Using School-Gardens as a Physical and Virtual Modeling Environment

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UC Berkeley
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Vision

Students will engage in a multi-week garden unit with their science class where they tend to the ecosystem and make detailed observations of biotic - abiotic relationships.

They will test and model their ideas about the relationships in the virtual space, using others’ ideas to help them revise and refine their own.
Motivation

**Engagement**
Outdoor experiential learning offers the chance to personally connect to science content through multi-sensory activities, particularly students typically excluded from traditional STEM fields.

Bell et al. (2009); Ozer (2007); Ralston (2011)

**Complexity**
Students can develop both domain and complex systems knowledge by conjecturing about and programming their garden observations into an agent-based behavioral language.

Eilam (2012); Harel & Papert (1990); Manz (2012)

**Collective Inquiry**
Sharing models and iterating on ideas within a whole-class network can develop students’ understandings of both the physical ecosystem and its virtual representation.

Jacobson & Wilensky (2006); Lehrer & Schauble (2004); Wilkerson et al. (2015)
Research Questions

Learning through Design

What design-oriented scientific practices are occurring?
The garden model is collectively built with students. How can the design process itself be a productive learning opportunity?

Stakeholder Diversity

What needs and skills do they express?
Do students and teachers envision the same end-goal? To what degree are teachers’ concerns for students’ capabilities reflected in initial interviews?

Tools & Connections

How can they best support learning?
What supporting instructional materials can best contribute to the implementation of the activity sequence? How should they work?
Design Sketches/ Vision
Model 1 Components

- **Crops**
- **Weeds**
- **Background patches, depicting soil quality**
- **Farmer**

Components:
- **Setup**
  - Number of plants: 36
  - Spacing: 3
  - Plant cost: 1.00
  - Budget: 400

Actions:
- **Re-seed**
- **Apply compost**
- **Sell crop**
- **Apply herbicide**

Graph:
- **Populations**
  - Population vs. time

Graphical data visualizations include:
- **Money**
  - Value: 364
- **Crop harvest**
  - Value: 0
Project timeline

- **Fall 2015**: Idea conception and first model build, pilot student data collection
- **Spring 2016**: Data collection with graduate students
- **Fall 2016**: First round of analysis complete; presentation to environmental educators
- **Spring 2017**: Data collection with middle-school teachers
- **Next Steps**: Model revision; second-round student data collection; identify teacher-collaborator
Methodology
Participatory design-based research

- Middle-school with existing garden-academic project-based curriculum
- Longstanding relationship with district curriculum team, teachers, and principal

Analytical Constructs:

- Current education standards (science content and practices)
- Design heuristics and principles
- Application of external knowledge and contexts
  - Social-emotional learning, affect, and scientific identity
Theoretical Frameworks

- Social
  - Stakeholder roles
  - Rules
  - Division of labor

- Environmental
  - Resource systems
  - Instruments

- Conceptual Development
  - Modeling Proficiency (Manz 2012)
  - Ecological Complexity (Hmelo-Silver et al., 2007)

Social-ecological system

Activity network theory

Krasny & Roth (2010)
Engeström (1987)
Preliminary findings
### When Kids Co-Design and Offer Feedback

*Shaded regions indicate at least one occurrence of expressed learning by that student. The dark color of J’s model-based reasoning cell indicates advanced reasoning, to be explicated below.*

<table>
<thead>
<tr>
<th>Student</th>
<th>Disciplinary Content Learning</th>
<th>Scientific Practices</th>
<th>Design Attributes</th>
<th>Application of outside experience</th>
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<tbody>
<tr>
<td></td>
<td>Hericide</td>
<td>Plant Nutrition</td>
<td>Abiotic/Biotic Interactions</td>
<td>Making predictions/Constructing Explanations</td>
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Possible impact/ Contribution
“Typically middle school students haven’t ever been asked to develop the model itself... I can see that the garden gives them something really tangible to work with, that they can observe phenomena in nature and apply it to this model, [which] could give them some experience for...something that’s more abstract like a chemical reaction.”

-Science Teacher, Grade 8

“Meeting standards, cognitive challenge, and stepping stone to abstract systems & simulations.

“You can learn how plants actually grow”

-Amelia, Grade 6

Science learning can be enriched when hands-on experiences couple with virtual representations.
Thank you!

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[All images from thenounproject.org]
Round 1

- Existing knowledge generates ideas for model additions
- Code drives inferences about ecosystem properties
- Garden experience begets perception of applicability

Round 2

- Teachers view broad subject appeal (history, math, science)
- Different handles on the flexibility for student use