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

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**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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**BACKGROUND**

- Developing epistemic and representational practices such as modeling is central to the development of scientific expertise (NRC, 2008; Latour, 1999; Leher & Scharfe, 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, Pepple 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 2nd 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.

**ASPECTS OF INQUIRY LEARNING**

- Making Observations
- Identification of System Variables
- Keeping Notes and Recording Results
- Measurement
- Communicating Outcomes
- Reviewing what is already known based on experimental evidence
- Proposing explanations and making predictions
- Autonomous Agents
- Simple Agent-Level Rules
- Embodied Actions

**ASPECTS OF AGENT-BASED THINKING**

- Agent-Agent Relationships
- Emergent Aggregate-Level Outcomes

**DEVELOPMENT OF STUDENTS’ CONCEPTUAL UNDERSTANDING**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Percentage of Students who Identified variable as Important in Survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location of Flowers</td>
<td>73%</td>
</tr>
<tr>
<td>Length of Proboscis</td>
<td>66%</td>
</tr>
<tr>
<td>Flower Type (Tall or Short)</td>
<td>33%</td>
</tr>
</tbody>
</table>

**FOCI OF ANALYSIS**

- Pre- and 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.

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**URLS**

www.vanderbilt.edu/m3lab
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