Paper-to-Parameters:
Designing Tangible Simulation Input

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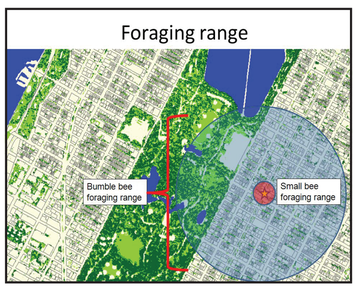
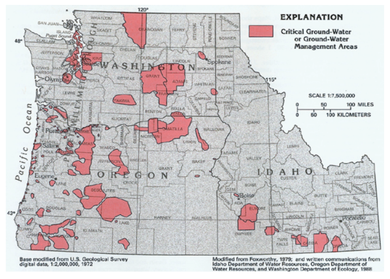
Problem Space: Environmental Science Education

- Redesigned educational standards stress:
  - Systems-based approach
  - Human-environmental interaction
- Need new tools to support content changes
- Many problems are rooted in spatial configurations
  - Green Infrastructure: Adding natural spaces to urban landscapes to support:
    - Groundwater sustainability
    - Pollinators





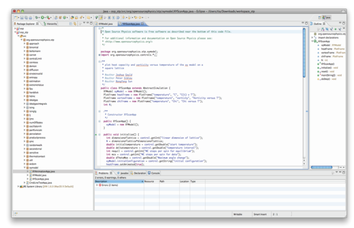
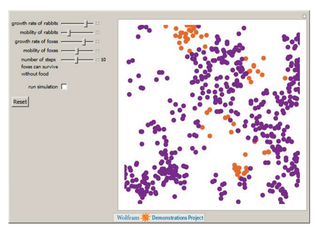
Top Left: Example of rooftop green infrastructure
Top Right: Example of planning community parks to support bee habitats
Bottom Left: Example of groundwater distribution across municipalities

Current Approach: Agent Based Models

- Tool frequently used by scientists for understanding human-environmental systems
- School standards stress importance of gaining familiarity with authentic tools

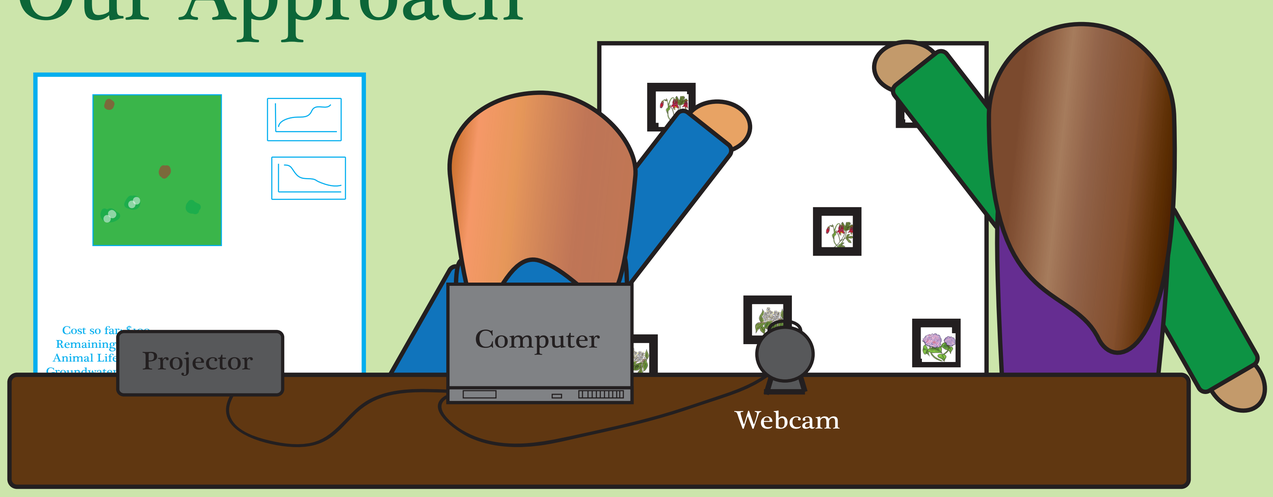
Prior Work:

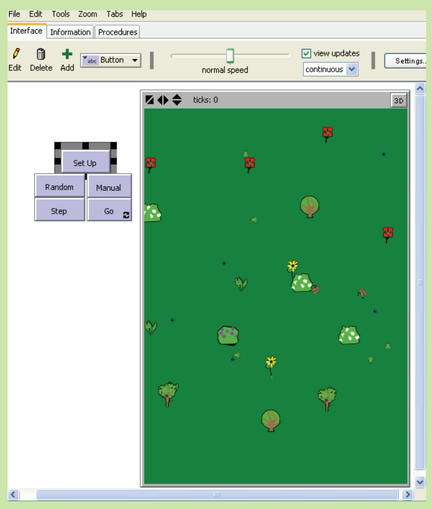
Many successful educational Agent Based Models (ABMs) already exist, but user interfaces tend to belong to two classes:

	Programming-based UIs	Slider-based UIs
UI designs impact how software is used in classroom:		
Instruction time	Long	Short
Exploration style	Open-ended	Structured
Student:Computer ratio	~~1:1 or 2:1~~	
Spatial manipulation	~~N/A: locations fixed or stochastic~~	

We want to support:
Get students into activity quickly
Allow for creativity
Many : 1, because most science classrooms only have 1 computer
Easy spatial manipulation

Our Approach





Paper-to-Parameters (PtP)

- Students place paper symbols on a wall as input

Examples:

- PtP uses computer vision to recognize symbols
- Symbol identity and location converted ABM input
- ABM projected on classroom wall

Advantages:

- Instruction time focused on content material, not how to use software
- Supports open-ended scenario construction without need to program
- Supports whole-class learning activities with a single computer
- Spatial manipulations accomplished by moving "puzzle pieces"
  - Similar to paper-based practices in urban planning

Initial Study

Goal:

Need to support efficiency in spatial manipulations to build the student's understanding of spatial interdependencies.
When manipulations are efficient, wider/deeper exploration of the problem space can occur.

Task:

Students may be expected to design yards containing 15-30 items; want to test placement efficiency
- We timed task of placing 16 items to match a given configuration, under 2 conditions:
  (1) PtP method
  (2) programming locations directly (the current standard approach)

Results:

Average item placement time:
(1) PtP: 4 seconds per item
(2) Programming: 31 seconds per item

Total time to place 16 items:
(1) PtP: 1 minute 11 seconds
(2) Programming: 8 minutes 8s

Future Work

Research:

We believe tangibles:
- Change the nature of collaboration
- Change the problem solving efforts

Thus, a user study comparing a dual-mouse drag-and-drop interface for the simulation with the tangible interface for the simulation is planned
- Pairs will perform an urban planning task together

Technical Development:

- Using OpenCV to eliminate the need for the thick borders around the images required by ARToolkit
- Integrating the simulation and OpenCV input for real time manipulation.

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We would like to thank Kevin Matteson for providing images.