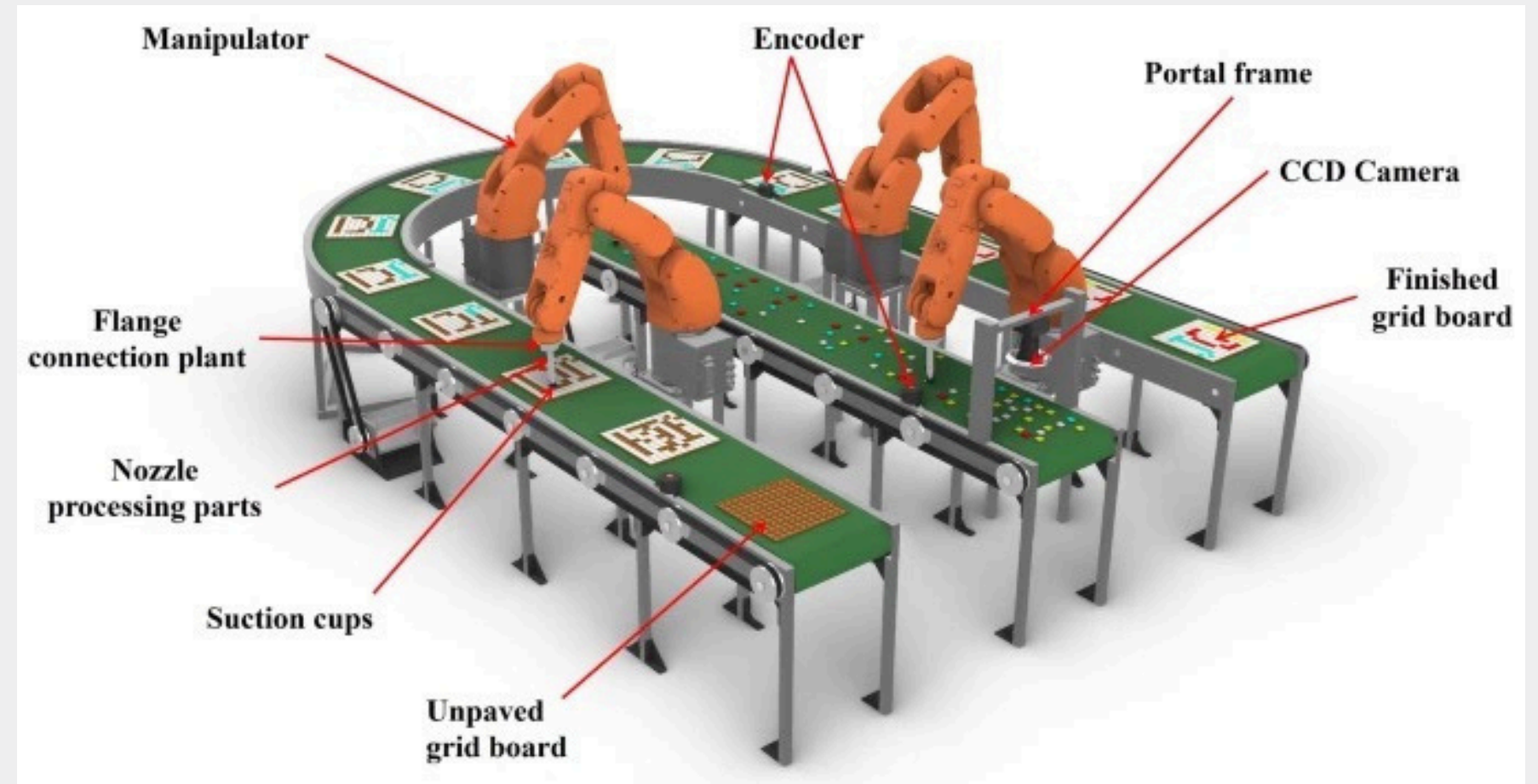
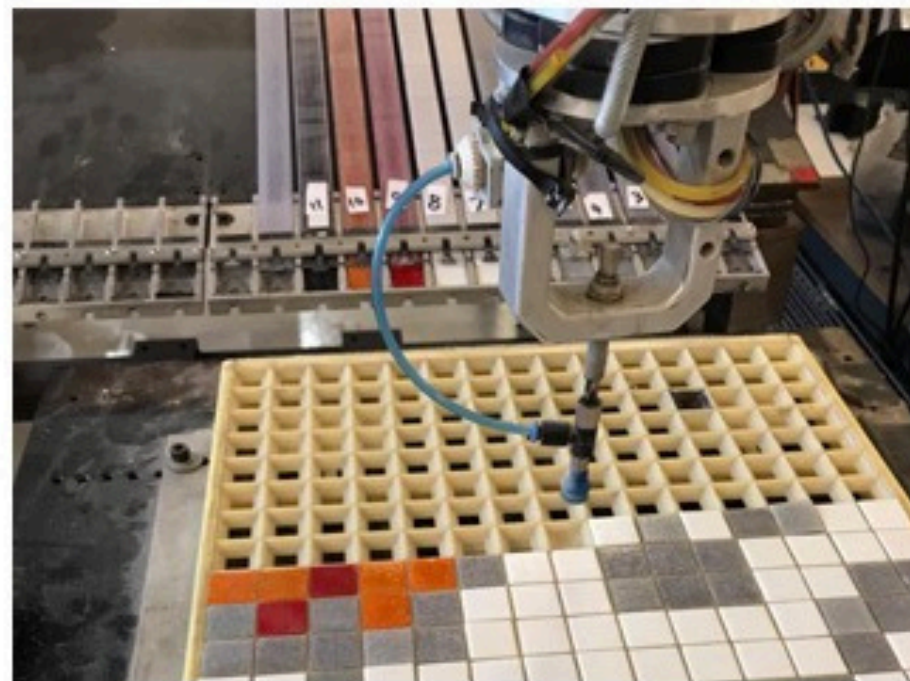
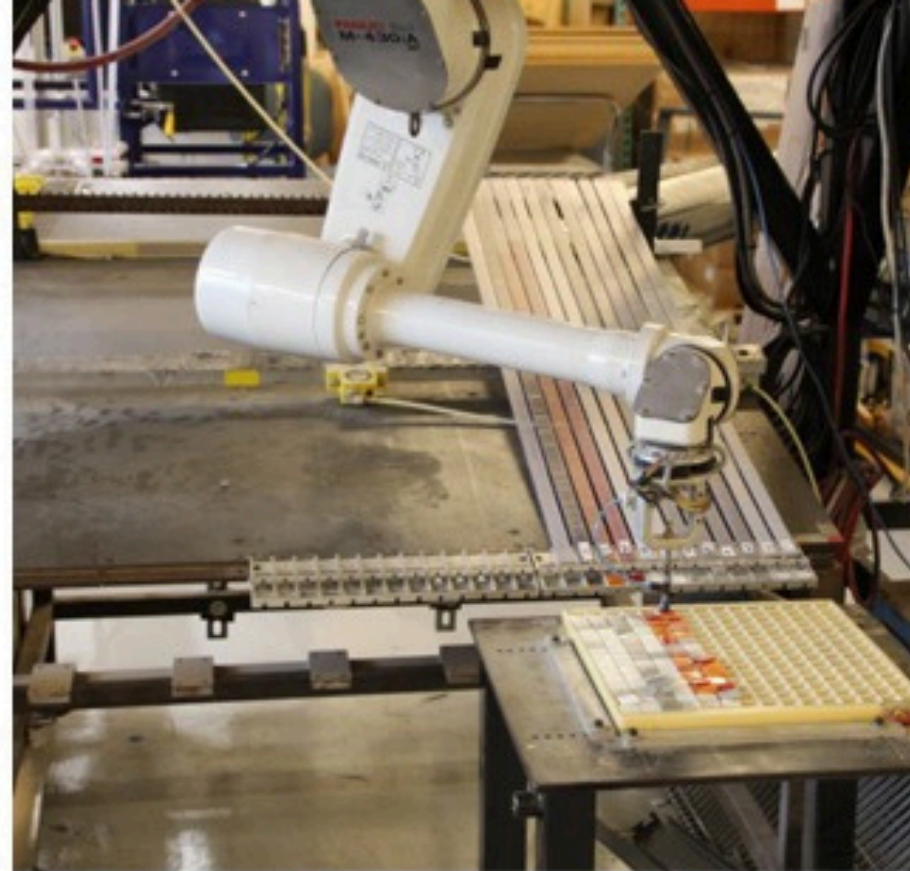
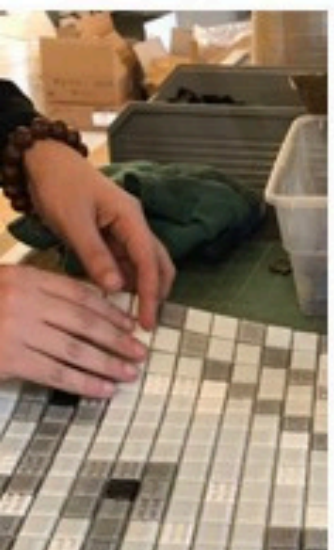
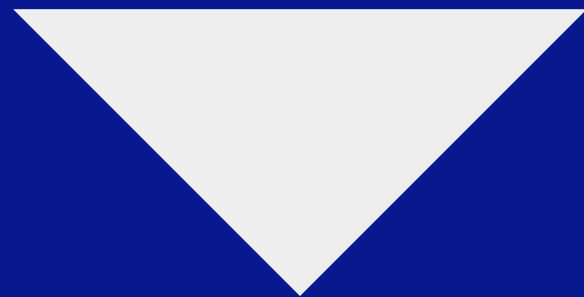


diagram of cooperative tiling system

Artaic, design studio, since 2009 producing custom tile mosaics using robots

<https://artaic.com>

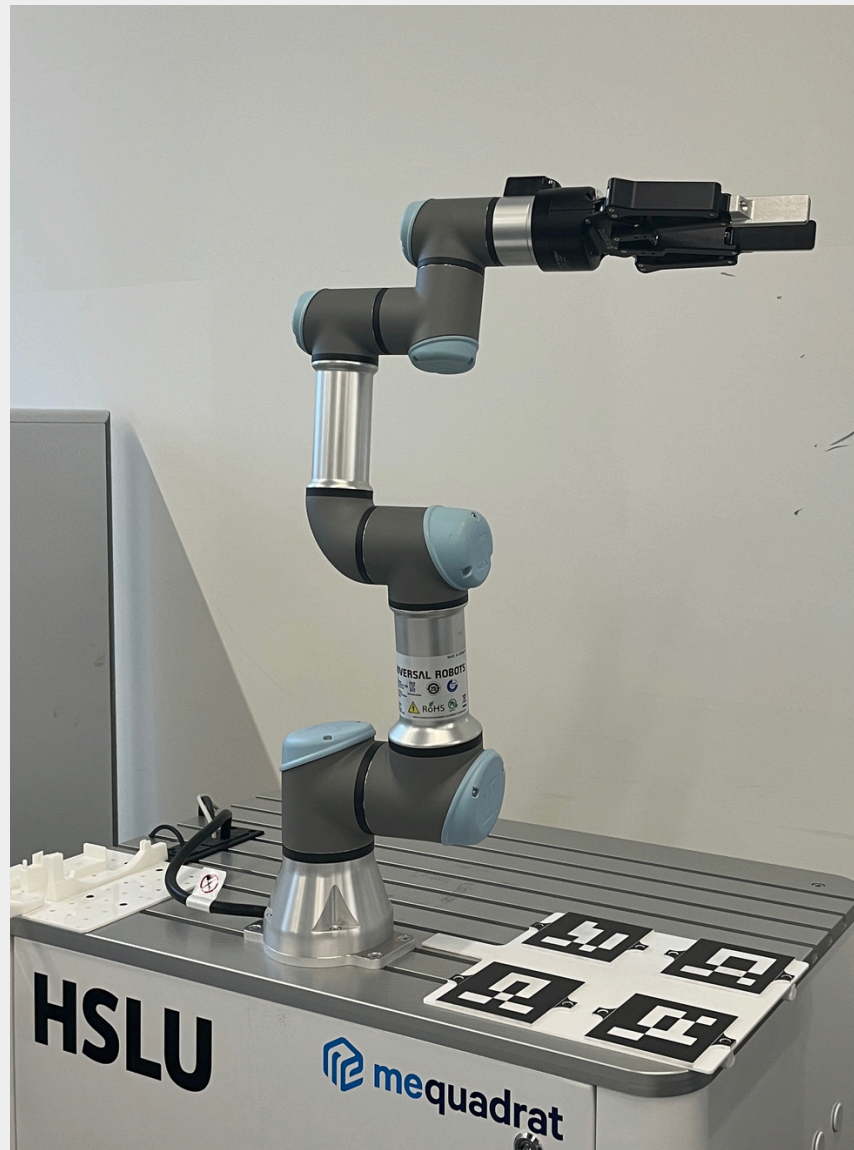




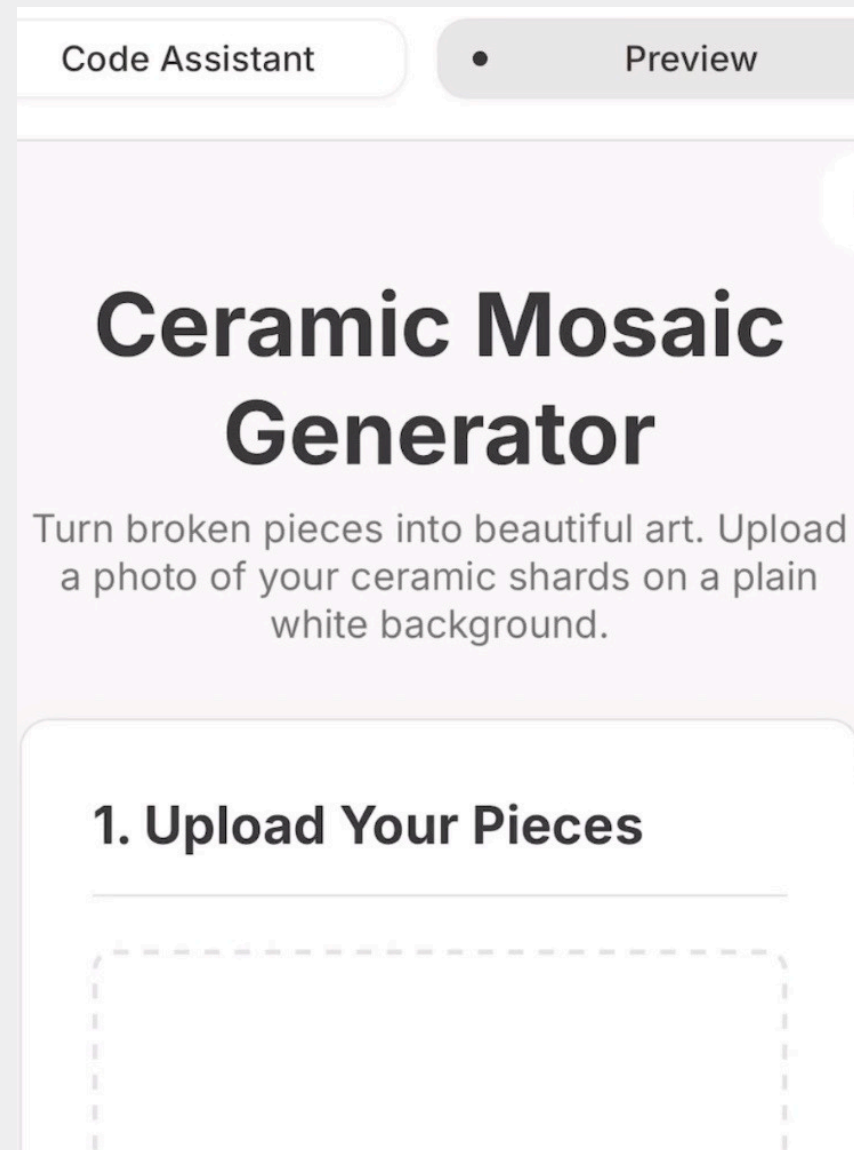
merging point

how can craft and technology work together to shape future design?

digital system for scalable solutions



robotic arm

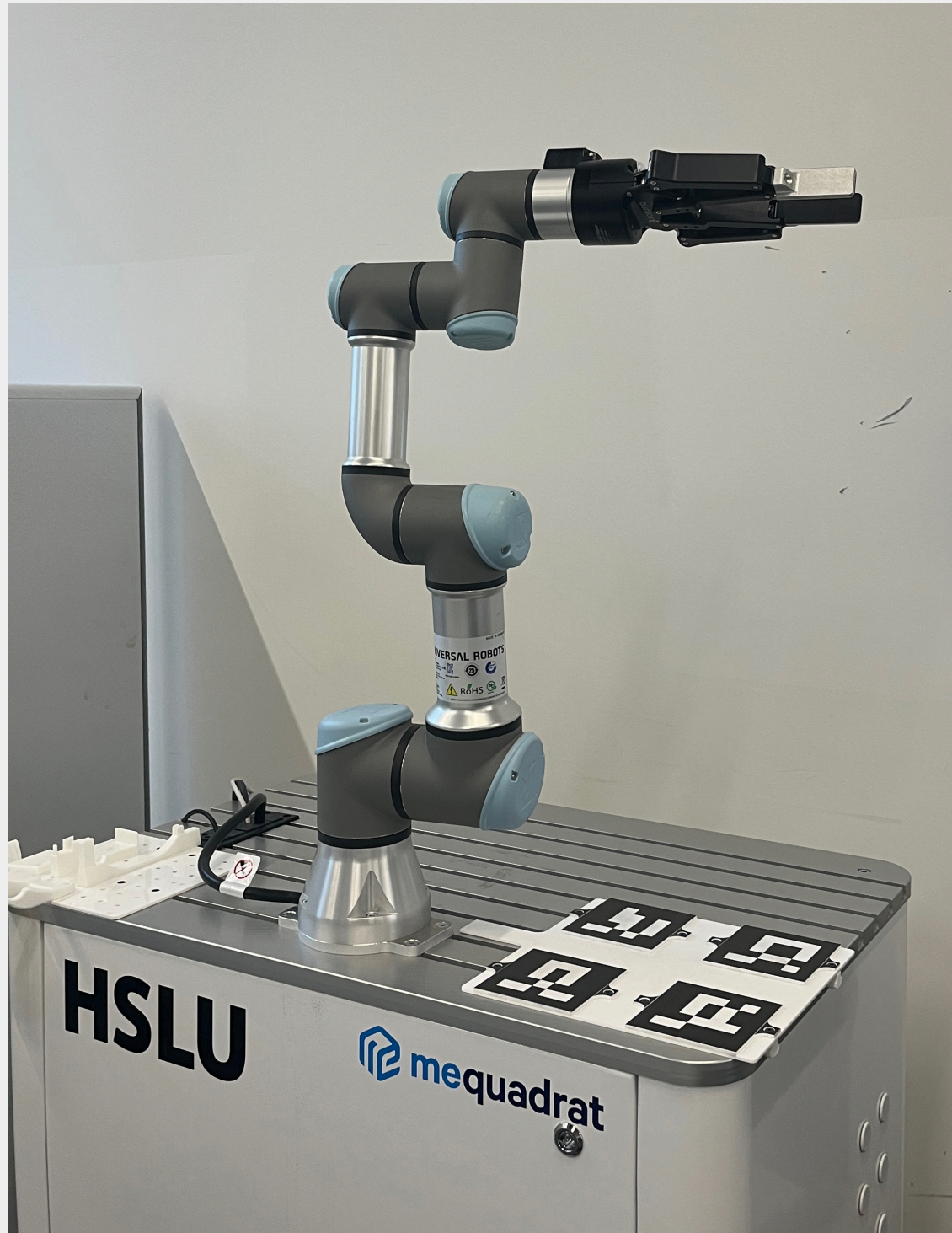


software/webpage tool



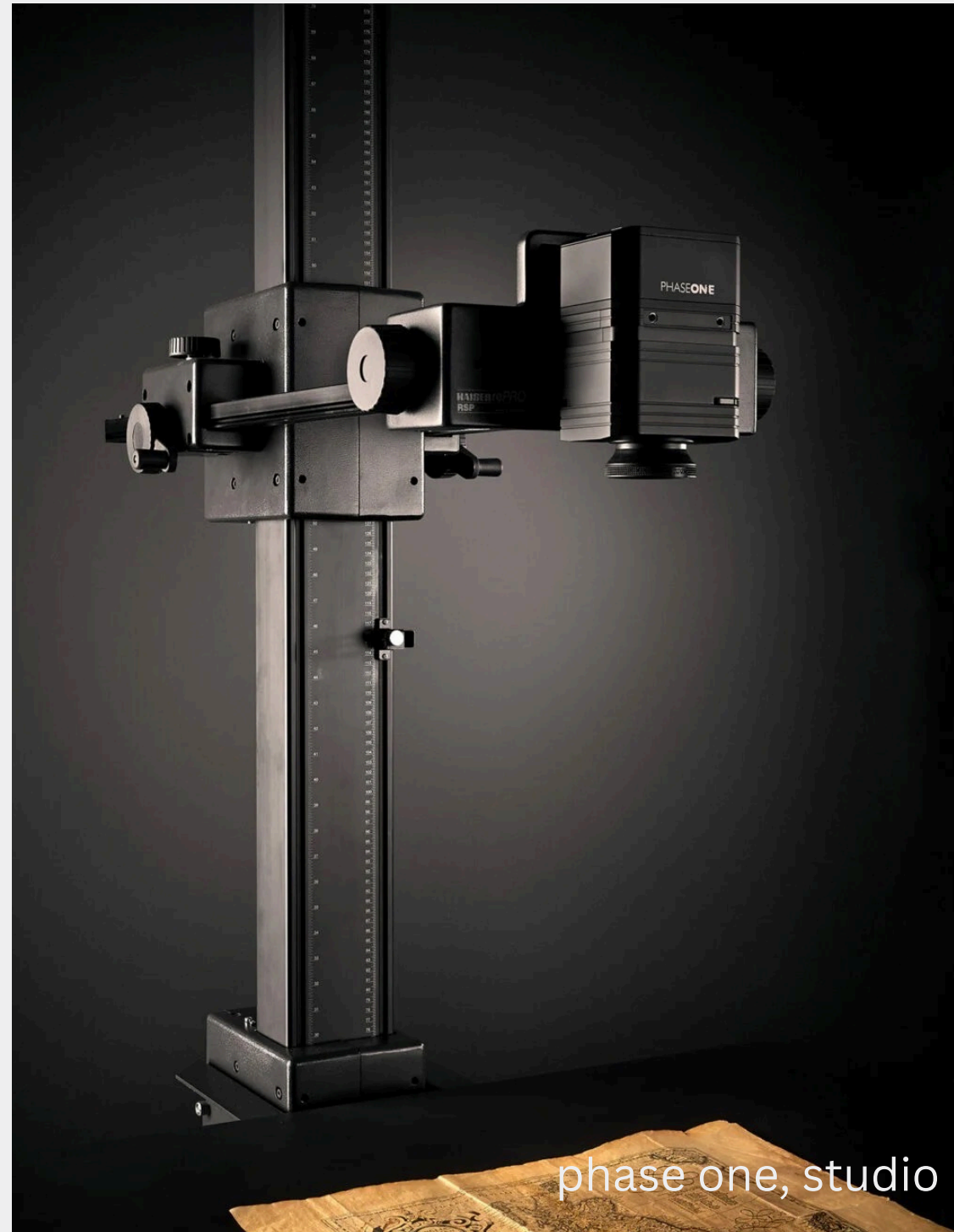
wide scale camera

robotic arm



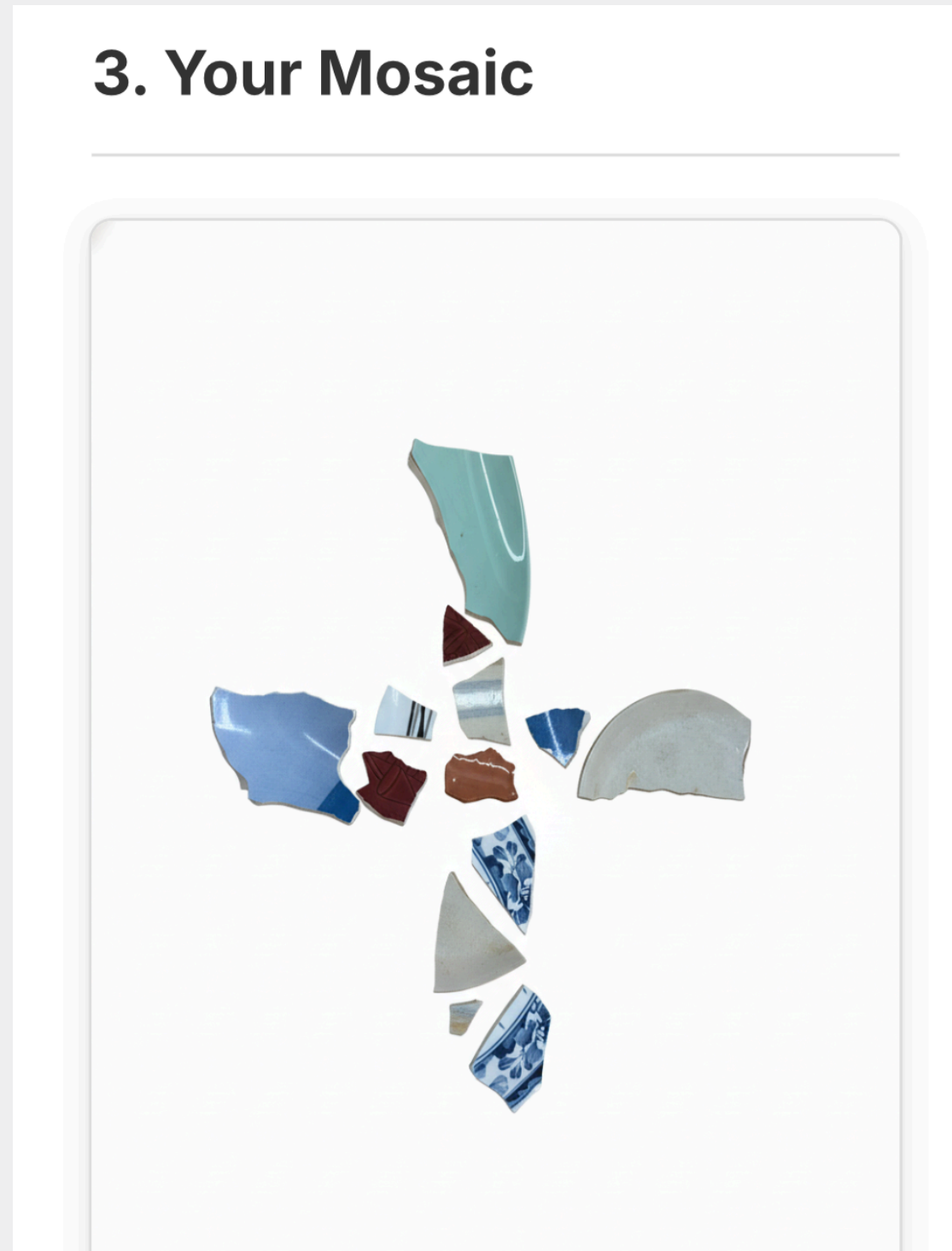
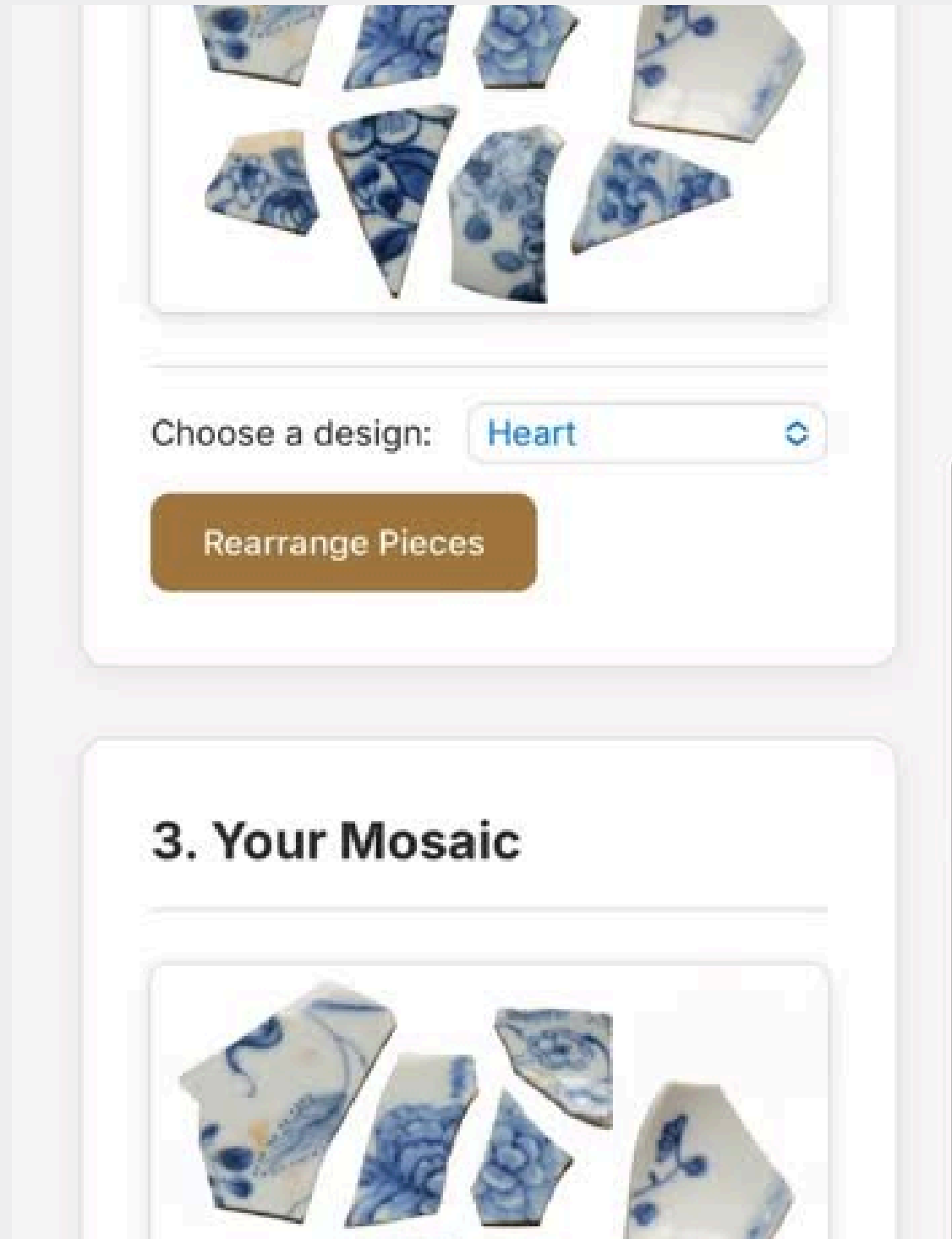
to place mosaic

wide scale camera



to create digital archives

software / webpage tool



to generate design variations

[HTTPS://CERAMIC-MOSAIC-GENERATOR-877392330512.US-WEST1.RUN.APP](https://ceramic-mosaic-generator-877392330512.us-west1.run.app)

process

2 mins video documentation

vision / feasibility



1

tiles (tiles system) production



for sale and custom orders



2

larger scale applications



murals, facades, floors, public spaces



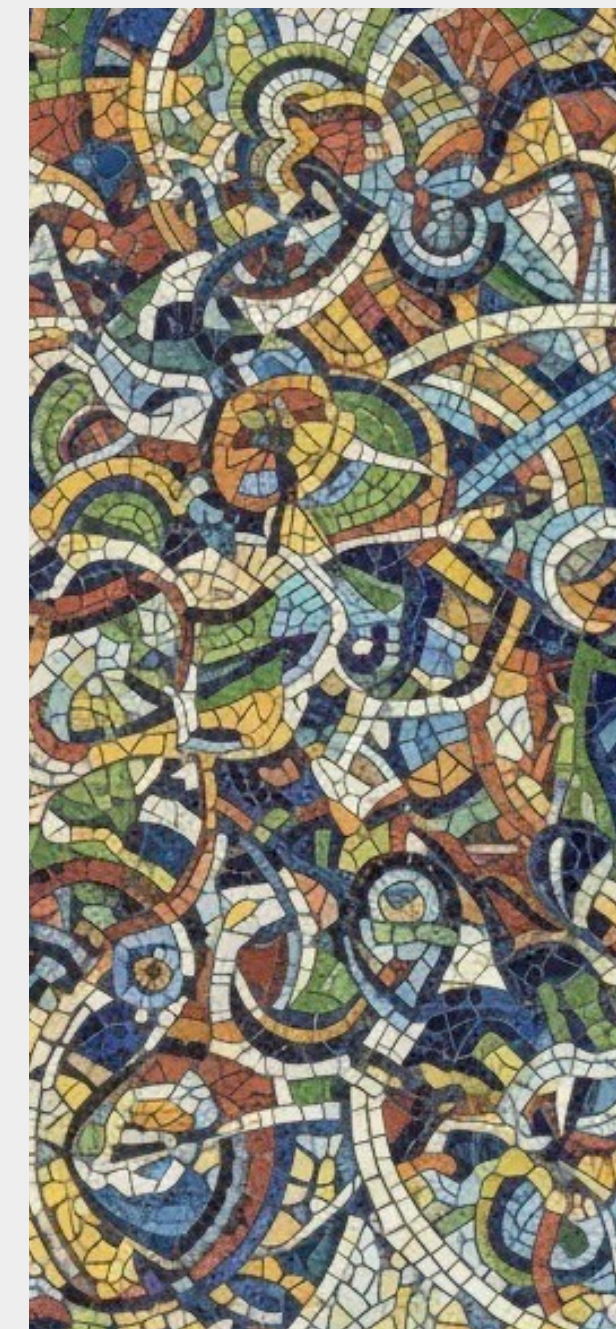
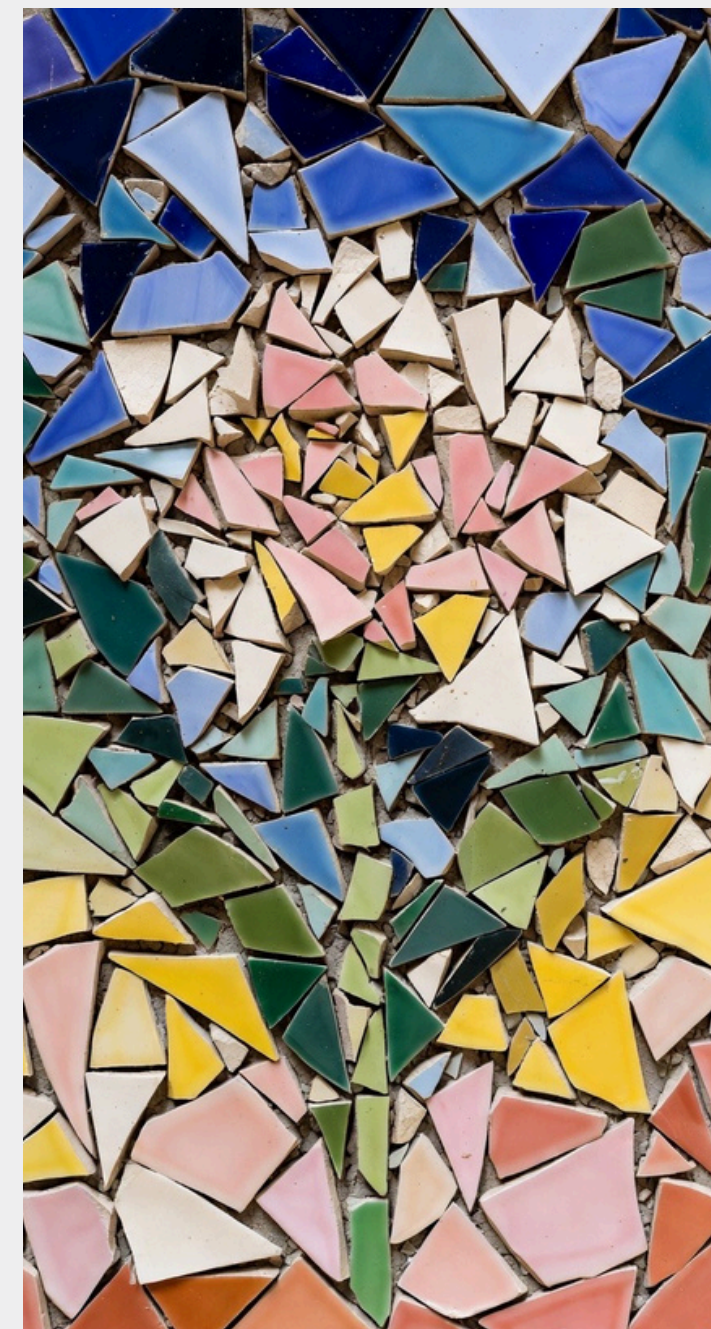
applicable for indoor and outdoor spaces



1 tiles production

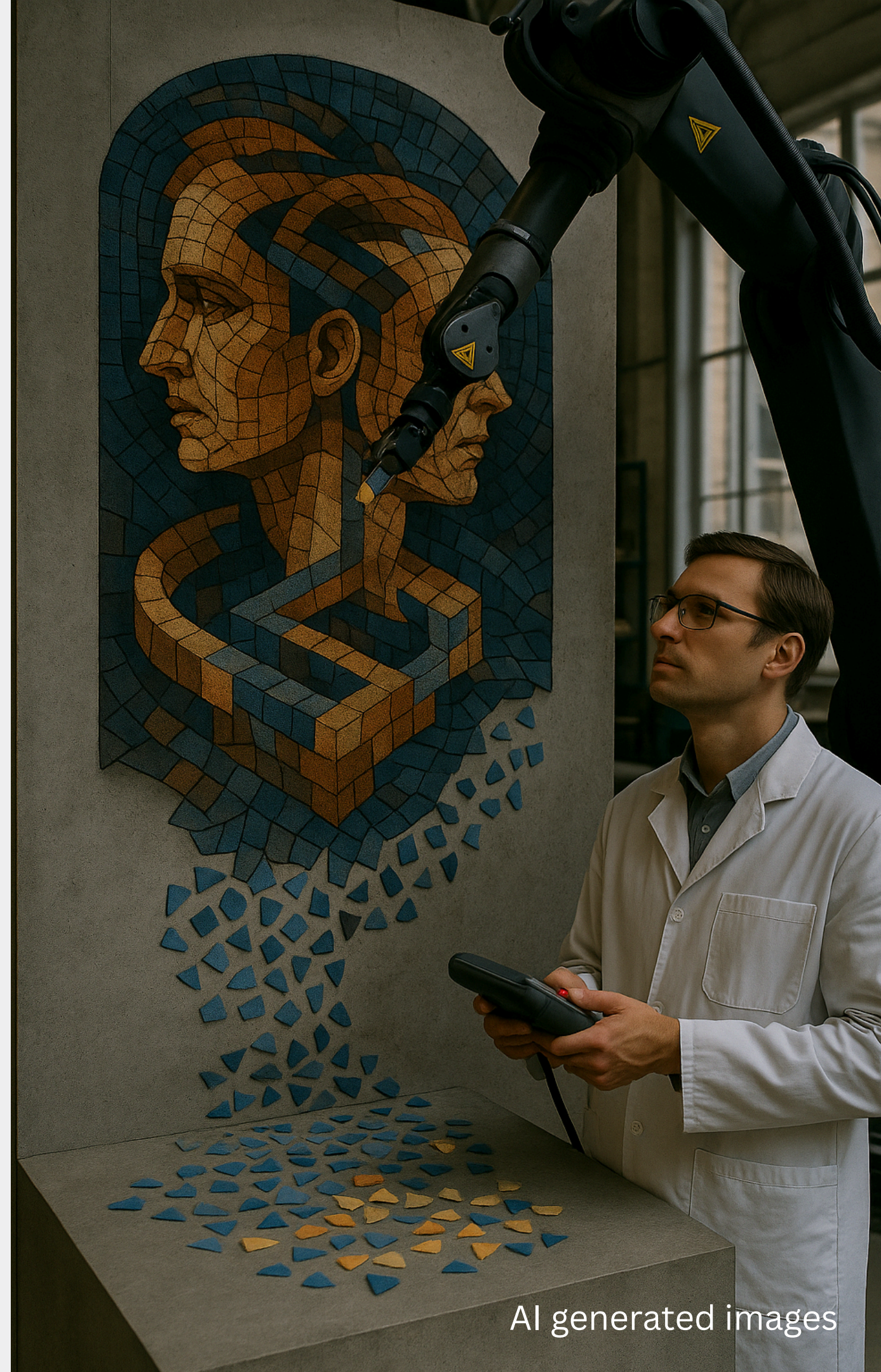
|
product from catalogs
or custom orders
design solutions

AI generated image



process of developing design applications

AI generated variations



2 large-scale applications

| murals, floors, facades etc

> production by sections

> production by direct applications

AI generated images

variations of use



Emmenbrucke, 2026

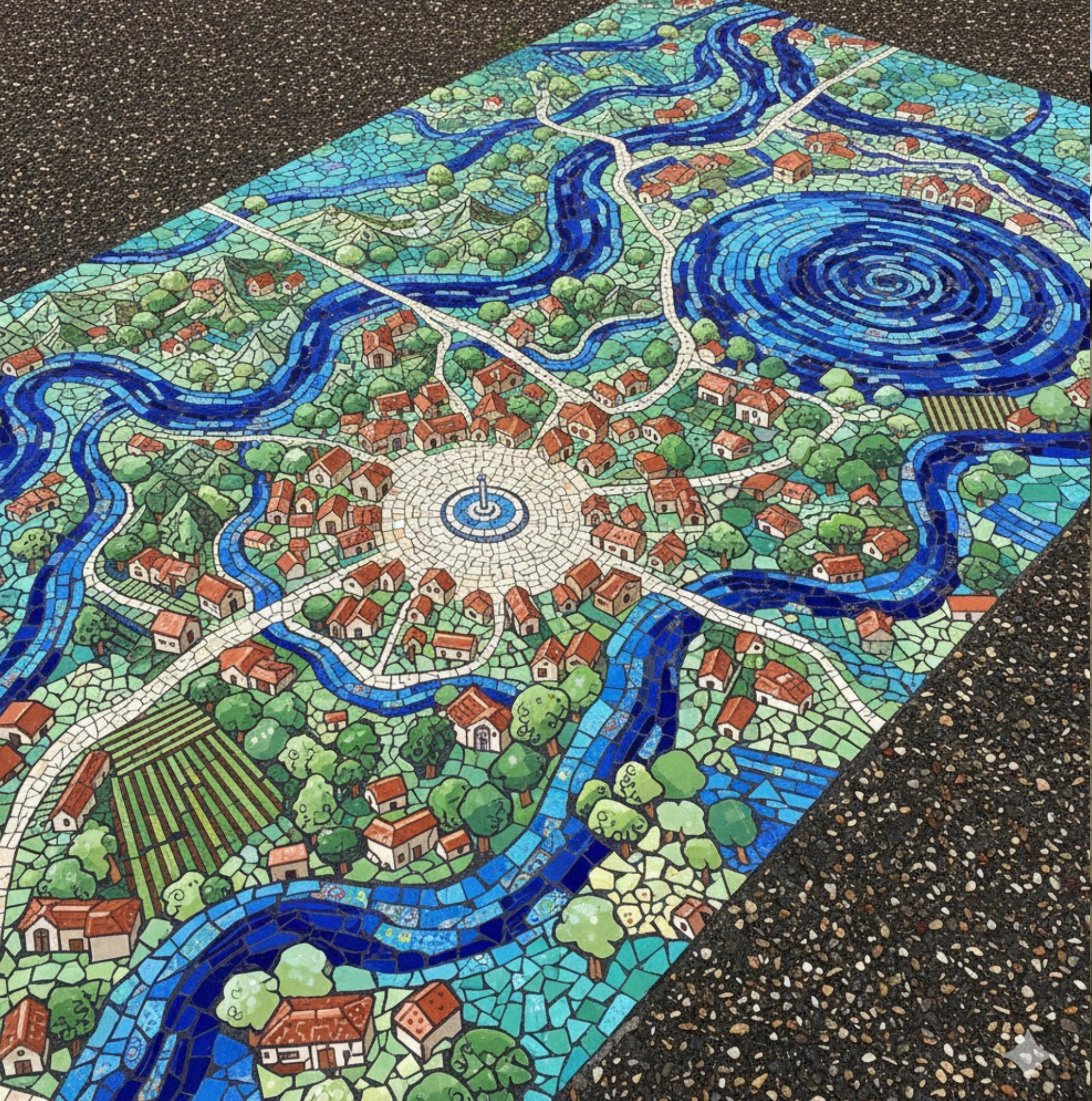


repair



long-lasting

AI generated images



AI generated images





cost estimation

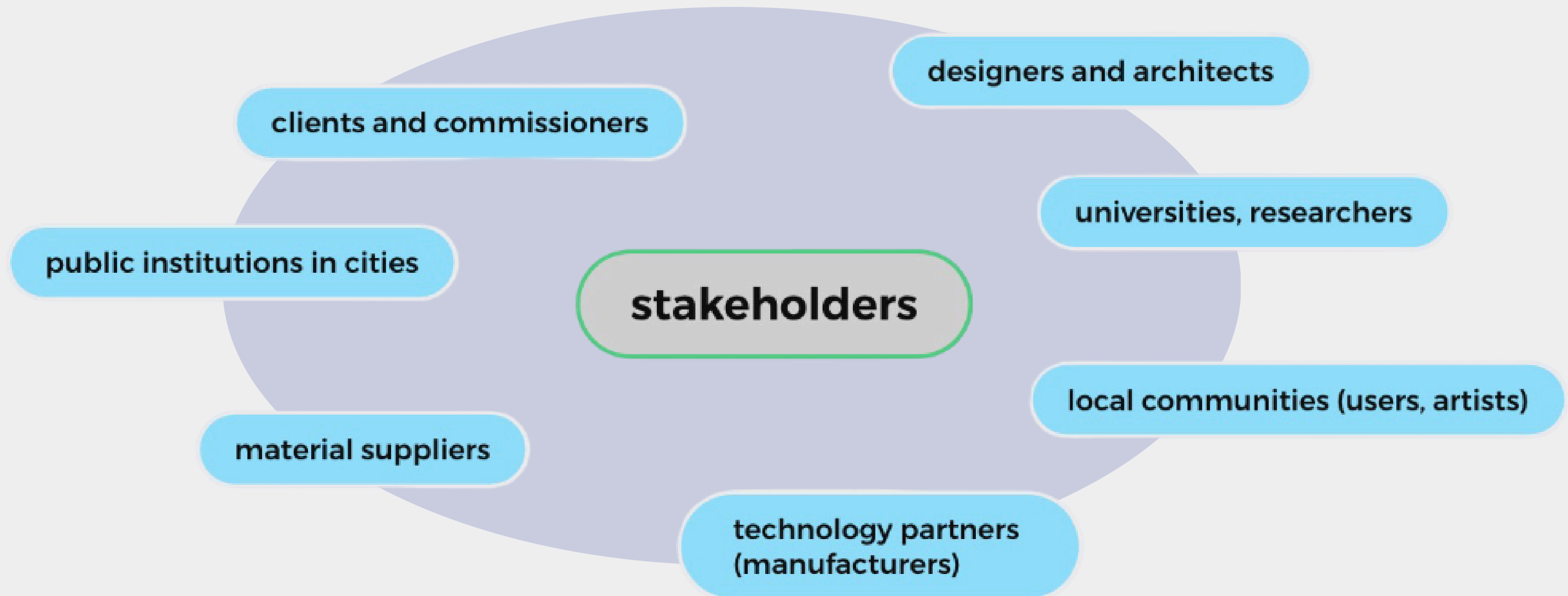
**larger surfaces increase efficiency
when using robotic assistance**

- Manual: ~1,800–2,800 CHF / m²
- Robot-assisted: ~1,200–2,000 CHF / m²

~30% reduction with existing robotic setup
rough estimation - see appendix

for whom?

the primary beneficiaries are:



process visualisation



prototyping on small scale



prototyping tiles

> testing material combination

net reinforcement, grout, concrete,
tiles glues

> quality assessment

strength & stability, surface durability

> aesthetic exploration

color and texture variations,
visual rhythm & layout styles





users testing / feedback

feedback summary



**advantages of
tiles covered
surfaces**



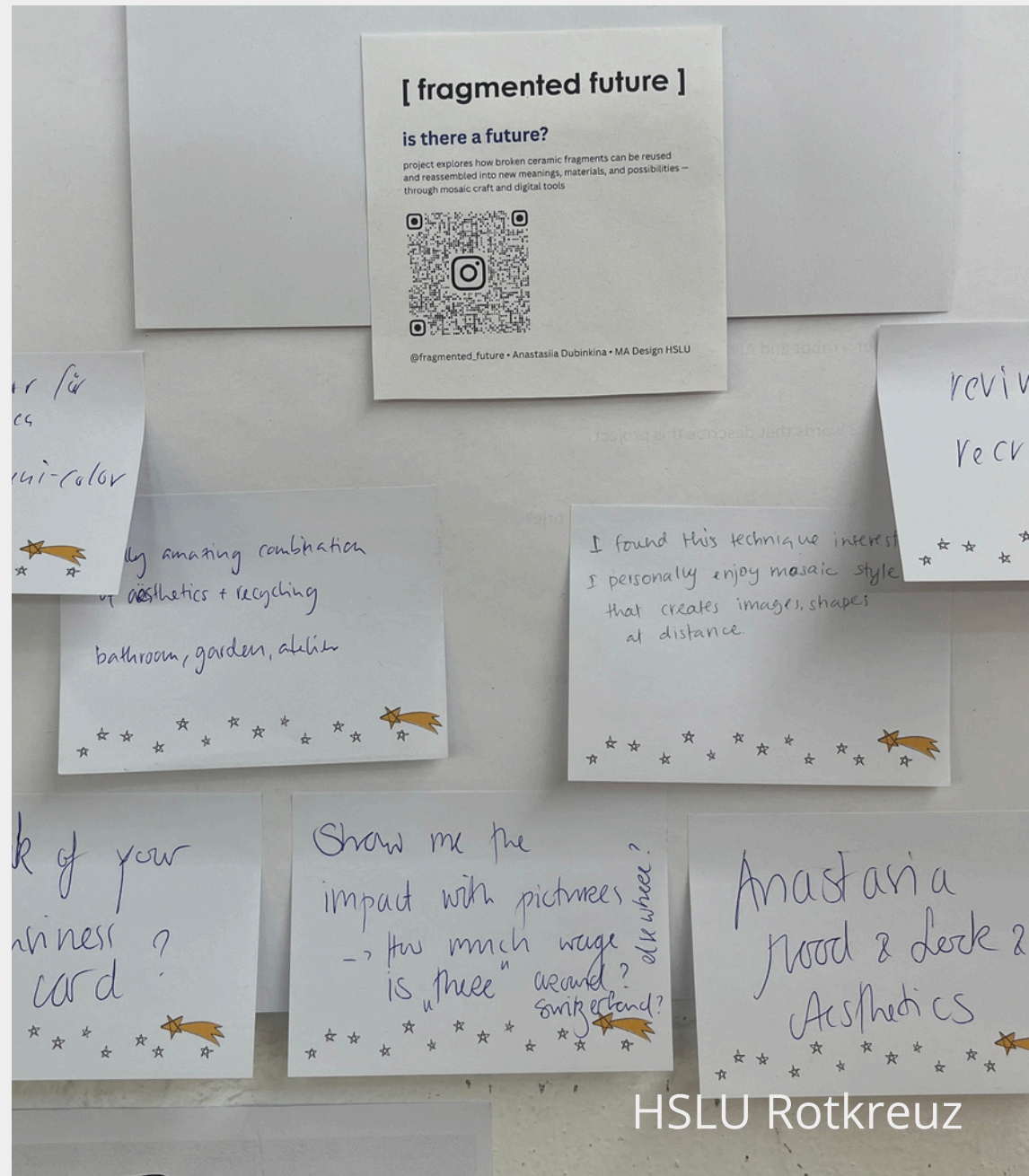
visual appearance



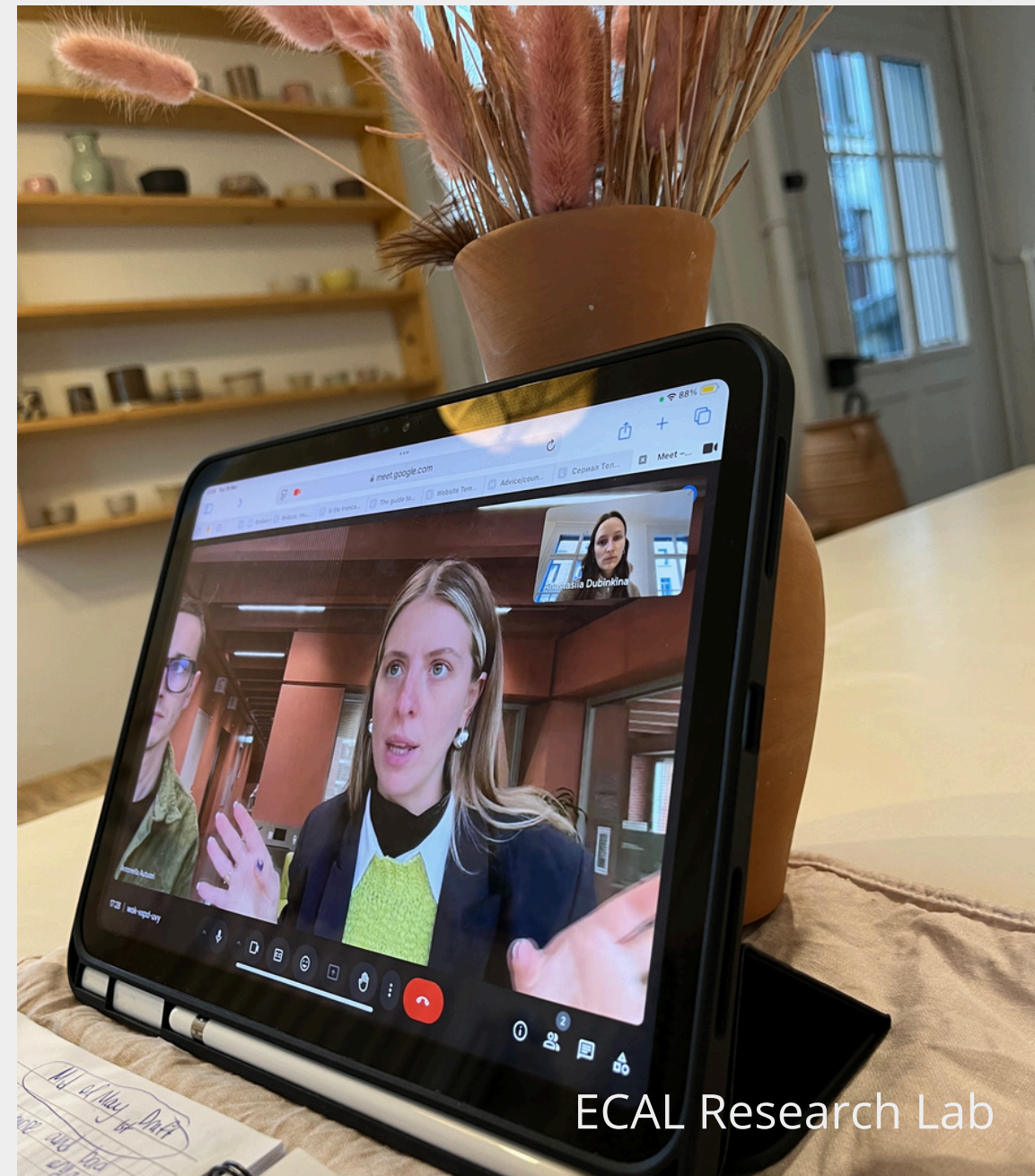
recycling aspect



ETH Zurich



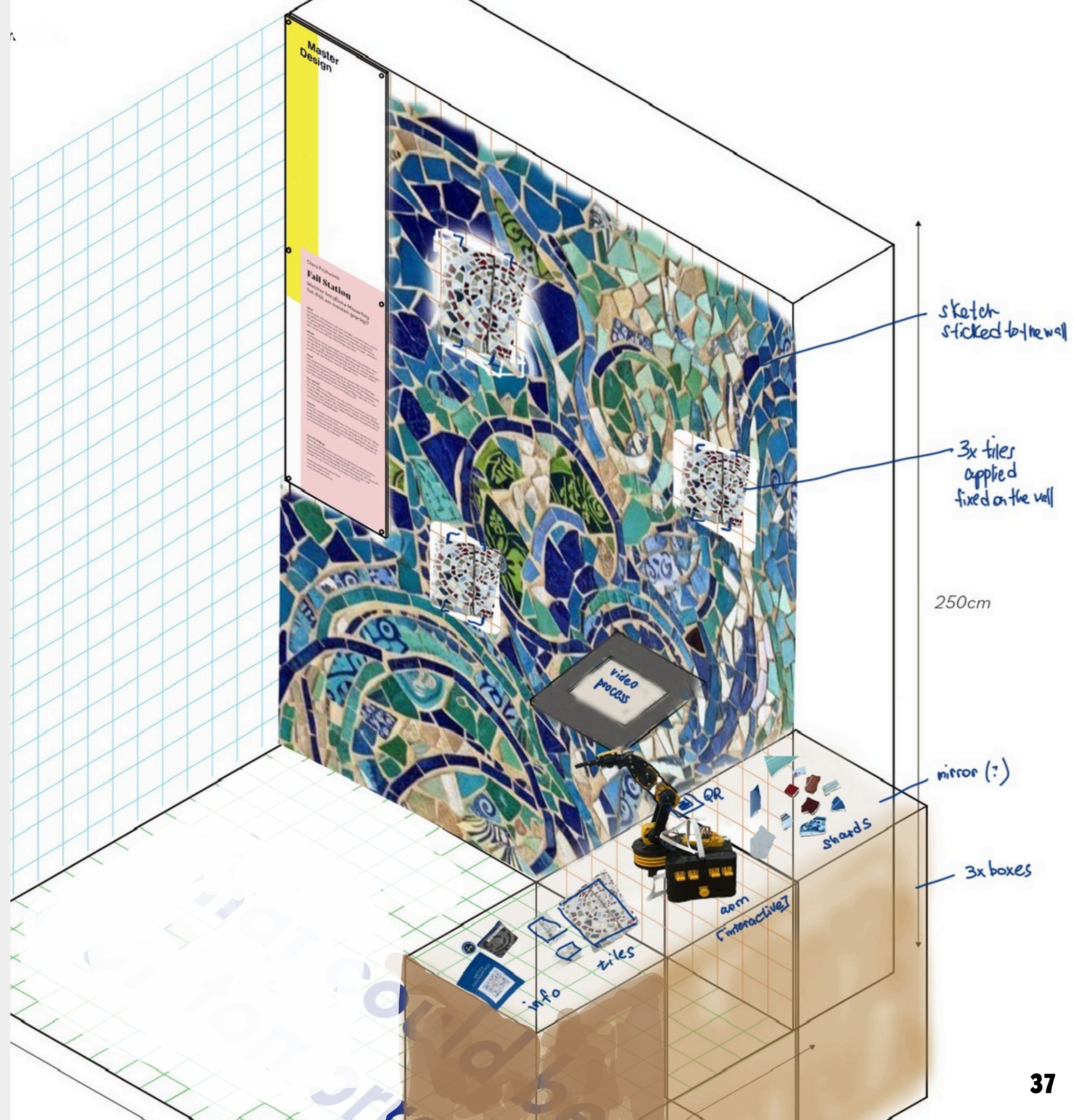
HSLU Rotkreuz



ECAL Research Lab

discussion with professionals

werkschau booth prototype



june, 2026



next steps

- collaborations
|
developing software
further (HSLU, Rotkreuz)
- user testing and more
feedback discussions
- apply for grants and
design competitions
- further developing of
project-case studies >

potential cases - community environments



studio business
unique tiles
production



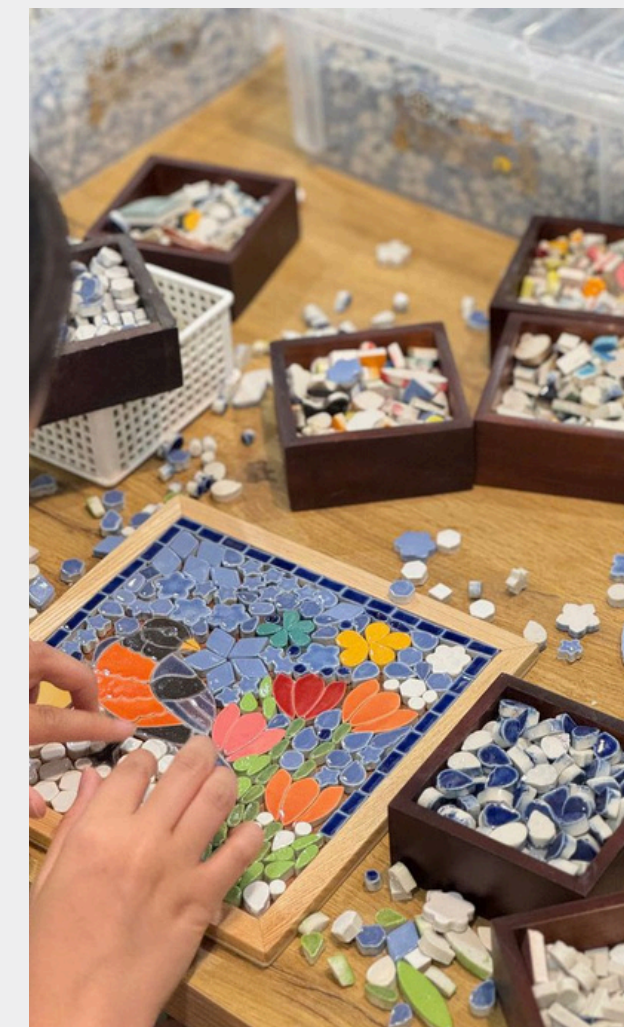
workshops
education
awareness



recycling station
collection points



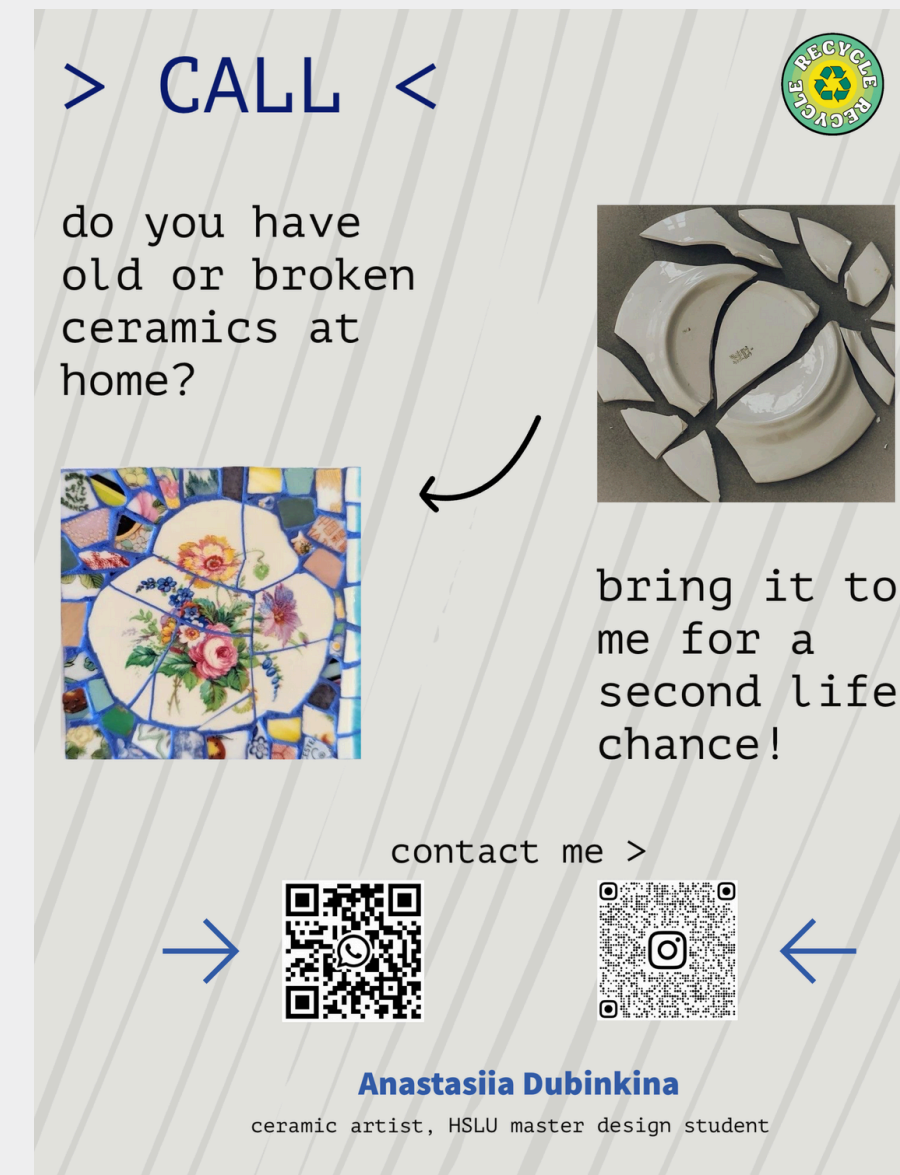
souvenirs
production



diy kit

supporting materials

for local community engagement and project promotion





personal input

throughout this project,
I expanded my practice
beyond my initial discipline

the outcome is a design
process and system, with long-
term potential

remaining applicable and
usable now

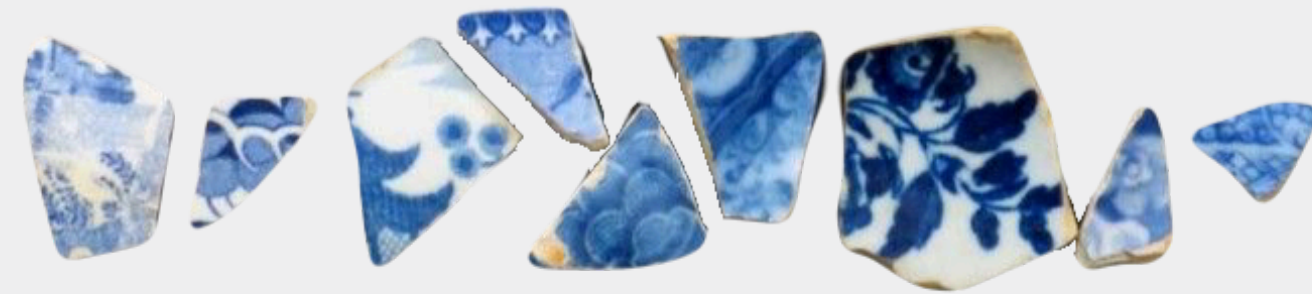
this thesis is a story of fragments becoming futures - not only materials, but also myself

**through research, people, and making, I moved beyond my initial field and built
something new and this is only the beginning**

thank you to everyone who supported me during his journey



thank you for your attention!



@FRAGMENTED_FUTURE

Anastasiia Dubinkina
Master Design 2026
ceramicsana@gmail.com
@fragmented_future

appendix

Photo sources are credited directly on the images.

All remaining photos were taken by the author (Anastasiia Dubinkina).

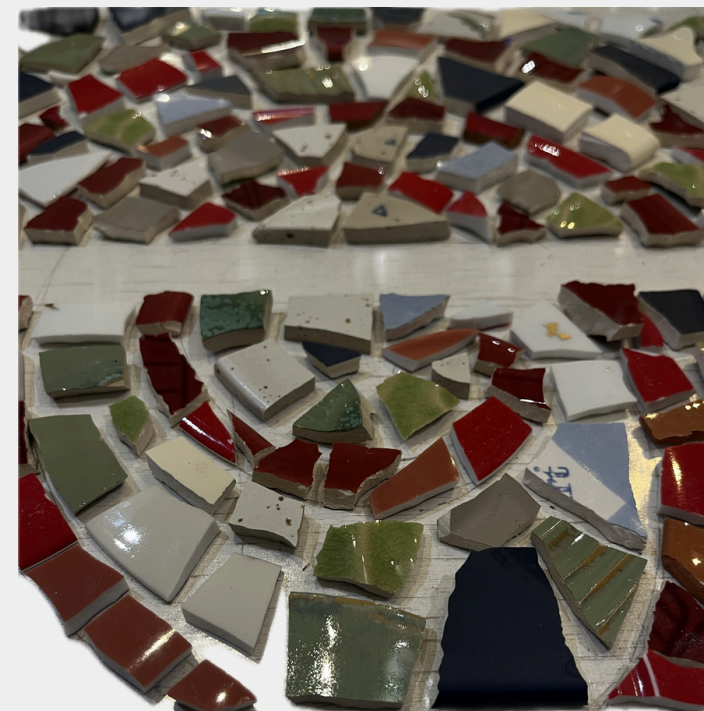
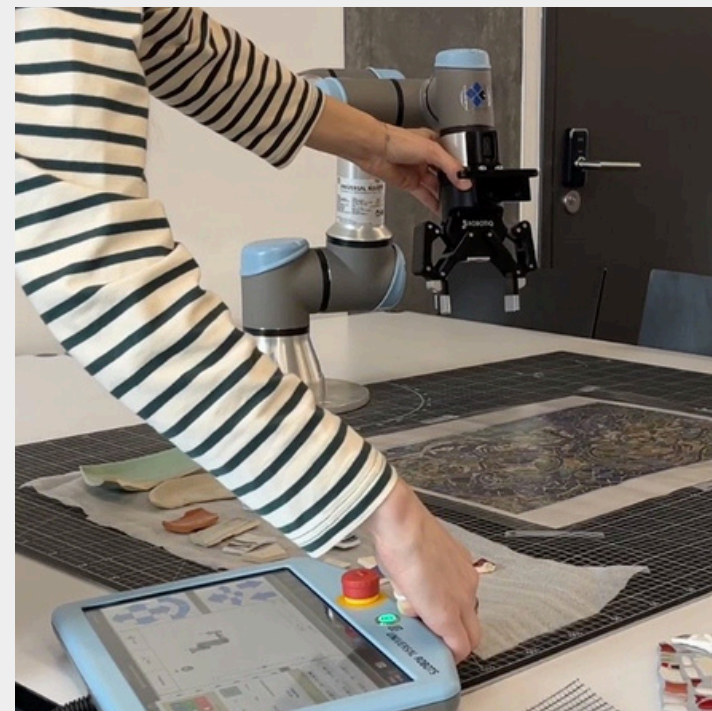
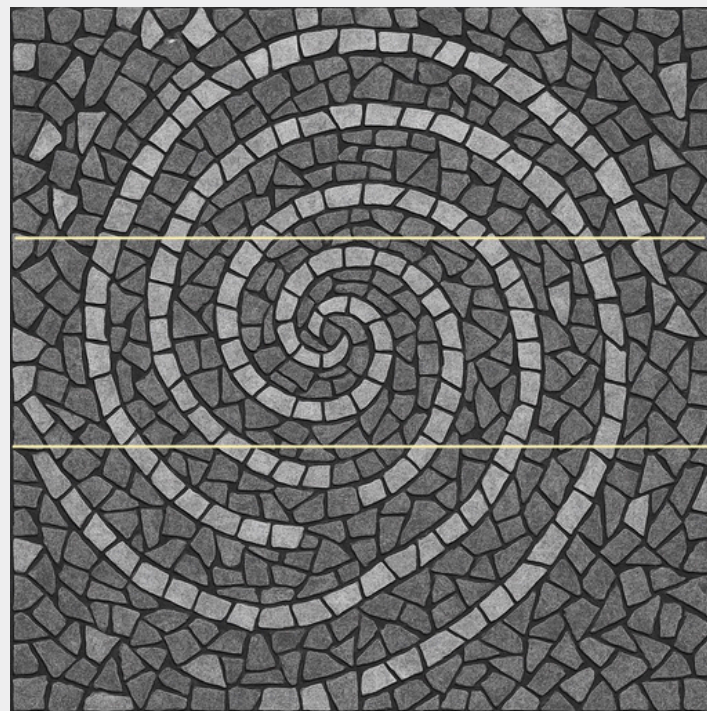
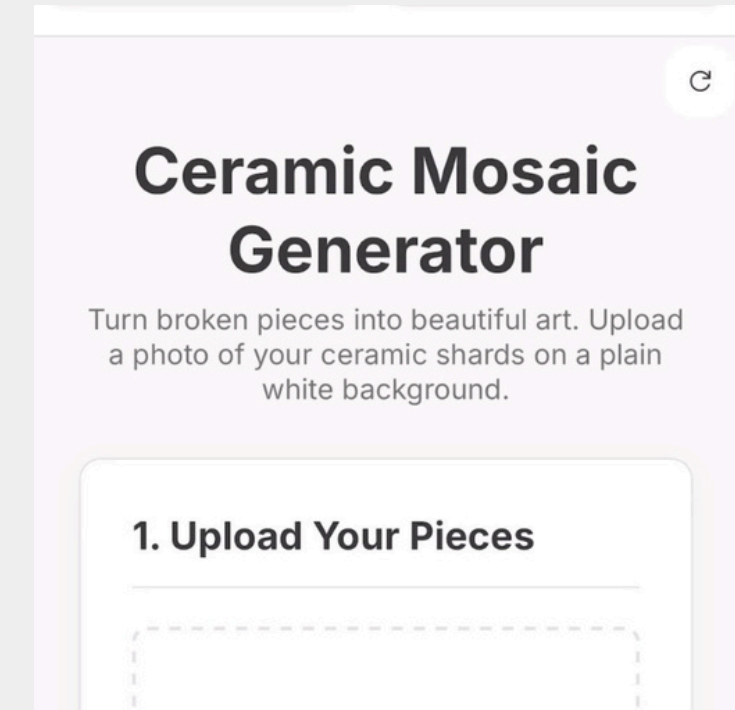
Master Design, HSLU, 2026

machines and humans – together > still hand make looking <



the workflow integrates both human craftsmanship and advanced fabrication technologies
despite its technical complexity, the outcome preserves the aesthetic of a handmade, one-of-a-kind surface
a fusion of industry and emotion – poetic in its own way

process step by step





box for crashing ceramics

Ceramic Waste Recycling - MEKA Global

MEKA Crushing Screening and Concrete Batching Plant Technologies

 mekaglobal.com

making process faster and pieces smaller

rough cost calculation

1) Product A: 1 m² “Designer Tile Panel”

Use case: interior wall feature / premium small commission

Cost blocks (easy to explain)

- Material & logistics: ~120 CHF
(collect + crushing share)
- Labour preparation + digital: ~740 CHF
(cut/sort + scanning + planning)
- Placement (main cost driver)
 - Manual placement: ~1,200 CHF
 - Robot-assisted placement: ~720 CHF
- Finishing + packaging: ~220 CHF
(net + concrete + transport)

Total cost

- Manual: ~2,260 CHF / m²
- Robot-assisted: ~1,780 CHF / m²

Key message:

Robot doesn't make it “cheap” yet – it makes it scalable + precise

All cost figures are rough estimations based on prototype testing and comparable systems; actual costs may vary depending on scale, setup, and production context.

2) Product B: 5 m² “Mural Commission”

Use case: statement wall for café / public space / hotel lobby

Cost blocks (5 m² total)

- Material + logistics + crushing: ~700 CHF
- Prep + archive + design approval: ~3,240 CHF
- Placement (main cost driver)
 - Manual: ~7,200 CHF
 - Robot-assisted: ~4,200 CHF
- Finishing + transport + installation: ~3,500 CHF

Total cost

- Manual: ~14,640 CHF total → ~2,930 CHF/m²
- Robot-assisted: ~11,640 CHF total → ~2,330 CHF/m²

Key message:

Larger projects become more realistic when placement time decreases.

Grow into Hybrid Studio

Phase 1 (0–10k CHF): archive + scanning rig + storage system

Phase 2 (10–50k CHF): robot + safety + gripper + calibration

Phase 3 (50k+ CHF): full automation + industry-scale workflow

Key outcome:

> technology reduces time → time reduces cost → cost enables architecture scale

can all types of ceramic waste be used?

Ceramic waste is not one material.

Low-fired clay → fragile → best crushed into powder and recycle completely

High-fired ceramics → thick/curved (sanitaryware, plate rims) → harder to cut and place flat in mosaics
> laser cutter and crash box can help to make it thinner and smaller



ecological risks

materials can be adapted or expanded depending on the client's requirements

hybrid material combinations (different tiles, adhesives, and grouts) improve performance but reduce recyclability at end-of-life

with high-quality materials and correct installation, the tiles are designed to remain durable for decades

