Learning topography with Tangible Landscape games

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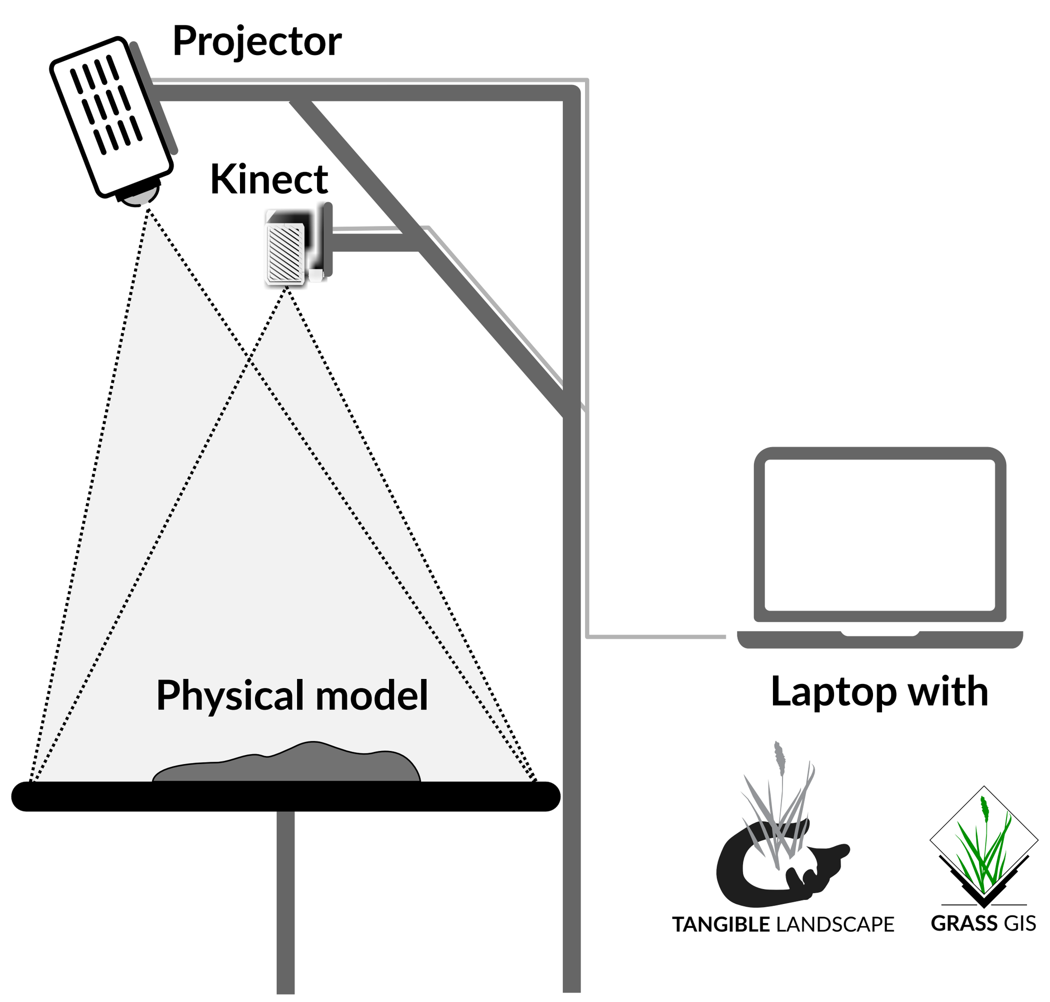
TANGIBLE LANDSCAPE

Introduction

We developed and tested a new method for teaching hydrology, geomorphology, and grading 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:

- feel and manipulate the shape of topography with their hands and use a variety of tangible objects
- sculpt a projection-augmented topographic model of a landscape while seeing dynamically computed projected geospatial analytics
- intuitively learn about 3D topographic form, its representations, and how topography controls physical processes



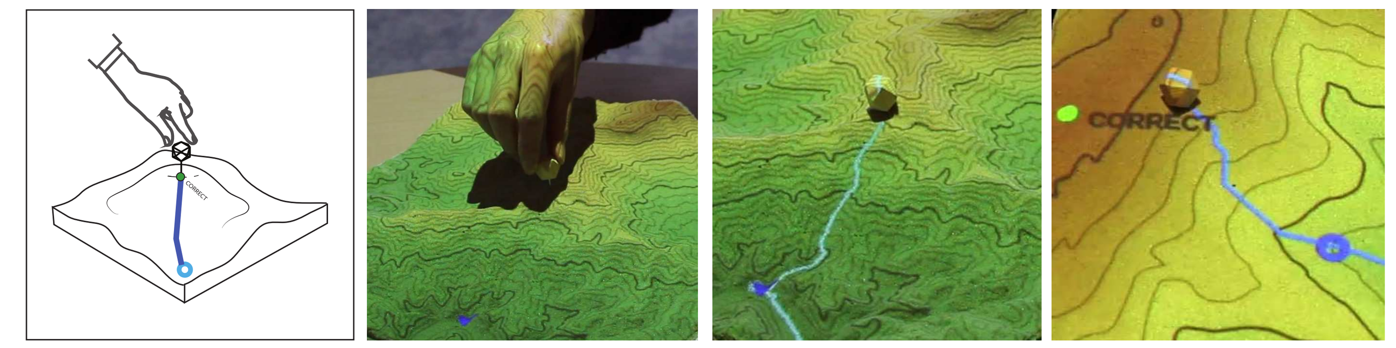
Tangible Landscape powered by GRASS GIS, an open source platform with extensive libraries for geospatial modeling, can be flexibly programmed to accommodate simple to complex geospatial applications and simulations, thus providing a broader range of teaching opportunities than preceding geospatial tangible user interfaces (TUI).

Tangible Landscape games

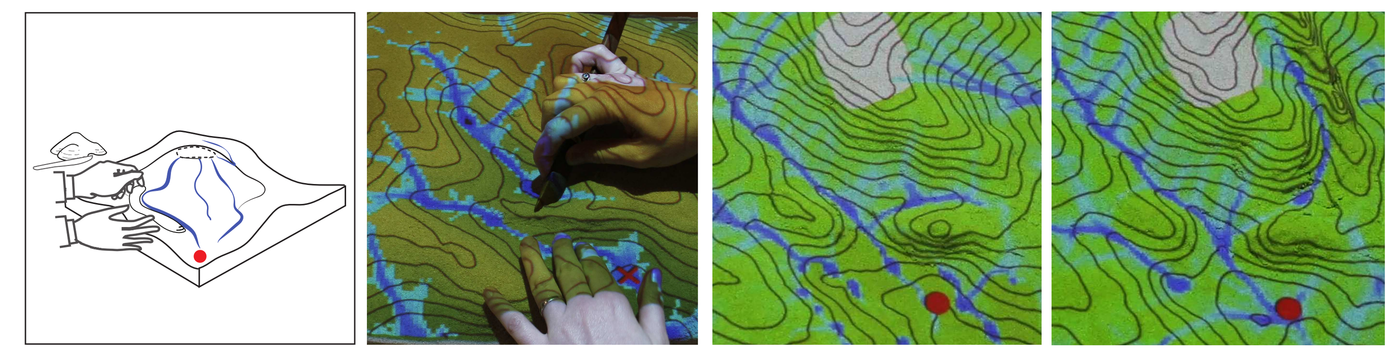
Students of a graduate level course on grading participated in a series of workshops, which were developed as serious games to encourage learning through structured play. The games focused on hydrology, geomorphology, and grading concepts.

Interaction | Feedback | Solution

Water flow task: Find the highest source point from which water will flow into the target point in the landscape. Mark the location of the source point location by inserting a wooden pin into the model.

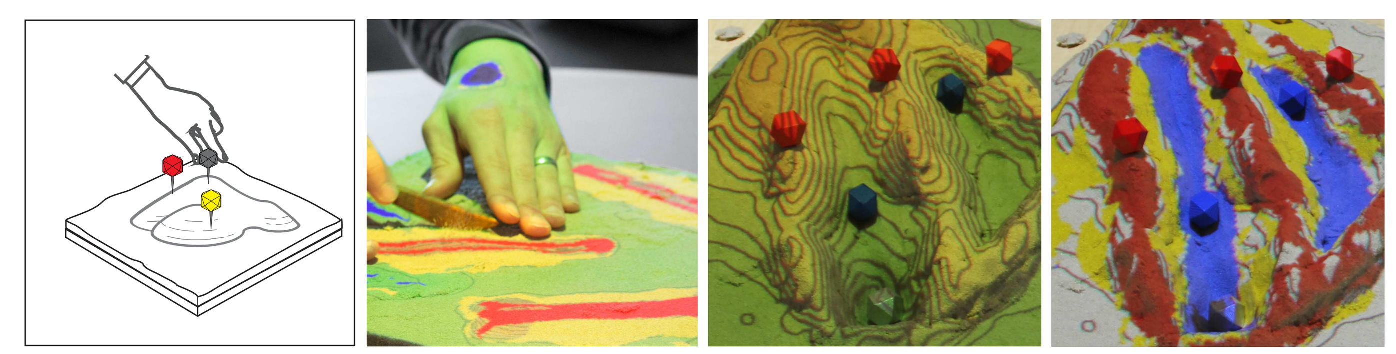


Channeling task: Modify the terrain with minimal changes to make water flow from the given source point to the given target point. Use your hands or sculpting knife to shape the topography.

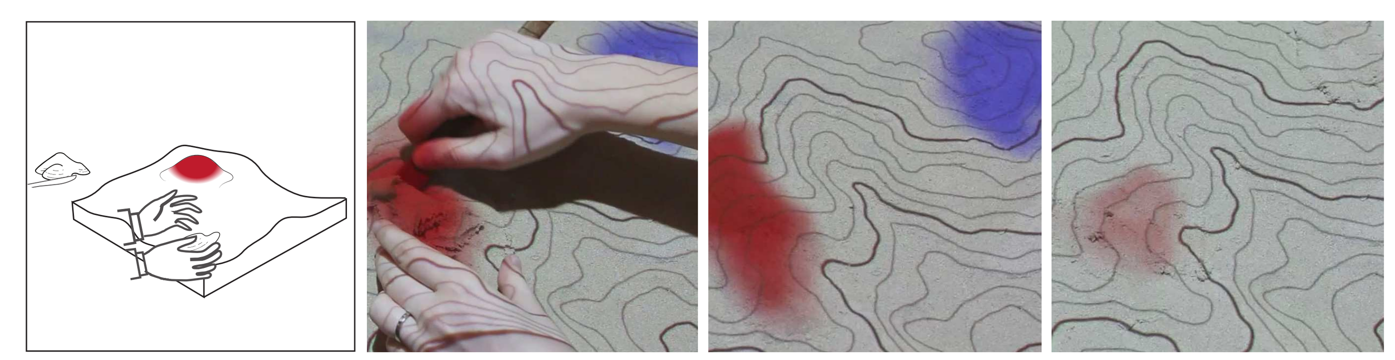


Ponding task: With the given amount of sand and the existing topography build a damn on a stream to impound maximum volume of water. Use your hands or sculpting knife to make dams in the landscape.

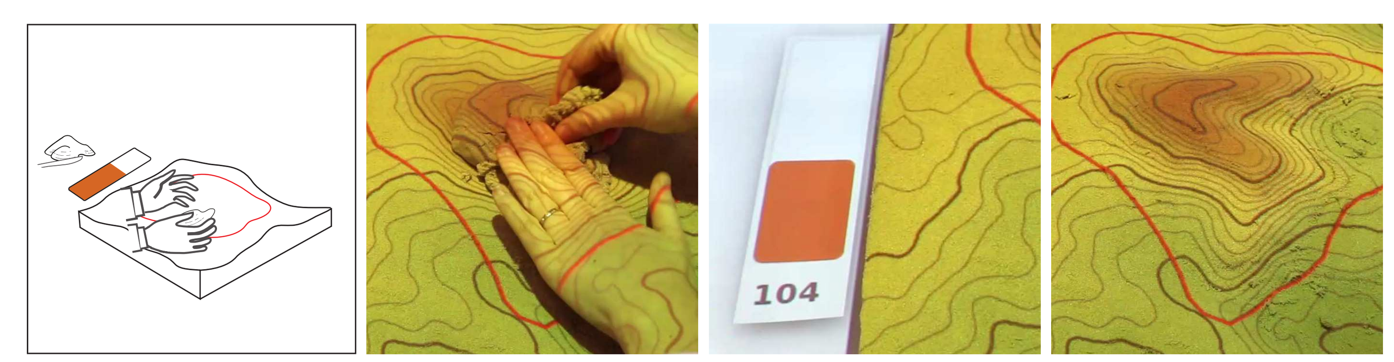
Landform task: With your hands sculpt combinations of specified landforms (depressions, ridges, valleys, peaks) and identify them. The combinations get increasingly difficult.



Simple cut & fill task: Modify a given landscape using dynamically computed cut and fill projection, where blue indicates the areas where sand should be added (fill), red indicates where sand should be removed (cut), and the color intensity indicates the magnitude of the difference.



Advanced cut & fill task: Modify existing topography in highlighted areas to match the projected contours and color by removing or adding sand. The indicator shows the total elevation difference between the scanned model and the expected topography.



The geospatial analyses displayed as feedback are implemented in the following GRASS GIS modules: r.drain (flow routing), r.sim.water (flow simulation), r.fill.dir (elevation depressions), r.geomorphon (landforms), r.mapcalc (elevation difference).

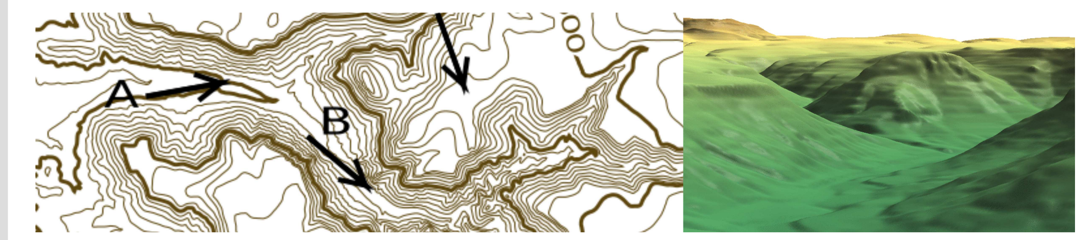
Pilot user study

Goal Test the effectiveness of a tangible teaching method — implemented with Tangible Landscape — for teaching concepts of grading, geomorphology, and hydrology.

Subjects 16 graduate students from a Landform and Grading course in the Department of Landscape Architecture

Assessment

- Usability and user experience (UX) survey designed and validated for geospatial TUIs,
- Three assessments administered before and after workshops to assess acquisition and transfer of spatial skills: topographic map assessment (TMA) and two assessments specific to landforms and cut & fill tasks



TMA example task

Results Findings provide evidence that Tangible Landscape supports improved UX and marginal, task-specific knowledge building.

- The objects' physicality enabled participants to effectively interact with the system, positively impacting ratings of the system's usability and UX.
- No significant response accuracy differences for TMA nor landform assessment, potentially due to mismatched psychometric properties of examining tangible (3D) teaching methods with 2D assessments of learning outcomes.
- Students scored significantly better on the cut and fill assessment after workshop, in comparison to before.

Additional resources

Tangible Landscape github.com/tangible-landscape
User survey and TMA osf.io/b6njq
NCSU GeoForAll Lab geospatial.ncsu.edu/osgeorel

References & Acknowledgement

[1] Petrasova, A., Harmon, B. A., Petras, V., Mitasova, H., 2015. *Tangible Modeling with Open Source GIS.* Springer International Publishing, 135 p.

[2] Neteler, M., Bowman, M. H., Landa, M., Metz, M., 2012. *GRASS GIS: A multi-purpose open source GIS.* Environmental Modelling & Software, 31(0), 124–130.

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