Agents, Agency, Equity: A Complexity-Studies Perspective on Classroom Participation Patterns

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IMBES, Fort Worth, TX, Nov. 1-3, 2007
Acknowledgments

Integrated Simulation and Modeling Environment (ISME)

Using Participatory Simulations to Investigate the Complementarity of Agent-Based and Aggregate Reasoning for Making Sense of Complexity

Overview and Rationale
Papers and Presentations
Classroom Resources
Tools and Technology
Sites and Collaborators
Team and Contact

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http://ccl.northwestern.edu/isme/
Education Research
With Agent-Based Modeling:
From the Students, With All the Students,
On the Students

1. Modeling as a form of inquiry
2. Participatory simulation activities
3. Modeling classroom participation patterns
1. Modeling as a Form of Inquiry


- **Students:**
  - Form hypotheses about scientific phenomena
  - Articulate hypotheses in the form of agent-based rules
  - Run simulations, evaluate results, and over again…

- **Challenges of scaling up**
  - **Logistics, technology:** Hard/soft-ware availability
  - **Professional development:** modelers, facilitators, advocates
  - **Policy constraints:** paradigm, curriculum, assessment
Wolf-Sheep Predation: Dynamic Stability of an Ecosystem

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2. Participatory Simulation Activities


• Design
  – *HubNet* (Wilensky & Stroup, 1999)
  – Group inquiry, group simulation
  – Students “are” avatars
  – Classroom-level facilitation
  – Use ready-made models, change code
Participatory Simulation Activity

Modeling and Simulation Environment

Technology facilitated: complex systems

Modeling-based inquiry

Content: mathematics (functions, statistics, geometry), civil engineering, robotics...

Domains: epidemiology, ...
“Disease”: Simulated Run of the Model in a Classroom of 30 Students

- One student-agent is “infected.” It infects others.
- The disease propagates, often as an ‘S-shaped’ logistics curve
- Students change parameters and rules, rerun, and explore mathematical representations of emergent patterns
Run, Run, Run… Compare! -- Interface Features Supporting Inquiry

It takes less time to get more people sick!

“What if” example:
What will the graph look like if we..

- Add androids? Purple
- Run regularly? Red
- Change step size > 1? Yellow

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“Disease”: Classroom Activities

Who Am I?

1st Run: show-ill? true

Discussion, Prediction

2nd Run: show-ill? false
Student Work *(classroom)*

18/24 students showed learning gains, 4/24 students showed ceiling effect
Pre-to-Post Student Interviews: Dimensions of Learning Gains

- **Process** in phenomena $t(15) = 1.56, p < .05$
- **Variability** within/between agents $t(15) = 2.31, p < .002$
- **Agent-based interactivity** $t(15) = 1.9, p < .007$
- **Agent-based rules** $t(15) = .75, p < .02$
- **Randomness** (not determinism) $t(15) = .75, p < .08$
- Use of **modeling kit** $t(15) = 2.62, p < .003$
- **Elaboration** (# utterances) $t(15) = 11, p < .02$
Conclusions of PSA Study

• **Effectiveness**: Transfer of PSA-based heuristics

• *Learning trajectories*: noting variability is key to moving beyond “knee-jerk linear heuristics”

• *Action (narrative) --> Rules (properties)*: “what the agent *does*…” --> “the agent *has* a rule”

• **Modeling** necessary to augment cognitive capacity

• **Limitations**: PD, students’ mathematical fluency
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**Rationale**

- **Elicit**: Data from DBR implementation
- **Build**: Analogical NetLogo model
- **Juxtapose**, evaluate
Computer Sciences
Networks
Games...
Chemistry & Physics
Earth Sciences
Social Science
Go Complex, Young Ed Researcher

• Complexity studies on the rise
  – Societies, journals, conferences…grants!..

• Social phenomena, too, are complex

• Specifically, education phenomena, such as collaborative learning, are complex

• Agent-based modeling may shed light on these phenomena, inform pedagogical policy
Education!

Education!

How can we foster equal learning opportunities in constructivist mathematics classrooms?

I’m particularly interested in the case of classroom collaborative projects.

Yeah, “kick-off” projects, e.g., Edelson, Pea, & Gomez, 1996; Kolodner et al., 2003; Wilensky & Stroup, 1999.
John Dewey (1916)

*Democracy and Education*

- "The point at issue in a theory of educational value is.... the unity or integrity of experience. How shall it be full and varied without losing unity of spirit? How shall it be one and yet not narrow and monotonous in its unity? Ultimately, the question of values and a standard of values is the moral question of the organization of the interests of life. Educationally the question concerns that organization of schools, materials, and method which will operate to achieve breadth and richness of experience. How shall we secure breadth of outlook without sacrificing efficiency of execution? How shall we secure the diversity of interests, without paying the price of isolation? How shall the individual be rendered executive in his intelligence instead of at the cost of his intelligence? How shall art, science, and politics reinforce one another in an enriched temper of mind instead of constituting ends pursued at one another’s expense? How can the interests of life and the studies which enforce them enrich the common experience of men instead of dividing men from one another? (p. 248)
Erik Erikson (1968)
Youth: Identity and Crisis

• "Two poles in American grammar school education may serve to illustrate the contribution of the school age to the problem of identity. There is the traditional extreme of making early school life an extension of grim adulthood by emphasizing self-restraint and a strict sense of duty in doing what one is told to do, as opposed to the modern extreme of making it an extension of the natural tendency in childhood to find out by playing, to learn what one must do by doing what one likes to do. Both methods work for some children in some ways, but impose on others a special adjustment. The first trend, if carried to the extreme, exploits a tendency on the part of the preschool and grammar school child to become entirely dependent on prescribed duties. He thus may learn much that is absolutely necessary and he may develop an unshakable sense of duty. But he may never unlearn an unnecessary and costly self-restraint with which he may later make his own life and other people's lives miserable, and in fact spoil, in turn, his own children's natural desire to learn and to work. The second trend, when carried to an extreme, leads not only to the well-known popular objection that children do not establish and preserve those "higher" institutions without which man's daily work has always seemed an inadequate self-expression, if not a mere grind or even a kind of curse."
Data Source:

*Connected Probability* (Wilensky, 1997) …

*ProbLab* (Abrahamson & Wilensky, 2002)

The “combinations tower”
“There Once Was a 9-Block…”
Abrahamson, Janusz, & Wilensky (2006) - *JSE 14*(1)
Not a Simple Task

\[
\binom{N}{n} = \frac{N!}{n!(N - n)!}
\]
Stratified Learning Zone: Different Learning Opportunities

- Engagement in Problem Solving
- Stages in the Production Line

"We draw straws…"

"Kinda organizing jobs"

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Findings

• Reinforcing students for group production increases students’ initial skills
• When role-rotation is mandated, production slows down yet eventually more learning occurs, per student, in all skills
Comparison between initial skill levels for retrievers and connectors
Low disparity of between-student skill distribution

High disparity of between-student skill distribution
Performance gains

Connecting skills

Retrieving skills

gain, normalized

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Evaluation

- ABM holds promise for illuminating issues of classroom participation patterns
- Proceduralization & exploration as a powerful idea
- Creating an analogue model:
  - Challenge of determining analogue
  - Generativity of analogue
- “Armchair turbo” experiment
- Safe experimentation with “human subjects”
- Data not optimally geared for analysis
- Requires more validation from source
- Human behavior is vastly richer
- Ignored students’ affective dispositions
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‘Bifocal’ (hybrid) Modeling (Blikstein & Wilensky)