Thinking Like a Butterfly: Leveraging Students' Embodied Intuitions in Elementary Ecology Classrooms

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BACKGROUND

- Developing epistemic and representational practices such as modeling is central to the development of scientific expertise (NRC, 2008; Latour, 1999; Lehrer & Schauble, 2006).
- Ecology is a complex system and young students face challenges in understanding complex systems (Danish et al, 2011; Wilensky & Reisman, 2006)
- Curricula which use multi-agent-based models, or MABMs, including participatory simulations, help novices understand complex systems by recruiting their embodied knowledge (Resnick, 1994; Klopfer, Yoon & Perry, 2005; Peppler et al, 2010; Dickes & Sengupta, 2012).
- Currently little is known about how MABMs can be integrated with existing science curricula at the elementary level.

RESEARCH GOALS

- To design a learning environment that integrates embodied modeling, graphing, and MABMs for learning ecology in 3rd grade.
- To investigate how students develop understandings of structure-function relationships through the generation of mathematical representations of embodied modeling activities.

METHOD

Setting & Participants:

- 100% African American, Urban charter school in Mid-South
- 18 third grade students (ages 8-10yrs)

Learning Activities:

- Duration: 7 class periods
- Pre- and Post Design Activities

Learning Goals:

1. Agent/Environment Relationships
2. Structure/Function Relationships
3. Population Dynamics due to Predation
4. Generating mathematical representations based on embodied activities.

Data Sources:

Videotaped lessons; Student interviews; Researcher field notes; Student artifacts

Sequence of Learning Activities: Supporting student inquiry through modeling and measurement

Phase I
Students investigated structure/ function relationships by participating in an embodied modeling activity of butterflies foraging for nectar

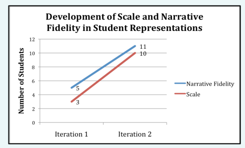
Phase II
Students reflected on their embodied activities by creating foraging maps and bar graphs of what their energy as a butterfly looked like over time.

Phase III
Students interacted with two different multi agent-based computational models designed in the Netlogo modeling platform

	Ecological System Variables	Aspects of Inquiry Learning	Aspects of Agent-Based Thinking
Phase I	• Structure-Behavior-Function • Agent-Environment Relationships • Location of Resources within System	• Making Observations • Identification of System Variables • Keeping Notes and Recording Results	• Autonomous Agents • Simple Agent-Level Rules • Embodied Actions
Phase II	• Variation within Ecosystems • Energy Conservation	• Measurement • Communicating Outcomes	
Phase III	• Predation • Camouflage • Phenotypic Variation	• Reviewing what is already known based on experimental evidence • Proposing explanations and making predictions	• Agent-Aggregate Relationships • Emergent Aggregate-Level Outcomes

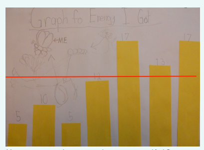
Development of Students' Conceptual Understanding:

Variable	Percentage of Students who Identified variable as important to Survival
Location of Flowers	73%
Length of Proboscis	60%
Flower Type (Tall or Short)	53%

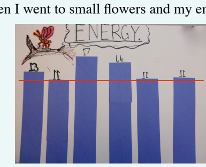


Model	Strategies used to Interact with Model	Percentage of Students who Used Strategy
Model 1: Camouflage	Systematic Exploration of Variable Space	86.7%
	Accident	13.3%
Model 2: Energy	Student Generated Energy Graphs	93.3%
	Other	6.7%

Phase I

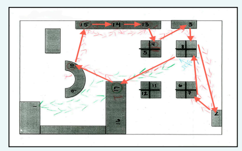


Researcher: Talk to me about what you did?
Jamar: I walked around and I had a short proboscis and I wasn't able to drink from the big flowers and then I was just wasting my energy and that's how my energy went down and down and then I went to small flowers and my energy went up.

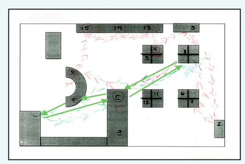


Researcher: What's important to a butterfly when it's looking for nectar?
Jamar: Some butterflies have a small proboscis and they can't drink from the big flowers and they waste energy if they go to a big flower.
Researcher: What does a butterfly think about its energy?
Jamar: It doesn't want to waste it.
Researcher: How does it not waste it?
Jamar: It chooses closer flowers that are its size.

Phase II

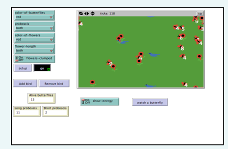


Examining Jamar's Spatial Energy Map, his non-strategic foraging pattern during Iteration 1 (red path) is explicit. During Iteration 1, Jamar visited flowers due to proximity only rather than proximity and flower type.

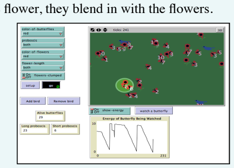


His more strategic foraging decisions in Iteration 2 (green path) are clear. In Iteration 2, we can see that Jamar chose to travel to not only flowers that were near each other, but those flowers that were near each other AND that he could drink from.

Phase III

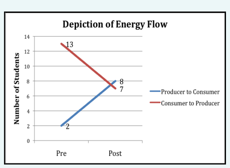


Researcher: How did the butterflies survive?
Jamar: Because the birds were full?
Researcher: What could be another reason? Why do you think the butterflies survive when you made the flowers red and the butterflies red?
Jamar: They blend in! When the butterflies are the same color as the flower, they blend in with the flowers.



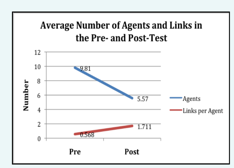
Researcher: What is the graph showing you?
Jamar: The butterfly's energy going up and down. It's energy along the way.

Pre- and Post-Tests:



- The pre and the post-tests were analyzed for growth in terms of system complexity
- The Number of agents and the interactions between agents in terms of energy flow was analyzed
- Statistical significance tested with two-tailed paired t-tests

Number of Agents in the System		Number of Links per Agent in the system	
Ave. Number of Agents Pre	9.81	Ave. Number of Links Pre	0.568
Ave. Number of Agents Post	5.57	Ave. Number of Links Post	1.711
Two-tailed P-Value	0.0013	Two tailed P-Value	<0.0001



FOCI OF ANALYSIS

- Pre- and post-test responses were characterized in terms of the relationships between the different entities depicted in the drawings.
- Student-generated graphs characterized in terms of the use of scale and narrative fidelity.
- Students' interview responses were characterized in terms of students' explanations of structure-function and agent-environment relationships.

DISCUSSION OF KEY FINDINGS

- We propose an activity system in which MABMs can be integrated with elementary science curricula by way of embodied modeling and measurement
- All students began to develop multi-level, nuanced understandings of structure-function relationships and complex inter-agent and agent-environment relationships in an ecosystem.
- Students' embodied reasoning and intuitive ideas were leveraged throughout the activities. Making decisions as agents within the ecological system focused students' attention to the role of the structure of agents, the structure of food sources and the spatial location of food sources within the environment emerged in agent survival.
- Students' conceptual development was deeply intertwined with the development of representational competencies.
- The representational activities gave students a chance to reflect on their decisions and then refine those behaviors in later activities.
- Student-generated mathematical representations of energy acted as a conceptual bridge between the embodied activities and MABMs

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URLs
www.vanderbilt.edu /m3lab
www.visualprogramming.org