Tangible Landscape: a hands-on method for teaching grading and geomorphology

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Abstract

We present a hands-on method for teaching grading, geomorphology, and hydrology using Tangible Landscape – a tangible interface for geospatial modeling. Tangible Landscape couples a physical and digital model of a landscape through a real-time cycle of hands-on modeling, 3D scanning, geospatial computation, and projection. With Tangible Landscape students can sculpt a topographic model of a landscape with their hands and immediately see how they are changing geospatial analytics like contours, hill-shading, and flow water. By kinaesthetically feeling and manipulating the shape of the topography students can intuitively learn about 3D topographic form, about topographic representations, and how topography controls physical processes. A series of experiments has demonstrated that Tangible Landscape is highly intuitive and can improve users 3D spatial performance by enabling embodied cognition. In this paper we propose tangible teaching methods using real-time geospatial analytics such as contour modeling, simulated water flow, landform recognition, cut-fill analysis, and landscape evolution. We also discuss how these methods can be integrated into landscape architecture and geomorphology curriculums.

Keywords: topography, grading, geomorphology, tangible user interfaces, geospatial modeling, education, embodied cognition, serious gaming

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1. Introduction

1.1. Why and how grading is taught

Understanding and representing the earth's surface
Cartography
Earthmoving
In landscape architecture and civil engineering:
Focus on contours for representation
Focus on meshes for computation and construction

Teaching grading
Represent and manipulate topography
Drawing 2D contours
Cutting 3D contour models

1.2. Literature review

1.2.1. Curriculum review

1.2.2. Methods review

1.2.3. Spatial cognition

1.3. Aims and objectives

Aim: Develop an intuitive method for learning about and manipulating topography, geomorphology, and hydrology that encourages embodied cognition and metacognition.

1.4. Concept

Tangible Landscape as an educational tool
3D rendering and VR
Serious gaming

2. Tangible Landscape

2.1. Technology

2.2. Experiment

[1]

3. Teaching methods

3.1. Water flow

Challenge: find the highest point from which water will flow to a given point
Analysis: r.drain / drain direction
Interactions: marker
Learning: water flow

Challenge: sculpt topography to make water flow to a given point
Analysis: water flow
Interactions: sculpting
Learning: water flow

Challenge: sculpt topography around exposed bedrock to make water flow to a given point
Analysis: water flow with exposed bedrock
Interactions: sculpting
Learning: water flow, volume

Challenge: given landcover sculpt the topography to make water flow to a designated point
Analysis: water flow with landcover
Interactions: sculpting
Learning: water flow, volume

3.2. Landforms

Challenge: each round build the specified landforms until the time limit
Rounds: 1. build a ridge, 2. build a valley, 3. . . .
Analysis: geomorphons, contours
Interactions: sculpting and section cut (Blender)
Learning: landform types, transitions, and relationships.

3.3. Cut-fill

Challenge: build a given landscape
Analysis: difference, contours
Interactions: sculpting
Learning: volume and cut/fill

3.4. Fabrication

Challenge: digitally 3D model a landscape, render in 3D, and 3D print, cast a sand model for TL, and scan the sand model.
Learning:

3.5. Evolution

Challenge: predict and model how a given landscape will evolve
Analysis: contours, water flow, erosion-deposition, landscape evolution, and difference
Interactions: sculpting
Learning: water flow, erosion-deposition, and landscape evolution

3.6. Trails

Challenge: find the easiest route across the landscape
Analysis: trail slope, trail profile, least cost path, r.walk
Interactions: markers
Learning: wayfinding

Challenge: find the easiest route to somewhere with a view of a given feature
Analysis: trail slope, trail profile, least cost path, r.walk, viewshed
Interactions: markers
Learning: wayfinding and viewsheds

3.7. Design

Challenge: grade topography and plant trees, shrubs, and groundcover to minimize erosion and make a beautiful landscape.
Analysis: water flow, erosion-deposition, 3D rendering, and VR
Interactions: sculpting, planting model trees, and placing felt groundcover
Learning: design thinking, water flow, and erosion-deposition

Challenge: place a house, make a lake in view of the house, build an access road, build a trail to the lake, fill the lake with a stream, and use all cut-fill.
Analysis: viewshed, water flow, ponding, difference, least cost path, r.walk, 3D rendering, and VR
Interactions: sculpting, markers, and objects
Learning: design thinking, viewshed, wayfinding, water flow, grading, and cut-fill

3.8. Detailed design

Challenge: Grade a road that stays dry with minimal cut-fill
Analysis: v.civil.road
Interactions: sculpting
Learning: grading details, water flow, and cut-fill

4. Results

5. Discussion

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Cognition, affect / emotion, motivation, and metacognition
Experimentation and evaluation
Integration with virtual reality

6. Curriculum

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7. Conclusions

Appendix A. Building Tangible Landscape

References

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