CAS in Education

Building an ABM of the Classroom

Ted Carmichael – SwarmFest 2014 – June 30th, 2014
Overview

• ITS and EDM are growing fields, but rarely use CAS modeling.
• Numerous non-linearities are found in classrooms, schools, and school systems.
• Data: what do we have; what do we need?
• An example: ideal class size.
• A pilot ABM model of the classroom and preliminary results.
Why ABM?

• Non-linearities are easy to represent.
• Highly transparent – the simulated agents are analogues for real-world agents (students, teachers, etc.)
• If we know the attributes + interactions of the agents, we can simulate emergent features.
• If we know the emergent features, we can guess the attributes and interactions.
It's all about the data...

- Available now:
  - demographics – age, race, gender, social-economic status, etc.
  - Test results – end of semester/end of year standardized tests; grades; SAT scores.
  - Other – absences, classroom assignments, school assignments, special programs, etc.
It's all about the data...

- What do we need?
  - Classroom structure.
  - Student-student interactions.
  - Student-teacher interactions.
  - Learner types (personality, mode of understanding, innate ability, etc.)
- ITS – transactional data – time-on-task, multi-step problem sets, mouse clicks.
- Online – peer-to-peer activity.
Vision: an ABM for schools

• A robust, multi-scale agent-based simulation.

Classroom simulation $\rightarrow$ feeds into:
  School simulation $\rightarrow$ feed into:
    District-level simulation.

• Help unravel causal interactions
• Optimize resource allocation
• Allow for “what if” scenario modeling.
What is the ideal class size?

- Tremendous amount of research in the literature on class size.
- However, many results are contradictory.
- Highly dependent on subject matter, student level, teacher skill, resources.

“The econometric evidence is clear. There is little reason to believe that smaller class sizes systematically yield higher student achievement. While some studies point in that direction, an almost equal number point in the opposite direction.” -E.A. Hanushek

- Malcolm Gladwell: David and Goliath.
Pilot Model: an ABM Classroom

- Classroom with up to 70 students; one teacher.
- Students hear lecture, then work on a problem set (default: 10 items).
- Teacher moves around to help students.
- Chance of completing one problem, based on “understanding.”
- Three types of learners: Common, Alternative, Outlier.
Pilot Model: an ABM Classroom

- Completing a problem (with or without help) increases understanding.
- Frustration level goes up with each unsuccessful attempt.
- Frustration level goes down with each successful attempt.
- Frustration gets too high, or all problems complete, and student goes “off task.”
Pilot Model: an ABM Classroom

- “Off task” students can influence nearby students to go off task.
- The teacher moves around to help, puts all nearby students back “on task.”
- With “help” enabled, students can ask nearby students for assistance.
- Stopping condition: All students completed all problems.
Goal: if ideal class size is a “U” shape, what (simple) factors can we incorporate into a model to produce this effect?

• Hypothesis: ideal class size is the “basin of attraction” for the system.
• This implies negative feedbacks that push the system toward this ideal.
• From the literature:
  – when the class size is too large, students suffer from lack of attention from the teacher.
  – when the class size is too small, there is a loss of diversity (of opinion, observations, etc.) and students are much less likely to contribute to the discussion.
Pilot Model: an ABM Classroom

- 30 Trials at each level, from 10 to 70 students; student help available, influence turned off.

No student help:

High level student help:

Moderate student help:
Pilot Model: an ABM Classroom

- 50 Trials at each level, incrementing by 5 from 5 to 70 students; both student help and influence available.

**Blue:** No influence, No student help  
**Yellow:** Influence, No student help  
**Red:** No influence, Student help  
**Green:** Influence, Student help

Two-way influence  
One-way influence
Pilot Model: an ABM Classroom

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**Blue:** No influence, No student help  
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Students initialized together, only 'alternative' and 'outlier' give help.
Summary

• Education is rife with non-linearities and potential for tipping points, as well as a tremendous number of complicating attributes. Thus, ABM can be a very useful technique for analyzing these systems.

• Variations in influence and peer-help – at least with this simple model – do produce some quantitative differences, but the qualitative results are fairly robust.

• Two factors – lack of diversity with small classes, and loss of individual attention with large classes – push the system towards an ideal class size.

• What other factors are important? What assumptions are unwarranted (or unimportant)?
Collaborators:

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Questions, comments, complaints...