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Gamification and Mixed Reality as Supplements to Geomorphology Education (Initial Ideas, Implementation and Experiences)

Workshop „Gamification in der Lehre“
Friday, 26th of January, 2024

Featured Topic: Recognising and Understanding Landforms

Geomorphology

deals with question why the shape of the earth's relief looks as it looks:
Different shaping forces in varying intensities and combinations over different timescales.
The shape of the earth's crust is (mostly) deterministic.

Relevance

Applying results of geomorphology is beneficial in all work dealing with
physical properties of a landscape.

Relief parameters closely relate to e.g. soil properties, local climate, mass movements,
drainage, flooding, snow deposition, infrastructure links, building costs,
telecommunication, solar potential, ...

Our starting point

Introducing students of IM programme Cartography into Geomorphology basics.

In particular: Recognition and characteristics of landforms
observed in the field in comparison to their portrayal in maps.

Challenge: Landforms are 3-dimensional features, maps are flat.
How accurate and smooth is the mental transformation from standard
2D depictions (as contour lines in maps) into a 3D shape perception (and back)?

Peculiarities of the Landform (Geomorphology) Topic

Challenges

Description and typification can best be performed by observations in the field, accompanied by topographic maps and aerial/satellite images.	Multiple perspectives/media
Landforms have mostly no sharp boundaries.	Delineation and description of ‘vague objects’
Focussed observations and precise descriptions need training.	Demand for examples/references
Recognition depends highly on existing mental maps of each relevant geomorphological feature (for comparison).	
One dominant process still allows a range of resulting shapes.	Shape variability
A proof for a correct typification is frequently impossible.	Verification problem

Potential Strategies in Teaching this Topic

Useful Approaches

Stimulate use of various media for cognition.

Connect information in different media (what is what
e.g. in a comparison photo – map)

Stimulate team communication (pool existing mental references)

Stimulate discussions leading to a typification.

Substitute 100% proof by high plausibility.

multiple perspectives

spatial linkage

experience

indicators

plausibility

Gamification: Recognition of Landforms Using a Simple Card Game

Idea of a Team Game with expected positive effects on activation, communication, exchange of knowledge.

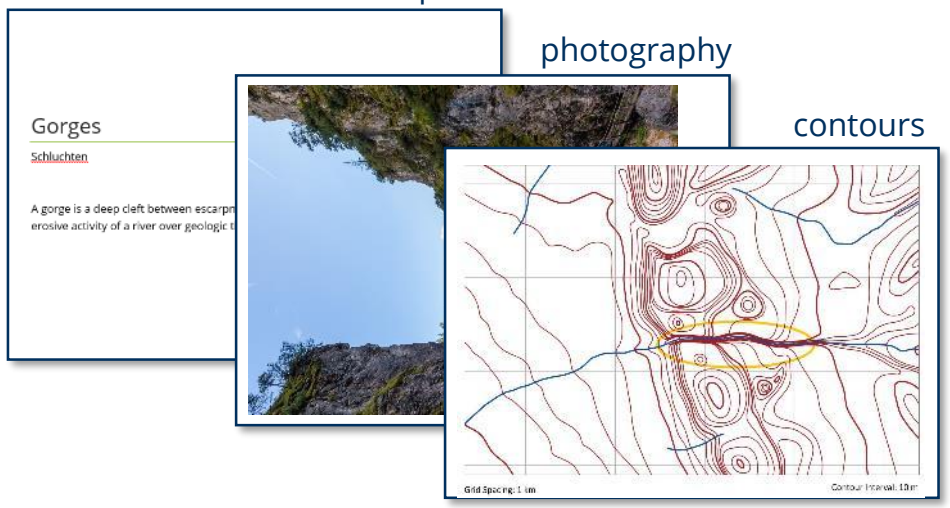
Originally analogue assets for indoor and outdoor use.

- Choice of specific landforms (~20).
- One instance of each landform (e.g. a glacial cirque) presented by three ‘derivatives’ printed on cards: verbal description, photography, contour map.
- Shuffle cards, so matching triplets description/pic/contours become randomly located.
- Let student teams reorder them.

description

photography

contours



Shuffled assets

Combining Gamification and Mixed Reality Potential (1)

3D in a class room should be ideal for educating 3D landforms,
but as a complement to teaching in the field, and not as a substitute.

The ‘detective’ work of forming landform triples from a stack of cards (task 1)
could nicely be implemented in the MR lab.
The physical presence in mixed reality environments facilitates team interaction.

Plug a card from a virtual gallery wall.
Place it in corresponding rows of 3 (verbal description, photograph, contour map)
at the apposite wall.
Simple strategy: Start with the more obvious examples and proceed to the complicated.
Discuss the correct combination among team members.

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Alluvial Fans

Schwemmkegel

An alluvial fan is an accumulation of sediments shaped like a section of a shallow cone, with its apex at a point source of sediments, such as a narrow canyon emerging from an escarpment.

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Photo: Adrian Michael – Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=10610601

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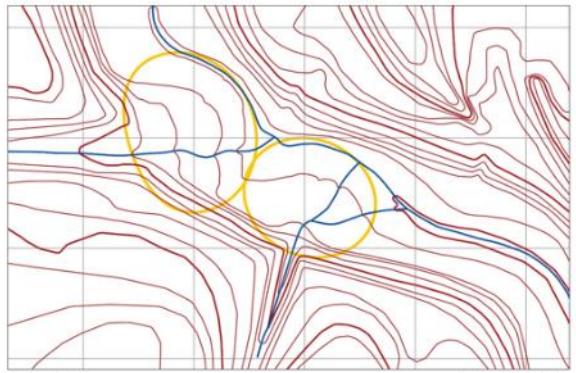


Grid Spacing: 1 km

Contour Interval: 10 m

Relief: Nikolas Prechtel

Combining Gamification and Mixed Reality Potential (2)

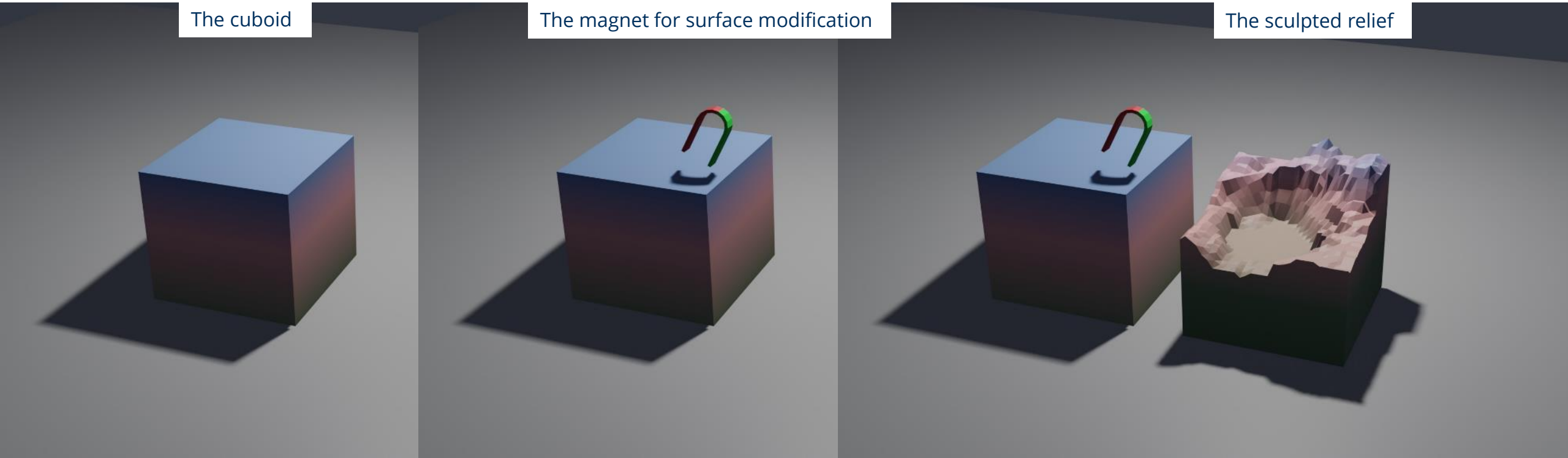
An innovative opportunity is the active virtual sculpting of selected relief forms from a simple virtual cuboid (task 2).

Active making of shapes may strengthen comprehension.

The task is more demanding in its implementation.

Ideal is to display assisting material (e.g. photos from different perspectives).

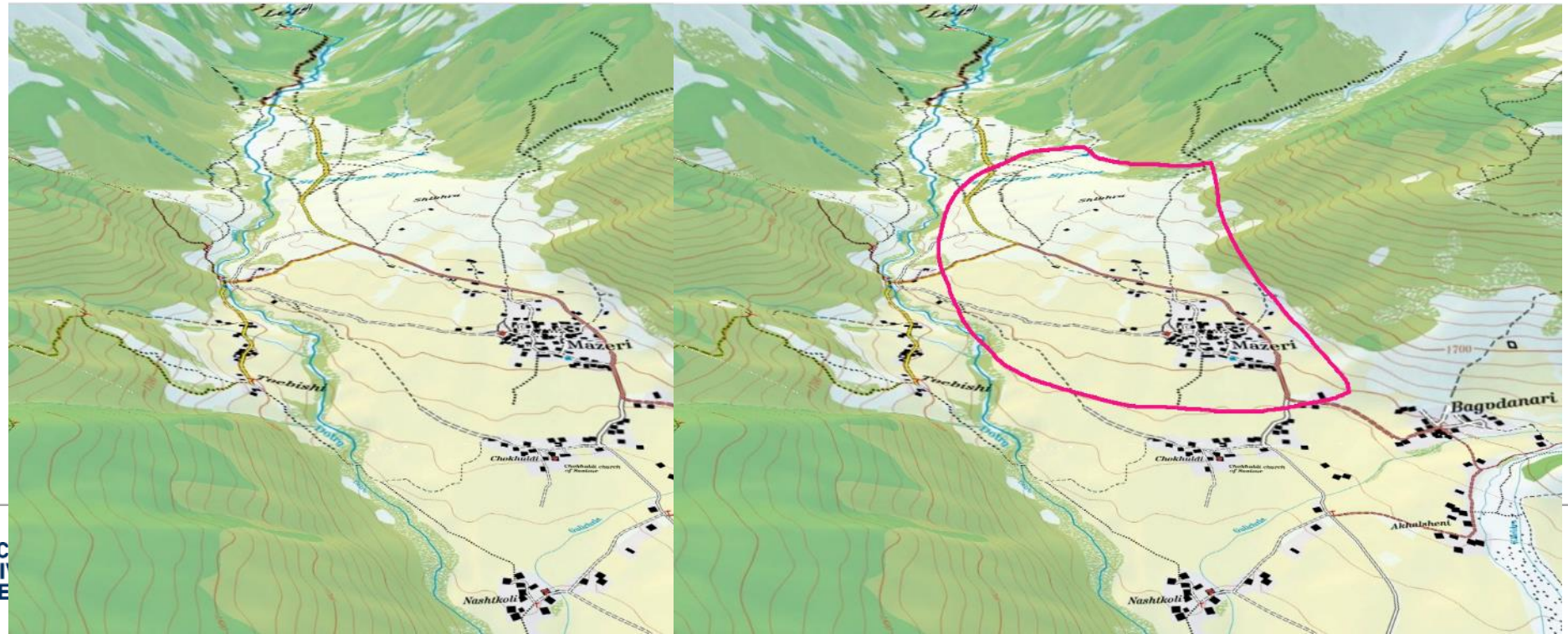
Results will be discussed in terms of plausibility/realism and eventually be improved with the help of the teacher.



Combining Gamification and Mixed Reality Potential (3)

Potential further activity (task 3): Active delineation of landforms in virtual 3D models.
Existing landscapes have to be chosen which display specific forms
in a prototypical way. Necessary sources (elevation grids and imagery) exist.

Task1 – task2 – task3 as a sequence of target skills:
'Recognising idealised landforms' –
'reproduction of landforms (sculpting) in a virtual 3D model' –
'detecting and marking landforms in a non-idealised model (taken from reality)'.



Preliminary Experiences

Students quite enjoyed gamification.
The ‘geomorphology card game’ works everywhere (analogue and virtual).
Sculpting landforms and delineating landforms are games designed for a MR lab.
The active delineation in 3D models is just an idea and not yet implemented.

Gamification + 3D viewing is an attractive solution for a topic that is about 3D shapes.

Virtual environments presenting landscapes in 3D are – if compared to field work:

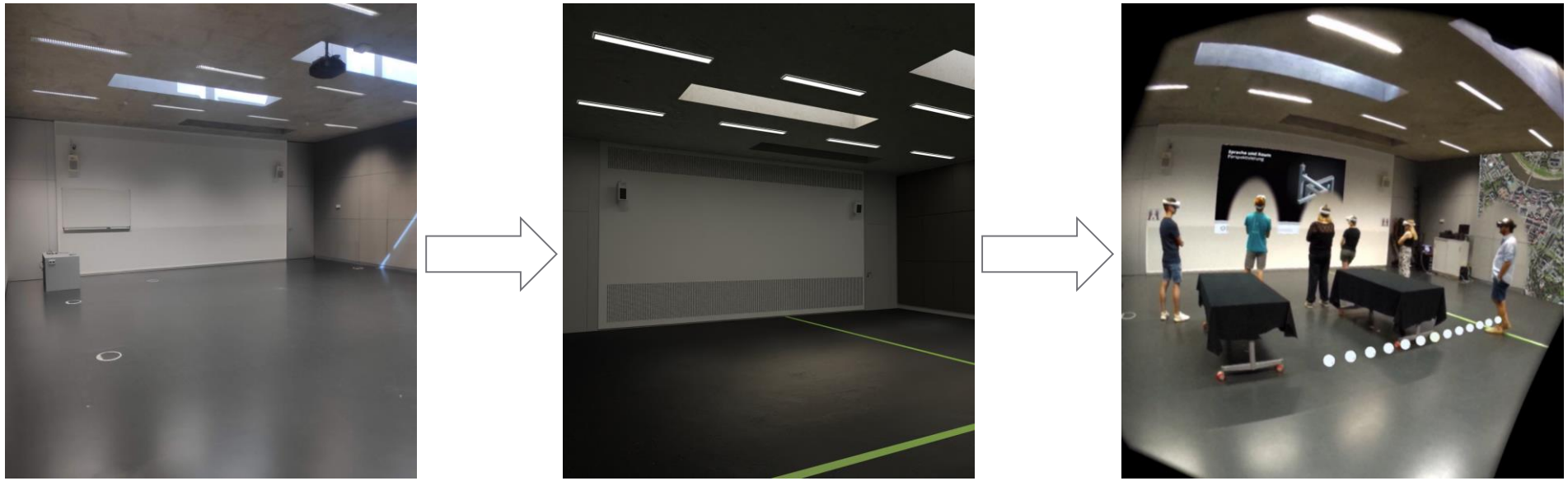
- barrier-free
- cost- and time-efficient.

However, they stay at the surface, and are limited to image and map availability, and will not replace field visits.

We have by no means fully exploited the potentials of MR and Gamification (our experience is based on totally one class of ~90 minutes).

Whether similar ideas may find entrance, has much to do with the implementation (skills, hardware performance, time invested, limits in number of attendants).

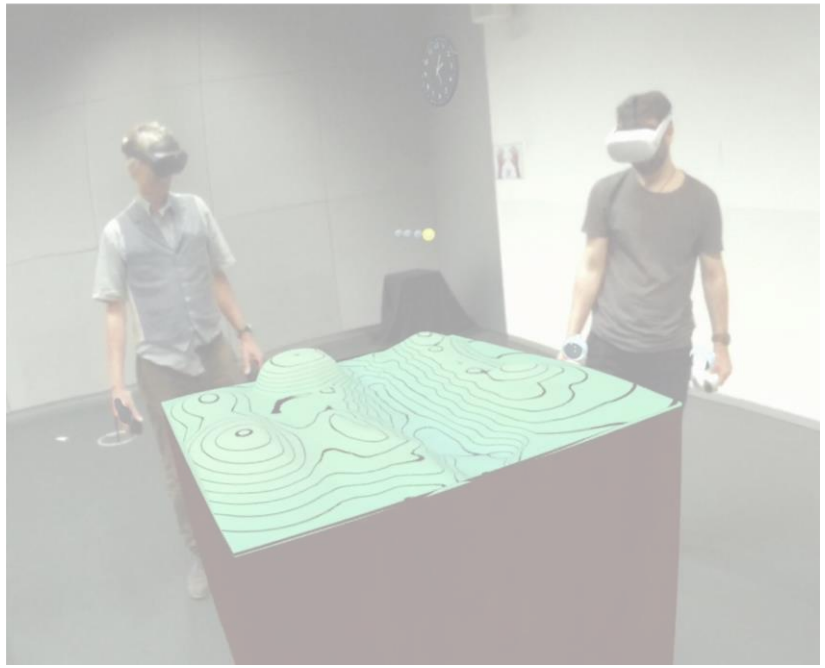
Aspects of Mixed Reality Implementation (1)



- Development of Mixed Reality Environment
- Digital Twin of 11m x 12m
- Our open source framework* for calibration, colocation, and mixed reality blending

* “ViewR: Architectural-Scale Multi-User Mixed Reality with Mobile Head-Mounted Displays." *IEEE Transactions on Visualization and Computer Graphics* (2023)

Aspects of Mixed Reality Implementation (2)

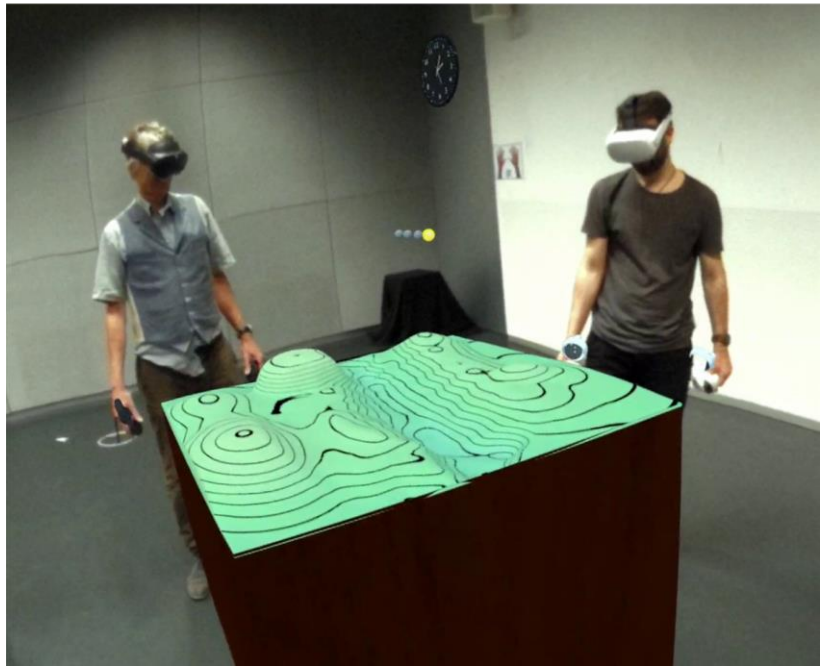


Geomorphology Card Game

- Dept. of Cartography provided digital version of cards.
- Interactable digital cards were implemented using our system.

* “ViewR: Architectural-Scale Multi-User Mixed Reality with Mobile Head-Mounted Displays." *IEEE Transactions on Visualization and Computer Graphics* (2023)

Aspects of Mixed Reality Implementation (3)



Active Virtual Sculpting

- Virtual Brush, with radius of influence
- GPU based implementation for faster execution
- For every vertex within the brush radius, the terrain basically adjusts the height addition or subtraction depending on the delta height of the vertex and brush positions.

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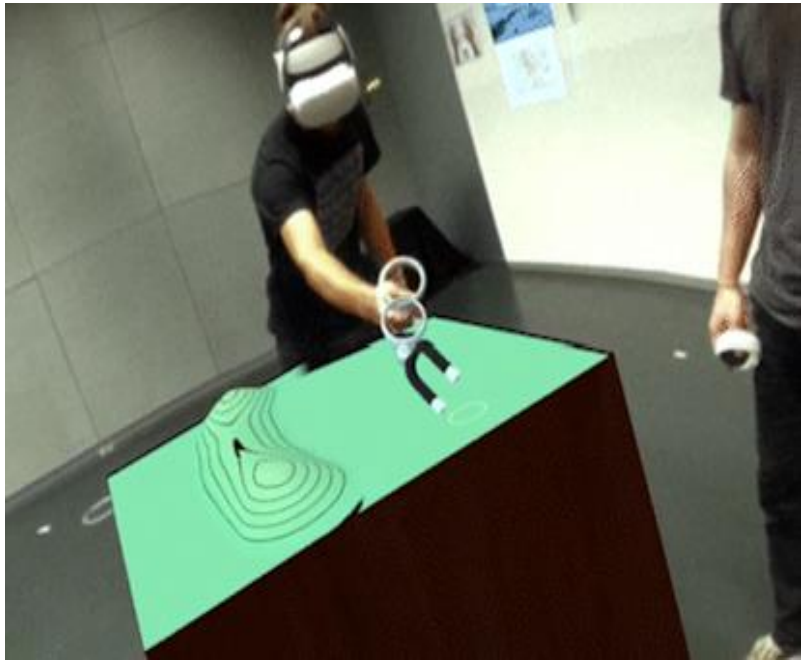
Aspects of Mixed Reality Implementation (4)



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