System Dynamics in Primary and Secondary Education

What we’re learning about how kids, and their teachers learn...

Lees Stuntz and Anne LaVigne
Creative Learning Exchange
ISDC 2018, Reykjavik, Iceland
Jay’s vision for K-12 – always present as a challenge
On the shoulders of giants, who have consistently stood by K-12 efforts from the beginning...

...and John Bemis

1980s

Today
With gratitude to so many *beyond* K-12 education, who have supported K-12 work from the past into the future...

Your Picture Here?

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System Dynamics is HARD – one reason why it’s difficult to increase adoption.

<table>
<thead>
<tr>
<th>Innovation Characteristics that influence Rate of Adoption</th>
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<tbody>
<tr>
<td><strong>1</strong> Relative Advantage</td>
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<tr>
<td><strong>2</strong> Compatibility</td>
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<td><strong>3</strong> Complexity</td>
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<td><strong>4</strong> Divisibility</td>
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<td><strong>5</strong> Communicability</td>
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Kids can’t start here...and neither can most people, for that matter.
Scaffolding – an engineering and an educational methodology
How do we scaffold the critical thinking skills generated by System Dynamics?

• Creating interesting and engaging contexts:
  • Stories
  • Games
  • Simulations

• Using age appropriate, visual tools
Barry Richmond’s Eight Systems Thinking Skills

• 10,000 Meters Thinking
• System as Cause Thinking
• Dynamic Thinking
• Operational Thinking
• Closed-Loop Thinking
• Scientific Thinking
• Generic Thinking
• Empathic Thinking
Habits of a Systems Thinker from the Waters Foundation

- Recognizes the impact of time delays when exploring cause and effect relationships
- Identifies the circular nature of complex cause and effect relationships
- Pays attention to accumulations and their rates of change
- Observes how elements within systems change over time, generating patterns and trends
- Uses understanding of system structure to identify possible leverage actions
- Recognizes that a system's structure generates its behavior
Scaffolding understanding of ...

• Behavior over time
• Feedback
• Accumulation
• Modeling
Scaffolding understanding of behavior over time through stories, simulations, and kinesthetic experience
Student graphs for a story ... up close
Representing continuous trends while playing the World Climate Simulation
Scaffolding understanding of feedback through stories, kinesthetic experience, and connection circles
Activities that engage and teach feedback concepts
Connection circles ... a tool created by educators

The Shape of Change

Desire to Protect Biodiversity

Eagles and Seals

Sand and Silt

Sea Otters

Fur Traders

Kelp Plants

Shrimp

Fish

Sea Urchins

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From using connection circles to find feedback...

Students identified feedback loops.

Fear in the Mouse Community

Teasing of Despereaux

Amount Despereaux tries to act mouse-like
...to drawing loop diagrams
Scaffolding understanding of accumulation through kinesthetic experience, games, simulation, and models
Thinking about their garden’s health, variable names are painted on rocks, so kids can “play” anytime.
Shoe stockroom – A variation of the In-and-Out Game from *The Shape of Change*.
Play a game, then use simulation or modeling software to explore related models.

The spread of a social media site

- Infection handshake game

- Total people

- Contacts between members and non members

- Contacts per person per month

- Likelihood of spread

- People joining

- Non member fraction

- Non members

- Members

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Simulation that engages within curricular contexts

- Exploring Springs: A Little Bounce in the World
- Population Dynamics: Connecting Past, Present and Future
- “The Infection Game” Simulation
- Living Lands – Forest and Town
- Thinking About Drinking

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Copying simple models within engaging topics and challenges

Model Mysteries
An Exploration of Vampires, Zombies and Other Fantastic Scenarios to Make the World a Better Place

Dive in – How can you stop zombie chickens from over-populating planet Earth?

Chickens, Public Domain [modified].

Anne LaVigne and Lees Stuntz
in collaboration with the Creative Learning Exchange
... then connecting the same model to other contexts.

Story 1: Dodo Disappearance

Overview
In the 1600s, the dodo, a type of bird went extinct. Use this model to consider the basics of why this animal became extinct and how that extinction might have been stopped.

Details
1. Time units
2. Dodos (stock)
3. Birth fraction
4. Death fraction

D Dare
1. Re-label and change the numbers in the previous model to make sense for this situation.
2. Determine how long it would take for the population of dodos to disappear.
In summary...

With scaffolding, students (and their teachers) can draw BOTGs, identify feedback, create S/F maps, and copy/modify models BUT... it’s still difficult for them to build their own original models.
What now?

• How do we make the “leap” for students and teachers from simulations and copying models to creating models?
• We needed a visual, attractive and easily understandable bridge between current effective K-12 methodologies and the abstract modeling software available.

Building a bridge...

From physical simulation and drawing on paper:
- Behavior-over-time graphs
- Causal loop diagrams
- Stock/flow diagrams
- Connection circles

To creating in a virtual space:
- Engaging, models in motion
From water in an MIT basement…..

“In 1968, Jay started a student-run System Dynamics Laboratory course. The lab part was a room in the basement of the Sloan School. The purpose of the lab course was to give students some hands-on experience and physical, intuitive feel for some systems behavior. I was asked to design the course and stock the empty room with slow-moving, intuitive physical systems. I procured tanks of water, plastic tubing, valves and clamps for hydraulic experiments, and also springs, weights, and electrical devices.”

David W. Peterson
The "Tubs and Pumps" activity, developed by Chris Browne, Barry Newell and Katrina Proust
...to *Splash!*

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<th>Systems Thinking Tool</th>
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Quotes from students at BETA testing

• “The animation of the particles in Splash! makes it much easier to see the relationships between different variables, as well as the making of Systems Thinking models much more interactive.” 8th grader

• “It is easy to use and the colorful liquid physics simulations make the modeling process fun and exciting. I think Splash! does a great job of making systems dynamics modeling intuitive.” 12th grader

• “The app is fun to use, the fluid is beautiful to look at! and it teaches you system dynamics without you knowing.” 10th grader
Splash! and SplashCards

A creative collaboration between

Splash! and SplashCards

Fun, Easy Experiments to Get You Splashing Right Away!
Going Forward

We need experienced SD professionals to reach out and motivate pre-college educators and students.

We are here to help, to cooperate with you, to support you in your efforts.
Going Forward

Resources available through the Creative Learning Exchange

• Splash!
• Simulations
• Books
• Curriculum
• DynamiQueST
• Capacity Building Workshops
Help us create systems citizens of the world who can handle complexity.

from the past into the future...

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