Scriptapedia

Version 4.0.6
August 2013

Acknowledgements
Scriptapedia is a collaborative effort to make group model building in system dynamics more transparent, accessible, and shared around the world. A number of individuals have been integral in initiating this effort (in alphabetical order): David F. Andersen (University at Albany New York), Annaliese Calhoun (Washington University in St. Louis), Peter S Hovmand (Washington University in St. Louis), Timothy Hower (Washington University in St. Louis), Etiënne Rouwette (Radboud University Nijmegen), Eric Steins (Kirwan Institute for the Study of Race and Ethnicity), George P. Richardson (University at Albany New York), and Krista Rux (Washington University in St. Louis).

Funding for Scriptapedia was initially provided by the Centers for Disease Control and Prevention through the Brown School Violence and Injury Prevention Center (1R49CE001510), National Institutes of Health (HHSN 276200900017C); and, the Social System Design Lab at the Brown School of Social Work, Washington University in St. Louis.

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> Hovmand, Peter S., Etiënne A. J. A. Rouwette, David F. Andersen, George. P. Richardson, and Alison Kraus. 2013. *Scriptapedia 4.0.6*

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Best Practices

Action Ideas

Context:
After a model has been developed

Purpose:
To identify and prioritize actions

Status:
Best practices

Primary nature of group task:
Divergent

Time:
Preparation time: 5 minutes
Time required during session: 30 minutes
Follow-up time: 30 minutes

Materials needed:
1. Sheets of office paper (enough for 5-8 sheets per participant)
2. 1 dark thick-tipped marker per participant
3. Blue "painters" tape for creating the wall, and labels for the axes on the wall

Inputs:
Causal loop diagram or stock and flow diagram

Outputs:
Prioritized list of potential actions

Roles:
- Facilitator experienced in small group facilitation and familiar with Meadow's (1999) paper on leverage points
- Co-facilitator/wall-builder able to organize the ideas
- Recorder to take notes on the ideas being suggested

Steps:
1. Ask groups to take 10 minutes to identify as many actions as they can that could impact the model from the previous exercise.

    - *What I would now like you to do in each group is take 10 minutes and use the diagram to help you identify as many possible actions to improve this system as you can.*

- *There are a number of places you can intervene in the system (adapted from Meadows), in order of effectiveness:*
  Variables (lowest)
  Connections
  Rules that govern the connections
  Goals in the system
  Mindset (highest)

- *You can develop interventions that impact variables directly. For example, you could come up with a way to decrease [variable 1; e.g. parent stress]. This may be the least effective way to intervene because it is only fixing a symptom in the connection circle. [variable 2; e.g. gangs] contribute to [variable 1] in the connection circle, and efforts to reduce [variable 1] would only have a temporary effect since the diagram suggests that [variable 2] would continue to contribute to [variable 1]. While addressing symptoms may not have the highest impact in a system, it is important to remember that they can still be beneficial.*

- *You can also develop interventions that impact a connection. For example, you could come up with a way to help increase [variable 3; e.g. healthy meals], even when [variable 1]. Doing this would change the system by weakening the connection from [variable 1] to [variable 3]. Ultimately, this type of intervention might eliminate the connection altogether.*

- *You can also consider interventions that create or strengthen a connection. For example, creating an intervention that is designed to help [variable 4; e.g. schools] more effectively address [variable 2; e.g. gangs] would strengthen the connection from [variable 4] to [variable 2].*

- *You can also come up with interventions that impact the rules that govern the connections such as the rules [insert policy intervention; e.g. regulate what foods a corner grocery store can sell].*

- *You can also address the goals in the system. [Insert example goal in topic system; e.g. examples of goals in the obesity system could be fitting into clothes, lowering stress, and eating healthy foods].*

- *And finally, you can develop interventions that aim to change mindset. [Insert example of changing mindset; e.g. Examples of changing the mindset from the obesity example could be*

changing how people view the cause of obesity from "parents just don't know how to cook" to "parents are too busy trying to make ends meet with their work and don't have the time to plan meals, shop, and cook."]

- *There are many different types of actions you can come up with but they should all be focused on [topic].*
- *For each action, I want you to write a name that identifies the action on a sheet of 8.5x11 paper.*
- *Since we will be posting and organizing each action, write only one action per sheet of paper and please use the large thick markers.*
- *Specifically, look at the diagram and identify places where you might intervene.[Give example; e.g. For example, in the obesity example, we might try to implement a program to decrease the consumption of unhealthy snacks and call this intervention "Providing healthy snacks at church" or something like that. We would then write the name of this ("Providing healthy snacks at church") one sheet of 8.5x11 inch paper using the markers.]*
- *After 10 minutes, I will ask you to share in a round-robin fashion the results of your list of actions by going to each group and asking you to share your most important action.*
- *For each action, I want you to tell us:*

  (a) describe the action,
  (b) identify where it would impact the model,
  (c) identify how easy or hard it is to implement, and
  (d) if successfully implemented, how much impact might this have on the [topic].

- *You will have 10 minutes to complete this task.*

2. Participants are given a 1-minute warning and told to sort their actions from the most important to the least important.

- *We're about to finish. Please complete your last action before we get started again in the large group.*
- *Please sort your actions from the most important to least important.*

- *Please stop.*

3. The facilitator then asks groups to share their actions, one at a time and in a round robin fashion starting with their most important action. If another group has already identified that action, then they should select their next most important action.

    - *As we did in the first exercise, I am going to ask each group to only share one action at a time because I want to make sure that everyone gets an equal opportunity to share their insights.*

4. The facilitator asks clarifying questions to make sure everyone understands the action and where the action would impact the system by referring to the model and then asks them to identify where the action should be placed on the wall in terms of workability and priority.

    - *Where do you see this action falling in terms of ease of implementation? How easy or hard would it be to implement this?*

    - *If successfully implemented, what do you see as the potential impact of this action on [topic]?*

5. As each group shares the action, the co-facilitator/wall-builder places the action in the quadrant identified by the group, while a co-facilitator or recorder writes the action and draws how it connects to other variables in the connection circle.

6. It is important that the group nominating the action determine where it fits in terms of workability and importance, as well as how it connects to other variables in the system. If other groups have a different opinion on where the action fits, they can nominate the variable on their turn.

7. Reflect back to the group your observations about the potential actions:

    - *Actions that are easily workable and high priority represent "low hanging fruit".*

    - *Actions that are hard and high priority represent areas where funders, policy makers, and researchers may be able to help in understanding or modifying the barriers to implementing high priority ideas.*

Evaluation criteria:

- The exercise has led to a rich list of potential actions prioritized by the ease of implementation and potential impact
- Participants have high energy and express enthusiasm in finding potential solutions
- The group has developed a shared understanding of each intervention and how it maps into the system

Authors:
Unknown

History:
Originally based on an Action Ideas activity used outside of group model building and developed into a group model building script as part of the Rise, Sally, Rise project sponsored by the Ohio Department of Mental Health with funding from the Substance Abuse and Mental Health Services Administration.

Revisions:
None

References:
Meadows, D. (1999). Leverage points: places to intervene in a system. Hartland, VT: The Sustainability Institute.

Notes:
In its current form, the script is generally used after presenting a model in the form of causal loop diagram or stock and flow diagram. While the exercise was originally designed to work with participants studying a connection circle, the activity is much more effective with a causal loop diagram where participants can clearly see the feedback loops or a stock and flow diagram where participants can clearly see the material flows and buffers in a system.

A variation of this exercise will have a modeler adding the action ideas to a model in the modeling software as participants describes how their proposed actions will impact the system.

Causal Mapping with Seed Structure

Context:
At the beginning of a group model building process and there is an interest in quickly illustrating how a focal problem or situation could involve a system of interacting feedback loops

Purpose:
To elicit causal structures and quickly

Status:
Best practices

Primary nature of group task:
Divergent

Time:
Preparation time: 180 minutes
Time required during session: 90 minutes
Follow-up time: 90 minutes

Materials needed:
1. Overhead data projector & screen
2. Computer running modeling software (e.g., Vensim)
3. Recorder's materials
4. Flip charts with key words, posted in the room

Inputs:
Stock-flow seed structure from prior work with core modeling team.

Outputs:
Causal map of reinforcing and balancing feedback loops that identify variables and structures related to a focal problem.

Roles:
- Modeler with expertise in system dynamics modeling who can draw diagrams in real time
- Facilitator familiar with the situation and language used by participants to discuss the problem, and strong group facilitation skills appropriate to the culture of participation
- Recorders (2) with some exposure to system dynamics and/or familiar with the context of the issue

Steps:

1. The modeler and facilitator are at the front of the room along with the modeler, who is sitting with a laptop connected to a data projector.
2. The facilitator begins by explaining that "we're going to spend the next 90 minutes or so doing a causal mapping exercise" on the previously identified issue.
3. The modeler explains that the diagram that will result from this will be available to them. The modeler then introduces the seed structure with the stock and flows.
4. If changes are suggested or needed, the facilitator affirms the changes while the modeler captures the changes.
5. The facilitator then explains that participants can talk about their own experience or what they see in their family or community.
6. The recorders document working definitions used for key words.
7. The facilitator then asks questions that help identify impact and causal relations between identified key variables.
8. As someone suggests something, the modeler draws the link on the model in front of the room. The facilitator and modeler will then encourage participants to add variables and relationships. The modeler tries to get things recorded using exactly the same terms as the participants used.
9. Meanwhile, the recorders are taking notes on the variables named, relationships being described, and quotes or stories that help put some context around the story. If necessary, the recorder uses the number chart developed earlier to help identify who is saying what.
10. The modeler explains the notation as structure is drawn on the board. This includes arrows, polarity ('+', '-'), and feedback loops as they appear in the diagram.
11. The recorders write down relationships should, as much as possible, be written down with arrows in causal chains with '+' and '–' signs to indicate the direction of the relationship. A '+' indicates that increasing one leads to an increase in the other, and a decrease in one leads to a decrease in the other. A '-' indicates an opposite effect where increasing one leads to a decrease in the other, and a decrease in one leads to an increase in the other.
12. The recorders should avoid interrupting the flow of the conversation between participants and generally avoid asking clarifying questions or adding comments. They should simply make a note of the questions or comments in the margins and distinguish them from things that participants said (e.g., by using an *).
13. The modeler will interject when the first feedback loop has been formed.
14. If the group begins to slow down and there is time, or no feedback loop has been formed, the modeler will ask if there are any relationships between the identified variables that have not been

discussed. Doing this will help create loops that might otherwise have been missed.

15. The process continues until there are about 5 minutes left in the exercise, at which point the modeler points out that "we've only spent a little time, less than 90 minutes coming up with some of these relationships and already it is looking pretty complicated." However, this is still much simpler than the reality they are trying to manage in practice and research. Ask if there are any other important variables or relationships that haven't been described.

Evaluation criteria:

- Energized participants interested in more modeling.
- A causal map with multiple feedback loops.
- Recognizing that there is a feedback system producing the reported behavior.

Authors:

Unknown

History:

This particular script was first based on an activity conducted with Save the Children UK, Mongolia in 2006 and formalized as part of the Missouri Transformation Project. Lune-Reyes et al. (2006) describe a similar activity.

Revisions:

Revised 2013 by Peter Hovmand to reflect current practices.

References:

Luna-Reyes, L. F., Martinez-Moyano, I. J., Pardo, T. A., Cresswell, A. M., Andersen, D. F., & Richardson, G. P. (2006). Anatomy of a group model-building intervention: Building dynamic theory from case study research. *System Dynamics Review, 22*(4), 291-320.

Notes:

This exercise is based on a more general activity common in system dynamics modeling that follows from using system dynamics modeling software in classrooms, workshops, and group model building. The exercise works well for quickly conveying the ideas that (1) systems are complex, (2) introducing the language of system dynamics (e.g., balancing and reinforcing feedback loops, stocks and flows), and grounding the emerging model in participants' language. The exercise can be conducted with large groups up to about 50 or 60 individuals, but participation tends to be limited as the group size exceeds 20 individuals. The design of the seed structure is critical and should be piloted before attempting to conduct this exercise.

The connection circle exercise can be used as an alternative to this exercise when the goal is not to have participants identify and build feedback loops, especially in settings where building a model mediated by a computer and data projector is undesirable.

A variation of this exercise splits the facilitator role into two separate roles with a community facilitator familiar with the stockholders and the modeler facilitator familiar with system dynamics.

Concept Model

Context:
Early at the start of a group model building project

Purpose:
To introduce the process of modeling and symbolism of a model to participants.

Status:
Best practices

Primary nature of group task:
Presentation

Time:
Preparation time: 180 minutes
Time required during session: 30 minutes
Follow-up time: 0 minutes

Materials needed:
- White board and markers
- Computer and projector

Inputs:
None

Outputs:
- Familiarity with stock and flow and causal icons
- Understanding that maps can be quantified and simulated
- Understanding that models can be created for the groups' problem(s)
- Understanding that the model is owned by the group and can be repeatedly modified and improved

Roles:
- Experienced modeler to design the Concept Model
- Experienced helper to show and run the formal model

Steps:
1. The experienced modeler draws by hand the first version of the concept model on the white board. Demonstrate/draw the tub with faucet and drain to explain stock & flow icons.
2. The experienced modeler then projects the first quantified version of the concept model from the computer. The first quantified version of the concept model is identical to the first version drawn on the white board. Then, simulate and trace the behavior produced by the model.

3. On the white board add one or more elements to the first version to get an amended Concept Model (second version). The added elements are elicited by the experienced modeler from the participants. Project the second version of the concept model from the computer. Simulate the second version of the concept model and trace its behavior over time. The behavior should be different so as to demonstrate that "behavior is a consequence of structure."
4. Repeat step 3 one more time.
5. The experienced modeler summarizes the lessons as follows: the icons that will be used, maps can be quantified and simulated, behavior can be generated endogenously, changing structure changes behavior, maps and models can be repeatedly refined, and groups can own the models they create.

Evaluation criteria:

- Participants are talkative, wanting to tell the modeler how the model is wrong and can be improved.
- Participants can use the symbolism of system dynamics to express their own ideas.

Authors:
George P. Richardson

History:
First described by Richardson and Andersen (1995)

Revisions:
None

References:
Richardson, G. P. and Andersen, D. F. (1995), Teamwork in group model building. *System Dynamics Review, 11*, 113–137.

Richardson, G.P. (2006). Concept models. In A. Größler, E. J. A. Rouwette, R. S. Langer, J. I. Rowe, and J. M. Yanni (Eds.), *Proceedings of the 24th International System Dynamics Conference, July 23 - 27, 2006, Nijmegen, Netherlands.*

Notes:
Developing a concept model is insightful and tricky. Since it was first used in foster care workshops in early 1990s, Richardson and Andersen use concept models for every group model building intervention, however, it is not widely used (or understood) by others.

Creating a Shared Vision of Modeling Project

Context:
At the beginning of the project or as a means of revision for a long-term project.

Purpose:
To help the modeling team and community with whom they are working create a vision and understanding of the project process and goals together.

Status:
Best practices

Primary nature of group task:
Convergent

Time:
Preparation time: 45 minutes
Time required during session: 45 minutes
Follow-up time: 0 minutes

Materials needed:
Overhead projector and laptop or flipchart and markers for creating and editing modeling project description

Inputs:
None

Outputs:
Revised modeling project description

Roles:

- Facilitator with moderate skills in facilitation and familiar with stakeholders in room
- Gatekeeper who is advocating for the organization/community's interest in the model and value of model to the organization/community

Steps:

1. The facilitator presents the elements of a modeling project description, and if available, a draft modeling project description. A modeling project description has the following elements:

    - Name of modeling project
    - Describe background

        - What's the reference mode (in words or graph)?
        - Why is this problem important?

    - Problem type
        - What is the main barrier to solving the problem (e.g., learning, coordination, analysis, restructuring) and why?

    - System insights
        - What kind of system insights would be an improvement or contribution over "business as usual"? What would be the contribution of system dynamics over alternatives?

    - Define the primary audience(s) for the model
        - Who is the primary audience of the model? Us, organization, community, board of directors, researchers?

    - Resources
        - How much time is available? What types of skills and human resources are needed?

    - Values
        - What are the expectations and aspirations (e.g., provide opportunities to build capacity of program staff, involve stakeholders to inform design of project, advance science)?

2. The facilitator leads a discussion of the description and assists in editing the modeling project description to better reflect the focus of the modeling project based on participant input.

3. Repeat steps 2 and 3 for each section of the modeling project description, moving onto the next section only after consensus has been reached.

Evaluation criteria:

- Participants are engaging in the discussion, contributing, and indicate understanding of the terms of the modeling exercise, motivation, and purpose
- Clarity of the modeling project description document
- Consensus on modeling project description

Authors:

Foundation for Ecological Security, Gautam Yadama, and Peter Hovmand, 2010

History:
Originally developed and documented in Rajasthan, India by Foundation for Ecological Security, Peter Hovmand, and Gautam Yadama in 2010

Revisions:
Last revised on February 21, 2013 to reflect variations since its original development.

References:
None

Notes:
A variation of this script asks participants to develop a modeling project description on flip charts in small groups.

Debriefing

Context:
Immediately after a GMB session.

Purpose:
To allow the modeling team to share initial impressions of the GMB session, debrief, and provide support to team members for improving GMB practice.

Status:
Best practices

Primary nature of group task:
Evaluative

Time:
Preparation time: 0 minutes
Time required during session: 60 minutes
Follow-up time: 0 minutes

Materials needed:
None

Inputs:
Detailed agenda of session

Outputs:
None

Roles:
Debriefer skilled at facilitating group process, culturally sensitive, and generally only observing the modeling exercise

Steps:

1. The debriefer assembles the modeling team and announces the start of the debriefing session.
2. The debriefer reviews the process the team will use to conduct the review.
3. The activity begins with a check-in to see how people are doing. This is important regardless of whether the session went well or badly.
4. Ask the following questions:
   - *How are you feeling about how this GMB session went?*
   - *Overall, did we accomplish what the session was designed to do?*
   - *What went well during this session?*
   - *Were there any rough parts for you?*

- *What did you learn from this session?*
- *How could the session have been improved?*

Evaluation criteria:
The script should result in a stronger, more cohesive team after the debrief and a list of ways to improve the process.

Authors:
Amanda Lavallee, Timothy Hower, and Peter Hovmand, 2010

History:
Created in 2010 in preparation for a GMB workshop with the Buder Center at the Brown School of Social Work, Washington University

Revisions:
Revised 2013 by Peter Hovmand to reflect current practices

References:
None

Notes:
None

Dots

Context:
There are many times during GMB sessions where it is important to prioritize or reduce the number of items the group is working on. This might be to choose the top « X » Behavior Over Time Graphs (BOTGs) for inclusion in the model, or to pick the stocks that will be incorporated.

Purpose:
To sift through many possible choices and select those most important to the participant group.

Status:
Best practices

Primary nature of group task:
Evaluative

Time:
Preparation time: 0 minutes
Time required during session: 10 minutes
Follow-up time: 0 minutes

Materials needed:
1. Three to five dots per participant depending on the packaging of adhesive dots
2. Alternatively, this can be done using markers and check marks

Inputs:
An array of items to vote on with dots, for example, a set of behavior over time graphs

Outputs:
Prioritized choices

Roles:
Facilitator to introduce the exercise

Steps:
1. The facilitator gives every participant the same number of dots.
2. The facilitator instructs participants to place their dots beside the items they think are most important to them. They can distribute the dots any way they want (e.g. put all of them on behavior over time graph or spread dots out across several graphs).
3. The facilitator tallies the dots beside each item to create a ranked list of importance.

Evaluation criteria:
1. Participants have prioritized their choices.
2. Participants have achieved consensus on the most important items.

Authors:
Unknown

History:
Unknown

Revisions:
None

References:
None

Notes:
None

Graphs over Time

Context:
At the beginning of a group model building session as it is a springboard for discussion about the problem to be modeled.

Purpose:
To engage participants in a group model building session in framing the problem, initiating mapping, eliciting variables and gathering input in deciding the reference modes for the study.

Status:
Best practices

Primary nature of group task:
Divergent

Time:
Preparation time: 15 minutes
Time required during session: 45 minutes
Follow-up time: 0 minutes

Materials needed:
- Camera or other method to capture the graphs
- Stacks of 8.5x11 white paper with X and Y axes drawn on them
- Large blank wall (8'x10')
- Thick markers
- Glue sticks, Tacks or painter's tape

Inputs:
None

Outputs:
Candidate variables for the dynamic model or the map

Roles:
- Facilitator works with the group and has some experience with SD
- Modeler listens to what is being graphed and the way people are talking about the graphs. They must also be able to conceptualize early seeds of system structure.
- Wall builder to cluster graphs and talk about themes with little or no experience in SD
- Runner (optional) to bring the graphs from the community facilitator if the group is large

- Recorder to document the session and photograph the clustered graphs

Steps:

1. Based on group size, decide whether to break participants into subgroups. In smaller groups N<10, allow individuals to work and present independently. In larger groups N >10, divide participants into groups of roughly 10. Ask the subgroups to sit together.
2. The modeling team hands out sheets of white paper to each participant or group.
3. The facilitator gives an example of how to draw a graph over time, carefully labeling X-axis "Time" with start time, end time, and now indicated with a vertical dashed line. The Y-axis is labeled with a variable name. The facilitator then sketches the behavior over time.
4. The facilitator then asks participants to draw one variable over time per piece of paper. The participants should be given the option of including hoped for behavior, expected behavior, and feared behavior on the same graph.
5. The facilitator and wall-builder walk around and help participants with the task if they need it. Allow 15 minutes or until the group runs out of steam to complete the task.
6. Reconvene as a large group.

   A: If N<10, the facilitator takes one graph at a time from each participant, holds it up in front of entire group and asks him/her to talk about it. Ask for participants to share the "best stuff" first. Clarify timescale, variable names, etc.

   B: If N>10, instruct subgroups to share their graphs with each other and choose the ones they think are most important. The facilitator then goes to each subgroup and holds the first graph they have selected up in front of entire group. The subgroup spokesperson talks about the graph. Ask subgroups to share the "best stuff" first. Clarify timescale, variable names, etc.

7. The facilitator then hands the graph to the wall builder.
8. The facilitator repeats steps 6 and 7 with each participant or subgroup, taking one graph at a time until all graphs are shown or time has run out. Finish by asking if any participant has something else that really ought to be shown.
9. During steps 7-8, each graph is posted on the wall. The wall builder tries to cluster the graphs meaningfully on the fly based on themes and variables.
10. The facilitator asks the wall builder to explain the clusters of graphs on the wall. The wall builder tries to summarize dynamics that help to characterize the problem that emerges from the participants' graphs.

11. The facilitator enables the participants to talk about the clusters and the characterization of the problem they imply.
12. Consider labeling the clusters based on themes or related variables. There is potential for the modeler to close by highlighting the beginnings of feedback thinking in the dynamic problem.

Evaluation criteria:

- Interesting, self-sustaining group discussion after clusters described by the wall builder
- Meaningful clusters identified.
- Graphs tend to converge to a clear dynamic problem
- Some key dynamic variables emerge from reflecting on the graphs and thematic clusters
- Modeling team can begin to see key stocks and perhaps important feedback loops
- Members of the group appear to have better understand

Authors:

George P. Richardson and David F. Andersen

History:

First described in Luna-Reyes et al (2006)

Revisions:

None

References:

Andersen, D. F., & Richardson, G. P. (1997). Scripts for group model building. *System Dynamics Review, 13*(2), 107-129.

Notes:

None

Hopes and Fears

Context:
At the start of a GMB project.

Purpose:
To elicit and establish group expectations for a GMB session or project.

Status:
Best practices

Primary nature of group task:
Divergent

Time:
Preparation time: 0 minutes
Time required during session: 30 minutes
Follow-up time: 0 minutes

Materials needed:
1. Two different colors of office paper (8.5 x 11) for each participant
2. Thick markers
3. Blue "painters" masking tape

Inputs:
None

Outputs:
List of participants' hopes and fears.

Roles:
- Facilitator with good group facilitation skills and knowledge of the local language and topic
- Recorder to document the session

Steps:
1. Participants are given several sheets of paper in each color. The facilitator explains that they will be writing their hopes and fears for the project and then sharing them with the group.
2. The facilitator states which color represents hopes and which represents fears.
3. In a round-robin fashion, each participant then reads one fear and one hope. The facilitator takes each hope and fear that the participant has read and posts it on the wall. After each participant has had a chance to share once, the facilitator may open the floor to participants to offer

hopes and fears or may go around the room until everyone has shared all of their hopes and fears.

4. The facilitator then tries to identify some of the themes of the hopes and fears.
5. Recorders write down the hopes and fears in the session notes.

Evaluation criteria:
Participants have shared both their hopes and fears for the upcoming project; participants understand the overall themes of the hopes and fears.

Authors:
George P. Richardson and David F. Andersen

History:
First described in Luna-Reyes et al (2006)

Revisions:
None

References:
Luna-Reyes, L. F., Martinez-Moyano, I. J., Pardo, T. A., Cresswell, A. M., Andersen, D. F., & Richardson, G. P. (2006). Anatomy of a group model-building intervention: Building dynamic theory from case study research. *System Dynamics Review, 22*(4), 291-320.

Notes:
None

Initial Policy Options

Context:
Toward the beginning of a group model building session.

Purpose:
To help the team frame the problem and elicit variables (implicitly, by implication).

Status:
Best practices

Primary nature of group task:
Divergent

Time:
Preparation time: 5 minutes
Time required during session: 45 minutes
Follow-up time: 0 minutes

Materials needed:
1. Markers
2. 8.5x11" (or A4) paper
3. Glue sticks (blue tack, masking tape) for posting on wall
4. Wall for posting

Inputs:
None

Outputs:
The list of specific candidate policy options

Roles:
- Facilitator with modest experience in SD
- Wall builder to cluster the policy options on the wall and describe the resulting them groups (clusters)

Steps:
1. The facilitator sets up task by asking participants to write short phrases naming policies that participants would like to see discussed, modeled, and simulated in the course of the work. There should be one policy per page. They could be policies tried in the past or currently, or policies being talked about for the future including both ideas that are considered realistic or "wild" ideas that exceed expectations for what is feasible.

2. The participants may work in pairs to build confidence and share thinking while still keeping the divergent nature of the group task.
3. The facilitator collects policy pages one at a time (receiving one page per pair and going on to the next pair to assure complete involvement). Ask each pair to talk about their proposed policy option.
4. The wall builder posts the policy pages on the wall, clustering them on the fly according to emerging themes.
5. Repeat steps 5 & 6 until done, or time runs out.
6. The facilitator asks the wall builder to describe the theme groups (clusters), justify the choice of clusters, and talk about what he or she sees in the clustering.

Evaluation criteria:

- Long list of candidate policy options
- List of realistic and appropriate policy options
- List of policy options helpful for the model building?

Authors:
Unknown

History:
Used by Andersen & Richardson, individually and as a team, for years. Could be said to stem from Nate Mass's 1980 observation on a draft of the Richardson-Pugh text (expressed to Richardson) that defining problems dynamically is only part of the story, that many times consultants and modelers have only lists of policy options to use to begin the modeling process.

Revisions:
Some revisions have probably been made, but because the script is simple revisions would have been few and probably hard to identify. Clustering could have been a revision early on.

References:
None

Notes:
None

Initiating and Elaborating a Causal Loop Diagram

Context:
This script may be used at the beginning of a project in order to get an initial idea of central concepts and their relationships. If the aim of the project is to construct a formal simulation model, it is recommended to build a stocks and flows model. In addition, when accumulations are important in the issue (for instance when the problem is on a production chain or on human resources moving through different states), a stocks and flows model is recommended.

Purpose:
- Initiating mapping
- Eliciting relations
- Eliciting feedback loops

Status:
Best practices

Primary nature of group task:
Convergent

Time:
Preparation time: 20 minutes
Time required during session: 20 minutes
Follow-up time: 20 minutes

Materials needed:
Either: 1) three flip charts or wall space on which several flip charts are taped, or 2) whiteboard, markers and flip chart or 3) a projector and laptop with Vensim. In the latter case a second person is needed to draw the diagram in Vensim, in the first two situations one person may guide the group.

Inputs:
A list of variables

Outputs:
Deliverable: a causal loop diagram which may be described in a report (in the case only a qualitative model is built) or be used as a dynamic hypothesis on the basis of which formal modeling starts. Interim output/ product: increased consensus on dynamic hypothesis, or a possible structural explanation for observed behavior.

Roles:
- Facilitator/ modeler with experience in drawing causal loop diagrams, preferably with experience in building formal models as well
- Facilitator/ modeler and participants

Steps:

1. Remind the group of the problem variable, preferably sketched as a reference mode of behavior. Remind the group of the list of variables elicited before. Place the list of variables in such a way that it is visible to the group of participants. Write the problem variable in the centre of a white board or blackboard.

2. Build the model by following steps a, b and c in the figure below (cf. Vennix, 1996: 120).

   a. Ask participants which variable from the collected list is a cause for changes in the problem variable. When someone makes a suggestion, include this in the drawing of the model in order to visualize what is meant. Then check to see if everyone agrees with the proposed relation. If someone disagrees, ask for clarification and try to determine what the group thinks the relationship should be. If a discussion goes on too long, you can choose to temporarily 'park' this item and continue with another part of the model. Hopefully, there will not only be variables that have a direct relationship with the problem variable, but you will also build a few logical chains of reasoning (via intermediate variables) into the model. In addition check the polarity (positive or negative) of the relationship.

   b. After spending some time doing this, proceed to the consequences of changes in the problem variable.

   c. At the point where a feedback chain becomes closed, check with the entire group to see if the chain as whole is correct. Check again to see if a loop is positive or negative. The Ratio Exercise script may be used to draw out loops.

3. In the last part of the session, analyze the model by checking the feedback loops one more time. Before you close the group session, make sure you do the following. If there is a list of parked issues, go through them. State once more what has been done and what will happen with the final products. Formulate a few concise conclusions. As Andersen and Richardson (1997) say: ‘end with a bang!’ Make sure that all the information which is necessary for the report has been noted.

Evaluation criteria:

Improvement in quality of communication, insight, consensus on the problem and commitment with regard to actions.

Authors:
Jac Vennix 1996, used for bachelor (undergraduate) course by Etiënne Rouwette from September 2007

History:
Earlier publications Vennix

Revisions:
Explained steps in more detail for bachelor students with limited experience in modeling.

References:
Andersen DF, Richardson GP, 1997. Scripts for group model building. System Dynamics Review 13(2): 107-129.

Vennix JAM. 1995. Building consensus in strategic decision making: insights from the process of group model building. *Group Decision and Negotiation 4:* 335 – 355.

Vennix JAM. 1996. *Group model building: facilitating team learning using system dynamics.* Chichester: Wiley.

Vennix JAM, Akkermans HA, Rouwette EAJA. 1996. Group model building to facilitate organisational change: an exploratory study. *System Dynamics Review 12*(1): 39 – 58.

Notes:
None

Logistics and Room Set Up

Context:
Before the GMB session begins

Purpose:
To create an inviting and conducive environment for GMB participants.

Status:
Best practices

Primary nature of group task:
Offline

Time:
Preparation time: 30 minutes
Time required during session: 45 minutes
Follow-up time: 0 minutes

Materials needed:
Materials needed for group model building session.

Inputs:
A drawing for how the room should be set up

Outputs:
A plan for room set-up.

Roles:
Facilitators experienced in GMB and design of the workshop

Steps:

1. Arrange the table, chairs, flip charts in the room in manner conducive to upcoming activities and scripts. Consider how participants should be sitting:

   a. In a semicircle facing the wall where a model is projected, white board or chalkboard.

   b. In clusters of tables so participants can work in small groups.

2. Arrange power cords, tables, and chairs for members of the modeling not sitting at the table with participants (e.g., recorders, modelers, coaches).

3. Secure any power cords and extension cables with tape to minimize the risk that people may trip.
4. Arrange refreshments in a place that is convenient for participants to get up and access during the session.

Evaluation criteria:
Thoughtful room set-up that will contribute to participants' comfort, engagement and understanding.

Authors:
Andersen and Richardson

Date created:

History:
Documented by Annaliese Calhoun in 2010 based on Luna-Reyes et al. (2006).

Revisions:
Revised by Peter Hovmand in 2013 to provide more details on room arrangements

Date of last revision:

References:
Luna-Reyes, L. F., Martinez-Moyano, I. J., Pardo, T. A., Cresswell, A. M., Andersen, D. F., & Richardson, G. P. (2006). Anatomy of a group model-building intervention: Building dynamic theory from case study research. *System Dynamics Review, 22*(4), 291-320.

Notes:
Successful GMB sessions require the qualities and comfort of the physical facilities and the smooth handling of logistics for the sessions. This should include removing the participants from their phones and work site and providing a relaxing change from routine work. Multi-day sessions should be located and planned to provide high-quality lodging, meals, and opportunities for social interaction.

Model Review

Context:
After causal structures have been developed, typically at the end of a session.

Purpose:
- To summarizing dynamic insights and stories
- To clarify fuzzy ideas or capturing additional information about model structure needed to formulate the model
- To eliciting feedback from participants

Status:
Best practices

Primary nature of group task:
Convergent

Time:
Preparation time: 5 minutes
Time required during session: 15 minutes
Follow-up time: 0 minutes

Materials needed:
- Screen
- Projector

Inputs:
- Diagram of model

Outputs:
- List of main feedback loops and dynamics identified
- List of insights gained from the connection circle exercise and subsequent model

Roles:
- Modeler with experience building models
- Reflector with extensive experience building and analyzing system dynamics models
- Recorders with note-taking experience

Steps:
1. At the start of model review, the modeler moves up to the front of the room.
2. The modeler describes the causal loop diagram and stresses that this is another reflection of the exact same linkages and variables

discussed during the exercise and that none of these elements has been changed. Modeler notes that plus and minus signs mean the same as in the previous exercise.

3. In a causal diagram, the modeler takes care to explain reinforcing and balancing loops by tracing examples within the model (if available). Modeler introduces the reflector, for the reflector to discuss more insights regarding feedback within the model.
4. The reflector reviews key insights from the causal map and reads back the stories associated with major reinforcing and balancing feedback loops, intervention points, etc.
5. After the reflector has reviewed the diagram, the reflector then initiates questioning regarding what didn't get recaptured or is missing from the diagram. The reflector assesses confirmation of the adequacy of the diagram as a representation of the group thinking. The recorders document the insights shared.
6. The reflector also will point out subsequent, important changes in structure, help the group identify what is happening with the modeling, and highlight model based insights that emerge.

Evaluation criteria:

- A revised causal loop diagram that is based on an initial discussion
- A shared understanding of the changes in the model and insights that have emerged

Authors:
Unknown

History:
Based on original script "Causal Mapping from Discussion" by Peter Hovmand, created on April 19, 2010.

Revisions:
Revised May 22, 2012 by Alison Kraus and Peter Hovmand
Revised March 4, 2012 by Meagan Colvin and Peter Hovmand

References:
Richardson, G. P. (1997). Problems in causal loop diagrams. *System Dynamics Review, 13*(3), 247-252.

Notes:
None

Modeling Project Community Presentation

Context:
This script should be used at or near the beginning of the transfer of ownership phase at the end of a modeling project or major milestone in a multiphase group model building project.

Purpose:
To disseminate information about the modeling project and elicit feedback from community members.

Status:
Best practices

Primary nature of group task:
Presentation

Time:
Preparation time: 30 minutes
Time required during session: 30 minutes
Follow-up time: 120 minutes

Materials needed:
1. Markers, flip chart, blue tape, easels for flip chart and poster of model
2. Poster(s) of model
3. 11x17 printouts of model
4. Flyers advertising any other scheduled sessions such as conferences or future GMB sessions

Inputs:
Visually attractive and readable diagram of a system dynamics model

Outputs:
- List of modifications necessary to model
- Recorder notes

Roles:
- Facilitator familiar with stakeholders in the room and some group facilitation skills
- Modeler with expertise in system dynamics
- 2 Recorders (one for flip chart, one for detailed recorder notes)

Steps:
1. Facilitator convenes and introduces modeler/facilitator

3. Modeler provides overview of "agenda"
- Where we have been
- Where we are now
- Where we are going & how to get involved

4. Modeler reviews model and facilitator frequently checks for understanding and allows time for comment. Recorders capture feedback on flip charts and recorder notes
5. Facilitator closes the session

Evaluation criteria:
- Active participation from community. Spirited engagement
- A list of areas of model that were supported and what needs to be changed

Authors:
Timothy Hower and Peter Hovmand in 2010

History:
The script was originally created as part of a St. Louis Federal Reserve Bank project.

Revisions:
None

References:
None

Notes:
This exercise has worked well with diverse audiences and settings, from formal meetings of 70-100 people to bible study sessions of 30-50 people. A key ingredient to successfully presenting the model is a close correspondence between the stories shared during earlier settings during sessions with stakeholder groups and the language of the model.

Next Steps and Closing

Context:
At the end of a group model building session.

Purpose:
The objectives of this script are Identifying next steps and closing the session.

Status:
Best practices

Primary nature of group task:
Convergent

Time:
Preparation time: 10 minutes
Time required during session: 15 minutes
Follow-up time: 0 minutes

Materials needed:
None

Inputs:
Deliverables from session (e.g., printouts of model)

Outputs:
None

Roles:
- Facilitator familiar with system dynamics modeling process and next steps of project
- Modeler/reflector, usually the person on the team with the most expertise in system dynamics modeling
- Closer with status in the room, often the same person as the convener
- Recorder to take notes on any questions, list of next steps, and who is going to do the next steps and by when they are due

Steps:
1. The facilitator thanks participants for their contributions during the session and states that the team is going to tell them what's going to happen next. This can include:

    - Model cleanup and review: We are going to clean up the model by comparing what we have now to the notes and making sure that everything that was said is in the model. Next, we have a model

review session scheduled for "____". You are all invited to attend. (Note: If the session is out of town, describe ways that they can join via Go To Meeting, etc.) State that they are all invited.

- Updates: If participants cannot join the model review or do not wish to be involved but would like updates on the project, state that they can put their name and email on a sign-up sheet and updates will be sent about project progress. We can also send them copies of the model if they would like a copy.

- Involvement: Depending on the project, emphasize that we like for participants to remain involved if they would like to. This can be joining a planning committee if there is one within the project, coming to dissemination meetings, or even co-facilitating future sessions.

- Model ownership: If during the session a model has been created, state that we see the model as being owned by the participants because they have created the structure and have full rights to use it in any way they would like to. You can state that in the past, participants have used models by presenting them to their school board and incorporating it into grants. It can also be used as a talking piece in which to generate a discussion with other folks about an issue.

2. The facilitator asks if there are any questions.

3. The facilitator asks the modeler/reflector if they have any reflections, thoughts, or observations they would like to share. The modeler/reflector may share a few brief comments or overall impressions.

4. The facilitator then summarizes the list of next steps and who is responsible and indicates where participants can pick up deliverables from the session.

5. The convener thanks participants for coming and states that they can be available for additional questions or comments in the future.

Evaluation criteria:
Everyone in the room knows what the next steps are.

Authors:
Krista Chalise, Timothy Hower, Peter Hovmand, 2010

History:
Originally based on activities conducted by Timothy Hower and Peter Hovmand during St. Louis Federal Reserve in October, 2010.

Revisions:
Revised by Peter Hovmand in 2013 to reflect current practices

References:
None

Notes:
None

Nominal Group Technique

Context:
This subscript may be used at the beginning of a project in order to get an initial idea of central concepts or as a subscript (e.g., within Graphs over Time)

Purpose:
To generate an initial set of ideas (e.g., variables or dynamics)

Status:
Best practices

Primary nature of group task:
Divergent

Time:
Preparation time: 10 minutes
Time required during session: 20 minutes
Follow-up time: 0 minutes

Materials needed:
Either: 1) a flipchart and markers, or 2) a whiteboard, markers and flip chart or 3) a projector and laptop with Vensim. In the latter case a second person is needed to draw the diagram in Vensim, in the first two one person may guide the group.

Inputs:
None

Outputs:
List of variables

Roles:
Facilitator with experience in system dynamics modeling and NGT or brainstorming with groups

Steps:

1. Ask the participants to write down ideas about things that involve the problem variable. These might be causes or consequences of the problem, or any elements a participant feels are important to the issue at hand. Ask the participants to do this as much as possible in terms of variables. Explain that a variable is something that may increase or decrease over time. It does not already have a value on a particular scale - as in 'young employees'. In this case we would include average age of employees so that the value may increase or

decrease over time. It is also not a categorical or nominal variable – as in type of holiday chosen. Duration of holidays or costs of holidays are aspects which may be used in a model. If it is not possible to formulate an idea as a variable, it does not really matter; the facilitator and the rest of the group can work together to find a variable.

2. Give the participants a few minutes to write down their own ideas.

3. Explain that you are going to gather ideas and show them on the board or computer screen for everyone to see. Ask each participant for one idea and write this on the white board or blackboard. Pay attention to the conversion into variables and check to see if the other group members know what the person contributing the idea means. Allow a clarification of meaning, but not a discussion on the relevance or importance of the idea. Explain that in this phase, the person contributing the idea has the last word: if he or she prefers a particular formulation even if other object, the proposed formulation will be put on the central board or screen. In the next phase, when starting to build the model, a relation will only be included when all participants agree. So while in NGT an individual participant 'has the power', in the phase of drawing relations we strive for consensus.

4. Stop collecting ideas after two or three rounds. Emphasize that the aim of this phase is only to create an initial list of variables so that model building can begin, and that variables that were not written on the board for the group are not automatically discarded. During the model building process, variables from the individual lists or even entirely new variables can be added.

Evaluation criteria:
Number of ideas generated, extent to which meaning of ideas is clear to participants

Authors:
Jac Vennix, 1996

History:
Originally developed as an alternative to brainstorming (see note below).

Revisions:
Script revised for use with undergraduates by Etiënne Rouwette in 2007

References:
Delbecq A, A. Van de Ven, G. H. Gustafson. 1975. *Group techniques for program planning: a guide to nominal group and delphi processes.* Glenview: Scott, Foresman and Co.

Vennix JAM. 1996. *Group model building: facilitating team learning using system dynamics. C*hichester: Wiley.

Stroebe W, BA Nijstad, EF Rietzschel. (2010). Beyond productivity loss in brainstorming groups: the evolution of a question. *Advances in Experimental Social Psychology 43:* 157-203.

Notes:
There are two main reasons for using NGT instead of brainstorming in this phase (in brainstorming all participants may contribute ideas simultaneously, which will enliven the atmosphere in the group). First, by gathering ideas in a round robin fashion, the facilitator controls how many ideas are brought to the board or screen. We are not looking for dozens of ideas, only an initial list to get started with modelling. Second, research (see Stroebe, Nijstad and Rietzschel, 2010 for an overview). has shown that NGT results in more ideas and ideas of better quality than brainstorming. In particular the latter is important here.

This script is most effective when the central issue (indicated by the problem variable) is already discussed with the contact client and preferably also by the participants present in the session. In that way the group needs only a few minutes to discuss the problem variable and can then proceed to eliciting variables.

Process Mapping

Context:
At the start of GMB planning with the modeling team.

Purpose:
To plan and develop a shared understanding of the overall group model building process, identify the number of sess ions, and select how many people and who will be involved in each session. The inputs and outputs for sessions are also established.

Status:
Best practices

Primary nature of group task:
Offline

Time:
Preparation time: 10 minutes
Time required during session: 45 minutes
Follow-up time: 10 minutes

Materials needed:
1. Drawing program (e.g., Visio, PowerPoint, iDraw)
2. Blank or draft process map with basic phases of project
3. Data projector

Inputs:
None

Outputs:
- GMB process map
- Descriptions of modeling team and participants for each session

Roles:
- Facilitator familiar with group model building who can introduce scripts, share sample agendas, and different roles in GMB
- Recorder who is tracking categories of participants and facilitators during the discussion, and then confirming this list with participants at the end
- Recorder who is taking process notes on the planning session

Steps:
1. The facilitator introduces a blank process map
2. The facilitator explains the criteria for selecting stakeholder tracks.

The criteria for identifying a stakeholder group or track for a group model building session are primarily based on who you want to have in the room developing a particular model. You might want to think about what kind of conversation or dialogue you want to elicit from participants or who you want to be able to attribute the model to. For example, is it important to elicit divergent views on a subject where people might have different experiences? Is it important to be able to say that the model was developed by consumers or some other stakeholder group?

3. Begin by introducing the core modeling team as the first stakeholder track and different phases of modeling.
4. Then try to identify one stakeholder track and begin to identify some sessions. As the sessions are discussed, identify who is in the session in terms of facilitators and participants.
5. Continue to add and change sessions during the discussion with periodic checks to confirm the state of the process map.
6. Each session with the same agenda should have the same numerical prefix and be distinguished with a letter suffix (e.g., 6A, 6B, etc. would all indicate multiple sessions using the same agenda; 7, 8, 9, etc. would indicate multiple sessions with different agendas).
7. Identify inputs or outputs that might be needed in the session.
8. Near the end of the session, the recorder keeping track of descriptions of facilitators and participants starts a review by going through each numbered session. As the recorder lists the participants and facilitation team for the session, the facilitator with expertise in GMB gestures to that particular session.

Evaluation criteria:

- There is general agreement and buy-in on the overall plan for group model building among the core modeling team.
- The core modeling team has a clear idea of how many sessions are involved, when they will happen, and who will be involved.
- There is an initial sense of who will facilitate the group model building sessions and needs to be involved in the training.
- The core modeling team has sufficient information to develop an IRB application.

Authors:

Peter Hovmand and Timothy Hower, 2010

History:

This approach is based on David Straus's (2002) approach to designing collaborations and group process. The motivation for both using process maps and making the process explicit comes from the tendency to underestimate the amount

of planning required to design even relatively short group model building workshops.

Revisions:
None

References:
David Straus (2002). *How to make collaborations work: Powerful ways to build consensus, solve problems, and make decisions.* San Francisco, CA: Berrtt-Koehler Publishers, Inc.

Notes:
A common issue in identifying stakeholders is that groups will tend to generate long lists of people involved in the system or focus on recruitment strategies for getting them involved. These tend to be counter-productive starting places because it is often not clear what is being asked of individuals being recruited.

Ratio Exercise

Context:
After a Graph over Time and Concept Model exercise.

Purpose:
To elicit feedback loops (especially minor loops), variables within a causal chain, and in some special cases, can initiate mapping.

Status:
Best practices

Primary nature of group task:
Convergent

Time:
Preparation time: 30 minutes
Time required during session: 10 minutes
Follow-up time: 30 minutes

Materials needed:
1. Large erasable white surface (cling sheet wall or white board)
2. White board markers
3. Recorder will want to capture image in Vensim sketch or with a camera
4. Modeler reflector may redraw some of the mapped feedback loops on blank overhead slides using a water-soluble or dry-erase marking pen

Inputs:
This script cannot be completed until the group has defined pairs of stock variables whose ratio or difference make sense to the group (e.g., class size, caseload, vacancy rate, occupancy rate, etc.)

Outputs:
- Feedback loops
- Articulation and mapping of feedback effects

Roles:
- Facilitator with modest experience in SD; should be able to lead the group in mapping feedback effects (perhaps more skill is required in recognizing the stock variables and getting the exercise set up).
- Skilled modelers are needed in the "modeler feedback" follow up where the feedback loops elicited by the group are integrated into more complicated "cleaned up" feedback diagrams.

- Recorder who can operate a camera or sketch the geometry of feedback loops using software such as Vensim.

Steps:

1. The modeler picks out a pair of stocks to work with first.
2. The facilitator asks the group to name the ratio or difference (caseload, class size, etc.). The facilitator adds the ratio or difference variable using the exact name that the group has suggested (different groups use differing terminology for a similar concept. Additionally, some groups use differences and some use ratios--occupancy rate versus number of vacancies; it is important to use their terms).
3. The facilitator maps the ratio (or difference variable) with the incoming arrows marked with "+" or "-" as is causally appropriate.
4. The facilitator asks the question, "what would happen if this ratio were to go to zero or get unusually small" or "what would happen if this ratio were to become very large—how would the system react?"
5. The participants then start to tell feedback stories about how the system reacts when this key ratio (or difference) gets out of whack. When loops are completed, the facilitator traces them out for the group adding appropriate "+" or "-", telling the stories of the loops. These loops are almost always balancing loops.
6. Steps 2 to 5 are repeated with another set of ratios

Evaluation criteria:

- This script will usually fill a white board with lots of feedback loops very quickly
- Participants will "get the hang" of what feedback loops are, how they work, and will start to look for them.
- A very good map will have feedback paths that connect to other important stocks in the system (other than simple first order loops). These insights that pass through other stocks are especially important.

Authors:

David F. Andersen and George P. Richardson

History:

This script was first developed and used by Richardson and Andersen in the 1990s, and described in Richardson and Andersen (1995).

Revisions:

None

Date of last revision:

References:

Richardson, G. P. and Andersen, D. F. (1995), Teamwork in group model building. *System Dynamics Review, 11,* 113–137.

Notes:

This script typically develops off-line when the modeling team realizes that a strong and clear set of stocks and flows exist to under gird this system and that aging chains of usually service loads (students, patients, clients) can be linked to some resource of stocks (teachers, nurses, caseworkers) so that the pairing of related stocks makes sense. Sometimes the modeling team realizes this quite early on (sometimes they have a strong hunch before the session even begins). It is a real "work horse" script, yielding lots of feedback in a reliable fashion. This is a gratifying script to use because it so often consistently and quickly populates the public diagram with a dense network of feedback loops.

Reflector Feedback

Context:
After each iteration of structure elicitation.

Purpose:
To summarize dynamic insights and stories told by the group. It also allows for clarification of fuzzy ideas or capturing additional information about model structure needed to formulate the model.

Status:
Best practices

Primary nature of group task:
Convergent

Time:
Preparation time: 0 minutes
Time required during session: 15 minutes
Follow-up time: 0 minutes

Materials needed:
1. Chalk/whiteboard markers
2. Flip chart/whiteboard
3. Overhead transparencies
4. Overhead projector

Inputs:
- Prioritized list of variables
- Behavior over time graphs (reference modes)

Outputs:
None

Roles:
Reflector

Steps:
1. The reflector presents a series of diagrams created during the group discussion. Diagrams and notes are usually captured in overhead transparencies using markers of different colors.
2. The diagram is presented in the simplest form on a transparency. More complex versions with additional variables are progressively layered on top of the first diagram. As the reflector places each layer on the projector, he/she presents the story behind the diagram.

3. The presentation includes comments about how a more operational version of the diagram helps to clarify causal relations and important feedback, and continuous confirmation of the adequacy of the diagram as a representation of the group thinking.
4. The reflector may add variables to the diagram at the group's request.

Evaluation criteria:
- Unclear ideas have been clarified.
- The group has a better sense of variables and causal relations needed to complete a model.

Authors:
George Richardson

Date created:

History:
First documented by Annaliese Calhoun in 2010 based on Luna-Reyes et al. (2006)

Revisions:
None

References:
Luna-Reyes, L. F., Martinez-Moyano, I. J., Pardo, T. A., Cresswell, A. M., Andersen, D. F., & Richardson, G. P. (2006). Anatomy of a group model-building intervention: Building dynamic theory from case study research. *System Dynamics Review, 22*(4), 291-320.

Notes:
Although the script is designed to be a presentation, listening to the group and using the pen and the eraser continue to be important during the process.

Scheduling the Day

Context:
At the start of a project this script will be used to create a master plan for the GMB workshop.

Purpose:
To plan the session, including which scripts will be used and process the approaches to be used in each script.

Status:
Best practices

Primary nature of group task:
Offline

Time:
Preparation time: 0 minutes
Time required during session: 180 minutes
Follow-up time: 0 minutes

Materials needed:
1. Paper
2. Pen

Inputs:
None

Outputs:
Final schedule of GMB session

Roles:
- Facilitator with moderate skills in facilitation
- Modeler with moderate to expert skills in SD and sense of how a model might evolve during the GMB session
- Gatekeeper with knowledge of what the participants might be expecting from the GMB

Steps:
1. The team should aim for a detailed plan that alternates convergent and divergent tasks. The tasks are used to elicit variables and model structure as well as incorporate reflection.

2. The facilitator, modeler, and gatekeeper discuss the agenda for the GMB session using 15-20 minute time blocks to discuss each activity

to be included. Some tasks may take more than 15-20 minutes to plan. Tasks should alternate between divergent and convergent.

3. The facilitator, modeler, and gatekeeper revise the agenda after the first version has been completed. The agenda may be revised multiple times.

Evaluation criteria:
• A complete and detailed agenda for the GMB session is created. A three to four column planning sheet is a good format for the agenda. It should include:
• Scheduled times for the activities
• The public agenda to be shared with the group
• A detailed agenda for the modeling team
• Notes on the preparation and materials needed for each part of the meeting or session

Authors:
Richardson and Andersen

History:
Originally described in Luna-Reyes et al (2006)

Revisions:
None

References:
Luna-Reyes, L. F., Martinez-Moyano, I. J., Pardo, T. A., Cresswell, A. M., Andersen, D. F., & Richardson, G. P. (2006). Anatomy of a group model-building intervention: Building dynamic theory from case study research. System Dynamics Review, 22(4), 291-320.

Notes:
None

Structure Elicitation

Context:
This script fits after exercises to elicit reference modes and a break have been completed.

Purpose:
To captures the key endogenous mechanisms elicited during a discussion that have the potential to explain the observed behaviors or dynamic hypotheses.

Status:
Best practices

Primary nature of group task:
Convergent

Time:
Preparation time: 20 minutes
Time required during session: 90 minutes
Follow-up time: 0 minutes

Materials needed:
1. Chalk/whiteboard markers
2. Flip chart/whiteboard

Inputs:
- Prioritized list of variables
- Behavior over time graphs (reference modes)

Outputs:
Basic stock and flow structure

Roles:
- Facilitator
- Modeler

Steps:
1. During the break after the reference mode elicitation script, the modeling team selects a couple of key behaviors from the reference mode elicitation exercise.
2. The facilitator starts the structure elicitation by suggesting two stocks. The facilitator explains that these stocks are initial simplifications of the system.

3. The facilitator asks the group to identify the variables that help to open or close the faucet of these two stocks. Participants suggest causal relations linked to these two initial stocks and their corresponding rates.
4. The facilitator clarifies the nature of the causal relationships with the group while drawing them on the board.
5. After adding a couple of variables and causal relations, the facilitator summarizes by telling the story embedded in the model so far and asks the group to add further causal explanations, stressing the importance of selective thinking about causality with the purpose of reaching a powerful and parsimonious explanation of the project success.

Evaluation criteria:
A basic stock-flow structure has been produced.

Authors:
Richardson and Andersen

History:
Originally described in Luna-Reyes et al (2006) and probably documented by Annaliese Calhoun in 2010

Revisions:
None

References:
Luna-Reyes, L. F., Martinez-Moyano, I. J., Pardo, T. A., Cresswell, A. M., Andersen, D. F., & Richardson, G. P. (2006). Anatomy of a group model-building intervention: Building dynamic theory from case study research. *System Dynamics Review, 22*(4), 291-320.

Notes:
This script based entirely on Luna-Reyes, et al's article.
The main limitation of this script is the risk of having a discussion guided by the group facilitator. The main advantage is that it is flexible and easy to prepare for. Initial aggregations can create conflict with the client group.

Usually, the facilitator or the reflector differentiates between detail complexity (many disaggregated processes), and feedback complexity (a rich feedback story with many loops), explaining that system dynamics modelers have found that it is much easier to increase the detail complexity once an appropriate level of feedback complexity has been reached than to increase feedback complexity when the desired level of detail complexity has been reached.

A very important element in the process is to write down (or erase) all group ideas on the board, even if they cannot be included easily as part of the feedback story.

Transferring Group Ownership from One Image to Another

Context:
After the first GMB session.

Purpose:
- To show the group the way in which insights and structures from the first session were incorporated into the simulation model.
- To "get permission" from the group to continue the modeling work starting with the new structural diagram.
- To move from a complex diagram created in a structure elicitation activity to a simpler and cleaner version created by the modeler/reflector.

Status:
Best practices

Primary nature of group task:
Convergent

Time:
Preparation time: 300 minutes
Time required during session: 25 minutes
Follow-up time: 0 minutes

Materials needed:
1. Copies of original diagrams and models that can be projected on wall
2. Copies of new simulation model that can be projected on wall
3. Overhead projector
4. Overhead transparencies

Inputs:
- Notes
- Diagrams
- Reference modes
- Products from previous GMB sessions

Outputs:
None

Roles:
- Facilitator
- Modeler/reflector

Steps:

1. The activity starts by projecting on to different walls of the room the different diagrams to be compared… [including] the final "icons" of the group theory from the first modeling session, and… the simulation model formulated between the two sessions.

2. A member of the facilitation team explains to the group how different components of the two diagrams created in the first session were incorporated into the simulation model.

3. The presentation includes amplifications of the main sectors of the model to make comparisons among the three diagrams easier. The modeling team comments and shows some of the basic assumptions and formulations in the model to the group.

4. At the end of the presentation, the facilitator "asks the group's permission" for using the new "icon" as the basis for further theory development.

5. Once the group agrees on the appropriateness of this new "icon", the two images from the first modeling session are taken away, and the conversation becomes focused on the simulation model.

Evaluation criteria:

- Participants to transitioned understood changes from one model to a more complex simulation model produced by the modeling team
- Participants take ownership of the more complex simulation model

Authors:

Andersen and Richardson

History:

Documented by Annaliese Calhoun, June 18, 2010 based on Luna-Reyes et al. (2006)

Revisions:

None

References:

Luna-Reyes, L. F., Martinez-Moyano, I. J., Pardo, T. A., Cresswell, A. M., Andersen, D. F., & Richardson, G. P. (2006). Anatomy of a group model-building intervention: Building dynamic theory from case study research. *System Dynamics Review, 22*(4), 291-320.

Notes:

This script based entirely on Luna-Reyes, et al's article

Variable Elicitation

Context:
Early in the modeling process

Purpose:
To facilitate consensus-based group discussion about the model problem and boundaries. It elicits key variables that become the input for other activities.

Status:
Best practices

Primary nature of group task:
Divergent

Time:
Preparation time: 0 minutes
Time required during session: 20 minutes
Follow-up time: 0 minutes

Materials needed:
1. Markers
2. Stacks of plain paper
3. Chalk/whiteboard markers

Inputs:
None

Outputs:
Prioritized list of variables

Roles:
- Facilitator with moderate expertise in SD and small group facilitation
- Modeler with moderate expertise in SD

Steps:
Part I

1. The facilitator gives each participant sheets of blank paper and markers.

2. The facilitator writes a task focusing question on the whiteboard or flipchart, such as, "What are the key variables affecting the process and outcomes of the [project name] project?"

3. The facilitator asks participants to write as many problem-related variables as they can on the sheets of paper. Participants are given a few minutes to work individually on their lists.

4. Once they have finished the individual exercise, the facilitator uses the same process used in the hopes and fears script to put all individual variables on the board. When a variable name is open to several interpretations, the facilitator asks for a brief description or definition of the variable, including the units in which the variable can be measured.

5. The facilitator writes the variable name on the board, including any additional information in parenthesis.

Part II

6. The facilitator asks the participants to prioritize the variables by simple voting mechanisms. Individuals can vote for as many variables as they want. The number of votes for each variable is also written down on the board.

7. The facilitator makes a summary of the variables on the board, while the recorder captures the products of the process either photographically or in a word processor.

8. The facilitator suggests which variables can be considered stocks as they are mentioned. If the participants agree, the facilitator can add the words "level of" to these variables.

Evaluation criteria:
Identification of key variables and stocks.

Authors:
Andersen and Richardson

Date created:

History:
Originally described in Luna-Reyes et al (2006)

Revisions:
Unknown

Date of last revision:

References:
Luna-Reyes, L. F., Martinez-Moyano, I. J., Pardo, T. A., Cresswell, A. M., Andersen, D. F., & Richardson, G. P. (2006). Anatomy of a group model-building intervention:

Building dynamic theory from case study research. *System Dynamics Review, 22*(4), 291-320.

Notes:
None

Promising Practices

Acceleration Review

Context:
After each GMB session

Purpose:
To help capture salient aspects of the GMB session and accelerate learning and improvement.

Status:
Promising practices

Primary nature of group task:
Offline

Time:
Preparation time: 0 minutes
Time required during session: 60 minutes
Follow-up time: 0 minutes

Materials needed:
None

Inputs:
Final, detailed version of the Script(s) from the GMB session being debriefed

Outputs:
List of actions necessary to implement improvements

Roles:
Debriefer (pre-assigned)
Recorder

Steps:

1. The debriefer assembles the participants and announces the start of the Acceleration Review.

2. The debriefer gives overview of the process that the team will use to conduct the review. Stress that the purpose of the Acceleration Review is Continuous Quality Improvement (CQI).

3. Review the script(s) from the GMB session being reviewed. These scripts outline what was supposed to happen and what the GMB session was supposed to accomplish.

4. Ask the following questions:

- *Going into the GMB session, did you feel prepared? If not, what would have helped?*
- *Overall, did we accomplish what the session was designed to do?*
- *What went well during this session? Specifically, what did we do that contributed to the creation of value for the participants? (each member of the GMB session team should offer a specific example of something that went well)*
- *From your perspective, what would have led to even more value creation for participants?*
- *Were there any rough parts for you? (All should have the opportunity to answer, but not all need to comment)*
- *What did you learn from this session? (all answer)*
- *What specific, actionable steps can we take to solidify this learning and improve the way we work?*
- *Who is there to appreciate?*

5. Close by thanking team for their time.

6. The recorder takes notes throughout the session.

Evaluation criteria:
• Everyone participates at some point.
• Improvement actions were identified.
• Some appreciation was expressed.

Authors:
Timothy Hower, 2010

History:
Original Script based on current practice and author's work.

Revisions:
None

References:
None

Notes:
None

Building a CLD with Paper

Context:
Early in the GMB process before any structures or diagrams have been made. This script can overlap with the "Graphs over Time" script or any discussion during which participants are discussing relationships within the system.

Purpose:
To capture the variables and causal structures emerging during a participant discussion.

Status:
Promising practices

Primary nature of group task:
Convergent

Time:
Preparation time: 10 minutes
Time required during session: 40 minutes
Follow-up time: 15 minutes

Materials needed:
1. Sheets of paper for each modeler or pad of paper
2. Pencils or pens
3. Large whiteboard, chalkboard, or flipchart paper to present initial diagram

Inputs:
Open discussion during which participants discuss variables within the system and links between variables (e.g., during the Graphs Over Time script).

Outputs:
Causal loop diagram

Roles:
- Recorder who is able to draw causal linkages as they emerge during the discussion and is able to identify variables
- Modeler with expertise in system dynamics who is able to quickly stitch together causal linkages to form a feedback model, also has experience in editing diagrams in system dynamics to make them correct.
- Facilitator to guide discussion among participants

Steps:

Part I:

1. Participants are engaged in a discussion, guided by the facilitator, about variables and behaviors within the system of interest. This type of storytelling could take place through a number of scripts, including the "Graphs over Time" script.
2. As the discussion proceeds, the modeler writes down variables named by participants and the causal links between variables on sheets of paper. Each link should relate at least two variables with a directed arc and identify the link as either positive or negative. Delays should also be indicated if they are mentioned.
3. Meanwhile, the recorder identifies variables named by participants and writes one variable in marker on each index card/post-it note.
4. If there are additional recorders, they can assist the modeler by also documenting causal loops on paper.
5. The modeler begins to create a complete causal loop diagram (CLD) based on the linkages identified on the sheets of paper. The modeler will often redraw the entire structure to produce a better layout. Be careful not to add links or variables that are not explicitly stated by participants.

Part II:

6. Take a group break.
7. During a break, the modeler and recorders discuss the variables and causal loops they have identified, making sure there is consensus on language used and connections made.
8. As a team, they identify 5-6 key variables with causal linkages. These index cards/post-it notes are then placed/taped on chalkboard or whiteboard. Causal arrows with polarities are drawn between the variables (these connections must have emerged from the participants' discussion during Part A).
9. All the other index cards/post-it notes with the other variables are placed in columns beside the initial Causal Loop Diagram (CLD).

Part III:

10. After the break, the modeler reviews the diagram with all of the participants, starting with, "This is what we heard you saying…" and then walks through the small CLD.
11. The modeler takes care to explain that:
    a. A '+' sign means same effect so that an increase in one variable leads to an increase in the other, and a decrease in one variable leads to a decrease in the other.
    b. A '-' sign means an opposite effect so that that an increase in one variable leads to a decrease in the other variable, and a decrease in one variable leads to an increase in the other.

c. The '+' and '–' signs are not "good" or "bad." They just reflect the direction of change.

d. The concept of reinforcing and balancing feedback loops should also be introduced and illustrated with the CLD diagram.

12. As the modeler introduces major SD terms (e.g. feedback loop, +, -) they should be written up on a flipchart/board by the facilitator along with a brief definition so that all participants can see and refer to it.

13. The facilitator then tells participants "This is only the beginning of a much larger system. During the conversation before the break, we were listening for key variables and we've written them all down on index cards. Now we want you to continue building this map of relationships. For example, how does X variable [choose an index card from columns] fit into this picture?" The facilitator then invites participants to come up and place the variable on the board, and draw an arrow connecting it to the existing CLD.

14. Whenever a participant identifies an additional variable or a connection between variables, the facilitator invites him/her to stand up, add the index card to the CLD and physically draw the modifications on the model.

15. The facilitator and modeler alternate inviting participants up to the board and coaching on polarities.

Part IV:

16. If time is running out or saturation has been reached, the facilitator asks for one or two last suggestions, and then stops the exercise.

17. The modeler will close with a summary of major feedback loops and key variables and highlight model based insights that emerge.

18. The facilitator than guides groups in reflecting on process.
    - What has this conversation and CLD brought up?
    - What are the implications for how you're going to approach the problem?
    - What have you learned about the system?
    - How do you want to move forward?

19. The recorder photographs the CLD diagram or collects the flip charts. The modeler transfers the CLD to Vensim.

Evaluation criteria:
Participants created a rich causal loop diagram (CLD) based on their thoughts and stories with the aid of the modeling team. CLD diagram created and drawn in Vensim.

Authors:
Annaliese Calhoun and Timothy Hower, 2010

History:
Based on Building a CLD from Discussion

Revisions:
None

References:
None

Notes:
None

Connection Circle Exercise

Context:
At the start of a session

Purpose:
To see important variables and connections between variables.

Status:
Promising practices

Primary nature of group task:
Divergent

Time:
Preparation time: 10 minutes
Time required during session: 30 minutes
Follow-up time: 15 minutes

Materials needed:
1. Sheets of large paper (such as butcher block paper) with blank connection circles (1 per small group)
2. Dark thick tipped markers (1 per person)
3. Photocopies of variable list (1 per person)
4. Example of completed connection circle on paper or in presentation slide format.

Inputs:
List of variables

Outputs:
Connect circle

Roles:
Facilitator

Steps:
1. At the start of the exercise, separate participants into small groups and give each group one blank connection circle and a set of thick tipped markers.

2. Introduce the Connection Circle exercise:

   - *The goal of our first exercise is to identify the variables and connections between them that are important in the system*

affecting [insert topic, e.g. the social and emotional health of African American girls.]

- *We are going to draw a connection circle. A connection circle is a visual tool that can help us identify and understand problems and see the connections in a system.*
- *First, let me show you an example.*
- *We are going to start with a large circle.*
- *You will then pick two variables that are connected and draw a line with an arrow pointing in the direction of influence. The arrow shows causality and it can indicate both a positive or a negative situation. Provide an example.*

- *Next, you will pick another set of variables that are connected and draw an arrow to show causality.*

- *After about 15 minutes or so, you might have something that looks like this. [Show example of completed circle]*

- *There are several points to keep in mind before we start.*

  First, if you want to have a connection that goes in both directions, draw two separate lines, one going in one direction and the other going in the other direction. Remember that the arrow shows the direction of influence, or of causation. The arrow can represent something positive or negative.

  Second, it may be easier to bend some of the lines to make them easier to follow, and that's OK.

  Third, the variables and connections can be based on the data sharing or your own experiences.

  Fourth, this connection circle is the overall or combined group picture of what may be happening for [topic]. Some variables and connections may be common to all communities. Other variables and connections may be specific to only one community or group.

  Finally, you do not need to choose a recorder for your group. Each person can participate by generating ideas and making connections on the circle.

3. Pass out the variable list (one per person) and give participants 15 minutes to complete the exercise and with a 5 minute warning.

- *You now have 15 minutes to work on the connection circle exercise.*

- *I will let you know when you have 5 minutes left, and then ask you to stop.*
- *Your task is to identify connections that impact [topic].*

4. As groups work on their connection circles, facilitators walk around the room, observe how the groups are doing, and coach them. Consider the focus of coaching in three phases:

A (beginning, first 5 minutes): focus on clarifying the instructions and provide positive reinforcement that they are on the right track. For example:

- *That looks great. You have several variables representing [topic] and connections with arrows pointing in one direction.*

B (middle): Focus on helping groups improve their skills in developing the diagrams and representing their discussion. For example:

- *Remember, if you want to show a relationship that goes in both directions, draw two separate lines.*
- *Seems like you're having a lot of disagreement about whether the variable is the same for all communities. Why don't you try adding a second variable and representing both ideas on the page, even if they feel a bit contradictory, or only relevant for some communities.*

C (end, last 5 minutes): look for a group that has a good example to start the next exercise, and role model how one explains the connections:

- *You have 5 minutes left before we return to large group.*
- *That looks great. I see how [variable 1] is influencing [variable 2], and this is influencing [variable 3], which then affects [variable 4]. Nice job.*

5. Tell the groups to stop after 15 minutes.

- Now, as a group, rank your top five connections on your connection circle. You can mark your connections like this [Show example].
- You have 5 minutes for this task.

6. Tell the groups to stop after 5 minutes.

Evaluation criteria:

• Connection circles with many connections including one or more feedback loops
• Participants see a system

Authors:
Unknown

History:
Originally documented as part of the Rise Sisters Rise project in July 2011 and based on materials developed by the Creative Learning Exchange

Revisions:
None

References:
None

Notes:
None

Parameterized Relationship between Two Variables (VISCONS)

Context:
VISCONS can be used at any stage in a GMB process when the concept is well known (for example a learning curve) but is best employed when parameterizing the simulation model with the client as both variables in the relationship would have been developed within the GMB session.

Purpose:
To quickly join experts views on such relationships in a clear way that makes use of individual views to produce a group norm representing consensus.

Status:
Promising practices

Primary nature of group task:
Convergent

Time:
Preparation time: 30 minutes
Time required during session: 30 minutes
Follow-up time: 0 minutes

Materials needed:
- overhead projector
- acetate sheets preprinted with a standard grid with variables of interest on either axis
- colored pens to mark acetate
- list of symbols to identify contributor inputs for discussion

Inputs:
No pre-requisite sequences needed but as a convergent parameterization method, it is likely that divergent scripts would have been used to establish group views on the topic.

Outputs:
- acetate sheet sketching most likely relationship between two variables is the deliverable
- group understanding of quantified relationship with enumerated output assembled into a graphical system dynamics converter

Roles:
- facilitator—expert in SD
- contributor – expert in the problem
- gatekeeper – translator of unfamiliar terms

Steps:
1. Explain graph axes before supplying acetate
2. Hand-out pens and symbols
3. Produce individual plots
4. Combine using overhead
5. Discuss whose logic best represents each x-y coordinate
6. Summarize results on another acetate

Evaluation criteria:
A single acetate plot
Group agreement on the nature of the bivariate relationship

Authors:
- David Carter
- Shaofeng Liu
- Jonathan Moizer

History:
None

Revisions:
None

References:
None

Notes:
None

Presenting the Reference Mode

Context:
After dynamics have been described by participants

Purpose:
To propose and develop consensus on a reference mode

Status:
Promising practices

Primary nature of group task:
Convergent

Time:
Preparation time: 10 minutes
Time required during session: 30 minutes
Follow-up time: 0 minutes

Materials needed:
White board or flip chart with markers for drawing one or more reference modes

Inputs:
Dynamics identified from previous activity

Outputs:
Reference modes

Roles:
- Modeler to introduce the concept of a reference mode and propose a reference mode for discussion
- Facilitator to manage the conversation

Steps:
1. Prior to the exercise (e.g., during a break), the team meets to review the dynamics that have been identified during the previous session, and then identifies one more more dynamics as candidates for reference modes.
2. The modeler then introduces the reference mode and presents one or more behavior over time graphs as the reference modes.
3. The facilitator then asks participants if this is correct or we should be focusing on something else.
4. As participants clarify their understanding of what a reference mode is and what is should be, the modeler redraws the reference mode.

5. The facilitator ends the exercise when participants have reached consensus.

Evaluation criteria:
1. A reference mode has been identified.
2. There is an initial consensus on what the dynamic problem is.

Authors:
Peter Hovmand

History:
Identifying a reference mode is a common activity. This script was based on a version of identifying a reference mode in Luna-Reyes et al. 2006.

Revisions:
None

References:
Luna-Reyes, L. F., Martinez-Moyano, I. J., Pardo, T. A., Cresswell, A. M., Andersen, D. F., & Richardson, G. P. (2006). Anatomy of a group model-building intervention: Building dynamic theory from case study research. *System Dynamics Review, 22*(4), 291-320.

Notes:
None

Appendix A: Glossary

Balancing loop	A feedback loop that counteracts a change and moves the system toward some goal (also known as negative feedback loop)
Behavior over time graph	Graph of one or more system variables over time showing the behavior of a system over time
System boundary	Conceptual boundary distinguishing endogenous from exogenous variables in a feedback system
Detail complexity	Number of components in a system
Dynamic complexity	Number of dynamic behavior patterns that a system can produce (e.g., oscillations, overshoot and collapse, etc.)
Endogenous variables	Variables in a model that are influenced by other variables in a model
Exogenous variables	Variables in the model that are strictly causes of other variables and not influenced by other variables in a model
Feedback loop	A causal chain that “feeds back” on itself.
Flow or rates	Movements of conserved quantities from one stock to another stock
Group model building	Process of developing a causal loop diagram or simulation model with participants in the system in a group format
Material boundary	Defines exchanges of conserved quantities (e.g., people, resources) with the environment, and often denoted with a cloud symbol attached to a flow or rate

Mental models	Mental representations of the real system used to solve problems and guide action
Reference modes	Description of the dynamic problem and usually described through a behavior over time graph
Reinforcing loop	A feedback loop that reinforces or amplifies a change (also known as positive feedback loop)
Stocks or levels	Accumulations of flows or rates, define the state of a system
System dynamics	A method for understanding systems and change using the concepts of feedback loops, stocks and flows, and computer simulation

Appendix B: Additional Readings in System Dynamics

Ford, A. (1999). Modeling the environment: An introduction to system dynamics modeling of environmental systems. Washington, DC: Island Press.

Forrester, J. W. (1961). Industrial dynamics. Waltham: Pegasus Communications, Inc.

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Levin, G., & Roberts, E. B. (1976). The dynamics of human service delivery. Cambridge, MA: Ballinger Publishing Company.

Meadows, D. H. (1980). The unavoidable a priori. In J. Randers (Ed.), Elements of the system dynamics method (pp. 23-57). Cambridge, MA: Productivity Press.

Meadows, D. H. (1991). Global citizen. Washington, DC: Island Press.

Meadows, D. (1999). Leverage points: places to intervene in a system. Hartland, VT: The Sustainability Institute.

Saeed, K. 1998. Towards Sustainable Development, 2nd Edition: Essays on System Analysis of National Policy. Aldershot, England: Ashgate Publishing Company. http://www.wpi.edu/Academics/Depts/SSPS/People/Saeed/Book/(available at http://www.wpi.edu/Academics/Depts/SSPS/People/Saeed/Book/)

Senge, P. (1990). The fifth discipline. New York, NY: Curency Doubleday.

Sterman, J. D. (2000). Business dynamics: Systems thinking and modeling for a complex world: Irwin McGraw-Hill.

Vennix, J. (1996). Group model building. New York: John Wiley & Sons.

Vennix, J. (1999). Group model-building: Tackling messy problems. System Dynamics Review, 15(4), 379-401.

Warren, K. (2002). Competitive strategy dynamics. West Sussex, UK: John Wiley & Sons, Ltd.

Warren, K. (2004). Improving strategic management with the fundamental principles of system dynamics. System Dynamics Review, 21(4), 329-350.

Appendix C: System Dynamics Modeling Software and Online Resources

Vensim software (Personal Learning Edition available at no cost)
http://www.vensim.com/

IThink/STELLA
http://www.iseesystems.com/

Strategy Dynamics
http://www.strategydynamics.com/

Social System Design Lab
http://www.gwbweb.wustl.edu/research/systemdynamics/

System Dynamics Society (includes links to conference proceedings)
http://www.systemdynamics.org/

System Dynamics and Systems Thinking in K-12 Education
http://www.clexchange.org/

MIT Roadmaps
http://web.mit.edu/sdg/www/roadmaps.html

Centers Disease Control Syndemics Network
http://www.cdc.gov/syndemics/index.htm

Appendix D: Roles in Group Model Building

Community Facilitator: This is a person who is familiar with the local or substantive knowledge of the problem being modeled and knows the local language and community norms in cross-cultural situations. The substantive expert/facilitator should have strong group facilitation skills, some exposure to system dynamics (e.g., through the planning process and training session or workshop), and have sufficient knowledge of the topic or community to anticipate and mediate conflicts that might arise within the group model building session. This person extends their social capital to help the community accept and work with the modeler facilitator.

Data Manager: Primary responsibility for making sure that the information collected during the exercises, including diagrams, group model building scripts, agenda, pictures, notes, electronic versions of diagrams, etc. are collected, appropriately archived, and made available.

Debriefer: Primary responsibility for facilitating the discussion after a group model building session. This is a rotating role among the core modeling team. The debriefer follows a semi-structured format asking for people's initial reactions, identifying areas of strength, and identifying areas of improvement for subsequent sessions. The debriefer essentially allows members of the core modeling team to debrief and reflect on group model building sessions in a systematic way for a limited period of time. The debriefer should not be someone who experienced a particularly challenging situation during the group model building.

Facilitator: Primary responsibility for facilitating the group model building sessions and managing the group dynamics during the session with training in system dynamics and group model building. The person must be able to provide participants with the right "facilitative attitude" (Vennix 1996; 1999).

Gate Keeper: Primary responsibility for making sure that the modeling project is meeting the needs of the client organization or community to the modeling team and communicating the modeling process and results to the client organization or community.

Meeting Convener (or Convener for short): Primary responsibility for starting the session, introducing participants to the exercise, making sure that participants understand the purpose of the exercise within the context of their organization or community, and introducing the facilitators.

Meeting Closer (or Closer for short): Primary responsibility for bringing the session to close and thanking participants for their time.

Modeler Facilitator: Primary responsibility for system dynamics modeling and group model building process. This is a person who is trained in systems thinking/system dynamics model with expertise teaching and leading groups in the use of systems/thinking/system dynamics. The person should also have experience facilitating groups and leading group model building sessions. If the goal of the project is to develop a simulation model, it is expected that the modeler/facilitator also be an expert modeler and able to anticipate and address the variety issues that can arise in data and modeling.

Modeler: Primary responsibility for building the system dynamics causal maps, models, and simulations with expertise in system dynamics modeling and software (Vensim, IThink/Stella, etc.), formulating and entering equations, testing and analyzing the model, and running simulations for answer policy questions.

Participants: Primary responsibility for contributing substantive and local expertise to the modeling sessions and effort. The participant plays a key role throughout the sessions in helping to develop problem definitions; identify variables of interests, major stocks and flows, defining; suggesting potential data sources for the model; and, generating policies for intervening in the system.

Process Coach: Primary responsibility for observing the group process with attention to how participants are experiencing the session. This role requires someone who is able to reflect on the group process and accurately identify what is happening for participants based on observing their behavior and language. The process coach also plays an evaluation role and helps provide accurate feedback to the core modeling team about how the sessions are going. The process coach should be noticing when group dynamics begin to interfere with the process and identify potential solutions.

Recorder: Primary responsibility for taking detailed notes during the modeling session. This person listens carefully to participants and writes downs the words, definitions, and terminology they use to describe causal relationships,

variables, and structures, as well as comments and questions asked. After the session, the recorder takes part in consolidating notes and materials from the modeling session to ensure that the model produced captures the full richness of the participants' thoughts and conversations. The recorder should have sufficient training in system dynamics to identify causal structures and stock-flow distinctions, strong note taking skills, and ability to integrate their notes from the modeling session into the final model.

Reflector: Primary responsibility for helping the group reflect on what they have done so far and recognize the issues/insights that have been developed during the modeling. This role requires someone who is familiar and comfortable with the language of system dynamics (e.g. can point out reference modes, stocks and flows that were mentioned, etc.) and has strong listening skills, especially in accurately paraphrasing participants' comments in their own words. The lead recorder is the person who ensures that all materials produced during the session are archived and made available to members of the team. The lead recorder also types up notes that summarize each modeling session and takes part in training other recorders on the team.

Time Keeper: Primary responsibility for managing the time of the group model building session, keeping the group on schedule by starting and ending on time and taking breaks, and ensuring that the overall structure of the session is predictable. When there is a need to adjust the schedule, it is the time keeper's responsibility to become aware of the issues and help negotiate a solution to end on time. It is overall very important to start and end on time as much as possible.

Appendix E: Script Template

Name of Script (e.g., "Graphs over Time")

Context	When should this script be used?
Purpose	What is the primary purpose of the script? (Delete bullets that do not apply)
Primary nature of group task	What is the primary nature of the group task? Only one of these should be listed • **Divergent**: activity designed to produce an array of different ideas and interpretations • **Convergent**: activity designed to clustering and categorizing ideas and interpretations. • **Evaluative**: activity designed to rank and choose between options and ideas • **Presentation:** activity designed to present information
Time	**Preparation:** Time that it takes to prepare for the script before the session **Session**: Time that it takes to complete the script before the session **Follow**: Time that it takes to complete follow-up after session
Materials	What kinds of materials are needed to complete this script? • (e.g. markers, overhead projector, flip chart) • • •
Inputs	What are the inputs from other scripts (e.g. behavior over time graphs, concept model, or "none" if this is a starter script)? • • •
Outputs	What are the outputs from other scripts? List specific products such

	as BOTG, system maps, etc and how these products will be used in the context of the whole project. Deliverables are on physical products. Interim outputs or products of primary interest to modeler. Deliverables of interest to group
Roles	What are the different roles required for this script and needed skill level (e.g. "facilitator/elicitor who is an expert in SD)? Note that one person may have more than one role during a script, but multiple roles per person should be minimized. • List roles in bold, then bold them throughout the steps section as they appear •
Steps	What are the specific steps in conducting this script? Each step should be specific enough that someone can do it who has not seen the exercise before. Steps that require project specific language should give a form for the script along with an example (e.g., "Draw graphs over time of things that affect or are affected by _____ "). 1. 2. 3.
Evaluation criteria	How would someone know that the script has been successful? For example, what are the behavioral changes in participants that one would expect, insights gained, products from the exercise that should be expected? List the observable process and outcome indicators of a successful evaluation.
Author(s)	Who created the activity? This can be a list of people, organizations or community year when the script was created (if known). Importantly, this is **not** the individual who documented the script. If no other is known, write "unknown"
History	What is the history of the script? This can include previous scripts, articles, other types of small group exercises, etc. The history should provide a name and date citation, and retain the entire history of the script, not just the previous version. If no history is present, write "None". This can also include when the activity was first documented.
Revisions	This is a version history of the script describing changes that have been made by the authors and when those changes were made. If no revisions are present, write "None"
References	List any publications or references to additional documentation using this script and cited in the history of the script. For example, if this script is based on another script that was described in peer reviewed research, then mention this under the "History" section with an

	author/year citation, and provide the full reference here in the references section. If no references are present, write "None"
Notes	This section can be used to describe variations of the script, observations about what makes it work, if it has only been used a few times, suitability for different audiences, etc.