Group Modeling: Theory and Practice

George P. Richardson and Peter S. Hovmand

2014 Systems Thinking and Dynamic Modeling Conference
Babson Executive Conference Center at Wellesley, MA, June 28-30
• How did it begin at the University at Albany
• Teamwork
• Scripts
  – Eliciting and clustering graphs over time
  – Stakeholder power/interest grid
• Scriptapedia
A Typical Room GMB Session
Graphs Over Time
Elicited in Pairs
Defining the Problem Dynamically: The Tobacco Use Sector
Idealized Graphs
(Reference Behavior Modes)

- Interest in cessation
- Smokers in the US
Tobacco Industry

- TI LOBBYING

- AWARENESS INCREASE
- TOBACCO TRADE INCREASE

- 1950
- 1960
- 1970
- 1980
- 1990
- 2000
- 2010

Time (years)
Posting and Clustering Graphs over Time
Behaviour over time

Overview
Behaviour over time 4

- **Work Load of CSIRTs**
  - 1995 - 2015

- **Complexity of IT Systems**
  - 2005 - 2008
  - More Complex? Robust

- **CSIRT Workload**
  - CGRT Ability to Respond Effect

- **Danger of Internet Break-Down**
  - 1990 - 2020

- **# of PCs Connected to the Internet**
  - 1970 - 2020

- **# of Emails Sent**
  - Year legitimate emails
Stakeholders in a Power/Interest Grid
Mapping and Modeling
Modeler Feedback – an Insightful Loop

DIAGRAM:
- Detection Capability
- Events
- Detected Events
- Perceived Need for Detection Capability
- Investment in Detection
- Other Cues

Feedback Loop:
- Detection Capability increases investment in detection.
- Detection investment increases other cues.
- Other cues increase the perceived need for detection capability.
- Perceived need for detection capability increases events detected.
- Events detected increase detection capability.
Scripts and Scriptapedia
# Scriptapedia

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Action Ideas</td>
<td>5</td>
</tr>
<tr>
<td>Causal Mapping with Seed Structure</td>
<td>10</td>
</tr>
<tr>
<td>Concept Model</td>
<td>14</td>
</tr>
<tr>
<td>Creating a Shared Vision of Modeling Project</td>
<td>16</td>
</tr>
<tr>
<td>Debriefing</td>
<td>19</td>
</tr>
<tr>
<td>Dots</td>
<td>21</td>
</tr>
<tr>
<td>Graphs over Time</td>
<td>23</td>
</tr>
<tr>
<td>Hopes and Fears</td>
<td>26</td>
</tr>
<tr>
<td>Initial Policy Options</td>
<td>28</td>
</tr>
<tr>
<td>Initiating and Elaborating a Causal Loop Diagram</td>
<td>30</td>
</tr>
<tr>
<td>Logistics and Room Set Up</td>
<td>33</td>
</tr>
<tr>
<td>Model Review</td>
<td>35</td>
</tr>
<tr>
<td>Modeling Project Community Presentation</td>
<td>37</td>
</tr>
<tr>
<td>Next Steps and Closing</td>
<td>39</td>
</tr>
<tr>
<td>Nominal Group Technique</td>
<td>42</td>
</tr>
<tr>
<td>Process Mapping</td>
<td>45</td>
</tr>
<tr>
<td>Ratio Exercise</td>
<td>48</td>
</tr>
<tr>
<td>Reflector Feedback</td>
<td>51</td>
</tr>
<tr>
<td>Scheduling the Day</td>
<td>53</td>
</tr>
<tr>
<td>Structure Elicitation</td>
<td>55</td>
</tr>
<tr>
<td>Transferring Group Ownership from One Image to Another</td>
<td>58</td>
</tr>
<tr>
<td>Variable Elicitation</td>
<td></td>
</tr>
</tbody>
</table>
Extension of Group Model Building

• Group model building…
  – As problem structuring and decision support
  – As research method
  – As teaching
System Dynamics

- System dynamics is the use of informal maps and formal models with computer simulation to uncover and understand endogenous sources of system behavior (Richardson, 2011, p. 241)

System Dynamics

• System dynamics is the use of informal maps and formal models with computer simulation to uncover and understand endogenous sources of system behavior (Richardson, 2011, p. 241)

• Foundations of system dynamics:
  – Endogenous perspective
    • Stock or level (state) variables representing accumulations
    – Flow or rate variables representing activity
      » Using computers to simulate more realistic mathematical models

System Dynamics

- System dynamics is the use of informal maps and formal models with computer simulation to uncover and understand **endogenous sources of system behavior** (Richardson, 2011, p. 241)

- Foundations of system dynamics:
  - **Endogenous perspective**
    - Stock or level (state) variables representing accumulations
    - Flow or rate variables representing activity
      » Using computers to simulate more realistic mathematical models

System Dynamics

- System dynamics is the use of informal maps and formal models with computer simulation to uncover and understand endogenous sources of system behavior (Richardson, 2011, p. 241)

- Foundations of system dynamics:
  - Endogenous perspective
    - Stock or level (state) variables representing accumulations
      - Flow or rate variables representing activity
    » Using computers to simulate more realistic mathematical models

System Dynamics

• System dynamics is the use of informal maps and formal models with computer simulation to uncover and understand endogenous sources of system behavior (Richardson, 2011, p. 241)

• Foundations of system dynamics:
  – Endogenous perspective
    • Stock or level (state) variables representing accumulations
      – Flow or rate variables representing activity
        » Using computers to simulate more realistic mathematical models

Examples of Informal Causal Maps

Figure 1: causal loop diagram

Figure 2: stock and flow diagram
Formal Model with Computer Simulation

Overweight mortality rate

4,000  3,333  2,667  2,000  1,333  666.67  0

Time (Year)

persons/Year

Overweight mortality rate : Prevention4
Overweight mortality rate : Prevention3
Overweight mortality rate : Prevention2
Overweight mortality rate : Prevention1
Overweight mortality rate : Baserun
Different Uses of Causal Maps and Models

• Analysis problems
  – Problem persists because we don’t know the right answer or where to intervene

• Coordination problems
  – Problem persists because can’t agree on what we should do

• Restructuring problems
  – Problem persists because system “is broken”

• Learning problems
  – Problem persists because actors in the system don’t have the system thinking skills to adapt and learn
Traditional SD

• Analysis problems
  – Problem persists because we don’t know the right answer or where to intervene

• Coordination problems
  – Problem persists because can’t agree on what we should do

• Restructuring problems
  – Problem persists because system “is broken”

• Learning problems
  – Problem persists because actors in the system don’t have the system thinking skills to adapt and learn
Traditional GMB

• Analysis problems
  – Problem persists because we don’t know the right answer or where to intervene

• Coordination problems
  – Problem persists because can’t agree on what we should do

• Restructuring problems
  – Problem persists because system “is broken”

• Learning problems
  – Problem persists because actors in the system don’t have the system thinking skills to adapt and learn
Use of Models in GMB for Teaching

• **Analysis problems**
  – Problem persists because we don’t know the right answer or where to intervene

• **Coordination problems**
  – Problem persists because can’t agree on what we should do

• **Restructuring problems**
  – Problem persists because system “is broken”

• **Learning problems**
  – Problem persists because actors in the system don’t have the system thinking skills to adapt and learn
Group Model Building as Teaching

- Founding of Social System Design Lab at Wash U
  - Core commitment to ST/SD in K-12
  - Collaboration with Ritenour School District
  - 2010 workshops with Dr. Tony Robinson’s students in the Safe School Ambassador’s program
Products and inputs in “Safe Schools Process”
Products and inputs in “Safe Schools Process”
Products and inputs in “Safe Schools Process”
Three Sessions on “Safe Schools”
Three Sessions on “Safe Schools”
Three Sessions on "Safe Schools"
Three Sessions on “Safe Schools”
Three Sessions on “Safe Schools”
Three Sessions on “Safe Schools”
Three Sessions on “Safe Schools”
Four Sessions on “My Opinion Counts”

- **Session 1**
  - Hopes and Fears
  - Graphs Over Time
  - Dots
  - Reference Mode
  - Causal loop diagramming
    - 4 teams

- **Session 2**
  - Stock and flow diagramming
    - 4 teams

- **Session 3**
  - Formulating simulation model of one stock
    - 4 teams
One-day GMB Workshop Led by Students on “Scaling-up and Sustaining Systems Thinking in Schools”
Setting Expectations with “Hopes and Fears”

- Nominal group technique
- Wall building
- Summary of clustering of themes
- Review at end of session
Problem Structuring...
Students as Stakeholders

- Graphs over Time
- Dots
- Selecting a Reference Mode
Boundary Objects

- Boundary objects (Black and Andersen, 2012):
  - Are tangible
  - Represent dependencies across disciplinary boundaries
  - Modifiable by all participants
  - Exist as a social construct
Introducing Stocks

• Pick a relevant stock that students can relate to
  – E.g., frustration with friend or sibling

• Demonstrate filling of glass with slowing inflow

• Make two points
  – Stock increases while inflow decreases – THIS IS COUNTER INTUITIVE
  – Response in a DYNAMIC system is a function of the state of the system
Working in Teams

• Working on:
  – Different parts of a model
  – In parallel on same model

• Three phases of coaching:
  – Interrupting unproductive group behavior
  – Coaching on drawing structures
  – Modeling how to tell the story

• Presentations
  – Whole team
  – Focus on what they did right, let them learn from each other

• Iterate
  – Mix up the teams!
Introduce Tangible Metaphors

- E.g., creating board games based on models
  - Computer simulation is abstract
    - “Where do the numbers come from?”
  - Implications of “perfect mixing” assumptions of stocks is hard to grasp
  - Clouds (sources and sinks) are often seen as their own stocks

- Systems Thinking Playbook
Using Concept Models

- **Introduce concept model**
  - State that an incomplete model will be drawn, and they will be asked to find the flaws

- **Draw**
  - Reference mode
  - First stock and flows
  - Introduce bathtub metaphor
  - Illustrate accumulations with pitcher and water
  - Complete the diagram
  - Highlight key structures

- **Show simulation model**
  - Correspondence
  - Simulations

- **What’s wrong or incomplete with this?**
  - Make changes as they are mentioned
Vaccination Concept Model
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Confidence</strong>: self-esteem, confidence, independence, success, failure, “my opinion counts”, insecurities, acceptance</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td><strong>Communication</strong>: communication with others, listening to others</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td><strong>Mental health</strong>: “down mood”, depression, pressure to pass, pressure to complete curriculum, frustration, discouragement, failure, stress</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td><strong>Drama</strong>: relationships that cause drama, student drama, teen pregnancy</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td><strong>Academic achievement</strong>: SAT/ACT, GPA, dropout, graduation, doing work, completion</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td><strong>Quality of student-teacher relationship</strong>: teacher respect students, teacher attitudes, one-on-one communication, positive relationships, perceive staff as supportive, trusting teachers/students, encouragement, caring</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td><strong>Student motivation</strong>: motivation, interest in school, determination</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td><strong>Student behavior</strong>: fights, put downs, classroom disruptions, bullying, mediation, desire to understand others, cultural awareness</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td><strong>School involvement</strong>: sports, student participation, clubs, FOR Club, meeting new people, opportunities for involvement</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td><strong>Student background</strong>: educational background, home conflicts, family support, education of family, intelligence</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td><strong>School pride</strong>: pride, bad publicity, positive school morale</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td><strong>Classroom environment</strong>: availability of textbooks, level of instructional rigor, class size</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>
Creating Concept Models

• Identify the essential *types of concepts* needed to model a problem

• Build a tiny simulation model
  – 4 or fewer stocks

• “Break the model”
  – Removing a structure that would be obvious omissions
  – Test to see if this makes a difference in behavior
  – Save this as the concept model for use in the concept model exercise

• Good concept models are effective as *teaching tools*
Resources

- Creative Learning Exchange
- Waters Foundation
- Scriptapedia: http://tools.systemdynamics.org
Five critical questions to consider before starting a system dynamics project

**Question**

**Answer**

1. **What is the problem? Is the problem dynamic?**
   - Drawing a reference mode with the desired and feared behavior over time over a defined period of time.

2. **What kind of problem is it?**
   - Primary diagnosis as a learning, coordination, analysis, or restructuring problem.

3. **Does the system involve feedback mechanisms?**
   - Drawing a diagram of the system that involves one or more feedback loops.

4. **What kinds of insights would help solve the problem?**
   - Identifying the types of model based insights such as visualizing the system or identifying leverage points that will help solve the problem.

5. **What is the purpose of the model?**
   - Write a model project description that defines the problem, explains why it is dynamic and involves feedback, and clearly states the purpose in terms of the type of insights that will help solve the problem.

Questions and discussion