

# LESSON PLAN #1

**Subject:** System Dynamics

**Title:** Feedback Loop Analysis and Narrative Building with Loops That Matter

**Level:** Undergraduate level and above

**Duration:** 105 minutes

## Pre-Requisite Knowledge

Before the lesson, students should already be able to:

1. navigate Stella Architect software;
2. build (simple) system dynamics models;
3. understand structural relationships and corresponding mathematical formulations;
4. understand the concept of feedback loops.

## Learning Objectives

After the lesson, students should be able to:

1. use Loops That Matter tools to construct a feedback narrative around the structure of any given model;
2. use Loops That Matter tools to analyse the feedback dynamics of any given model;
3. provide explanations for model behaviour with respect to its feedback narrative and dynamics;
4. understand the concept of feedback loop dominance, interaction, and shifting dominance.

## Lesson Activities

Activity	Instructions
Introduction to feedback loop analysis (10 minutes)	<ol style="list-style-type: none"><li>1. Introduce principles of system dynamics for behavioural explanations.<ol style="list-style-type: none"><li>a. Structure causes behaviour.</li><li>b. Endogeneity and feedback perspective.</li></ol></li><li>2. Recap previously taught mode of explaining simulation results using model equations, with calculate loop dominance information turned off.<ol style="list-style-type: none"><li>a. Take for example, the development of the key stock.</li><li>b. Explain stock development in terms of its flows. Explain flows in terms of instantaneous variables within the feedback loop(s) influencing the respective flow.</li></ol></li><li>3. Introduce a higher level of abstraction for explaining overall dynamics of model structure– feedback narrative.<ol style="list-style-type: none"><li>a. What are the main feedback loops in the system responsible for behaviour?</li><li>b. What is the feedback story of each loop?</li><li>c. What is the overall feedback narrative of the system, in terms of how the loops interact to produce the simulated behaviour?</li></ol></li><li>4. Discuss the importance and complementarity of the two types of structural explanations.</li></ol>
LTM tool demonstration with a small model (20 minutes)	<ol style="list-style-type: none"><li>1. Introduce Loops That Matter in Stella Architect as tool that can aid the analysis process.<ol style="list-style-type: none"><li>a. Emphasise that the tool can help structure and speed up the process, but it cannot replace your own analysis.</li><li>b. Provide students with the demo model beforehand so that they can follow the demonstration process.</li><li>c. Instruct students to turn on calculate loop dominance information in the model settings, before starting the demonstration.</li></ol></li></ol>

- d. Explain LTM as an analysis tool that measures the loop dominance profile of the model in the given scenario. Importantly, LTM measures changes in aggregate system behaviour and, therefore, requires a model that is changing – it cannot be in equilibrium.
2. Demonstrate **feedback story description**.
- In the LTM panel, highlight () the first loop to show the loop we will focus on in the model structure.
  - Click on the loop score variable () from the panel to place it onto the model canvas.
  - Move the loop score variable inside the identified feedback loop.
  - Inspect the structural formulation of each link in the feedback loop and reason about the behaviour.
  - Explain the role of parameters in creating a loop dominance profile. Exogenous parameters condition the strength/gain of the loop, even though the links are always grey – because parameters are constant.
  - After understanding how the feedback loop works, describe the process/story that the loop represents in the modelled system, in term of its real-world equivalent.
  - Give a pithy descriptive name for the feedback story, and then rename the loop score variable.
  - Repeat the steps until every loop has been described and named. (In the event that the model has a large number of loops, then select the loops that describe 80% of model behaviour or disregard loops that account for less than 5% of behaviour.)
3. Demonstrate **identification of loop dominance and shifts in dominance**.
- Redirect attention to the “Stacked Area” graph in the LTM panel.
  - Analyse the pattern of the graph to check for repeating patterns (cycles). If so, narrow the time range to analyse first two cycles (in the event that there is transient behaviour in the first cycle).
  - Click on the graph and drag your cursor to carefully follow the 50% line. When the colour along the line changes, from red to blue or different shades of the same colour, stop the cursor. Note the time of the shift.
  - At that point in time, identify the smallest number of feedback loops with the same polarity that is needed to add up to 50%. Take note of the feedback loop(s) that are dominant (more than 50%) at that point.
  - Move forward in time to continue analysing and documenting the shifts in dominance until the end of the simulation range selected.
  - The documented list is the progression of feedback loop dominance in the model responsible for the simulated development over time.
4. Demonstrate the analysis of the **overall feedback narrative** over time.
- Run the model with an appropriate time range for analysis.
  - Press on the Create CLD button to go into an auto-generated CLD view. Increase the Symbol Size to point where the development over time is visible. Increase Link Inclusion Threshold until a suitable level of aggregation is reached.
  - Drag the simulation time horizon at the bottom to observe changes in link strengths leading up to each identified shift in loop dominance from before.
  - For each period of dominance, describe the processes that are responsible for behaviour using the feedback story previously constructed.
  - For each transition of dominance, describe how and why the strength of the processes are changing over time. Importantly, explain how those changes create the behaviour of the stocks in the system.

	f. Summarise the overall feedback narrative of the system over time, in real-world terms as opposed to an overtly technical language.
Group activity to analyse a larger model with LTM (45 minutes)	<ol style="list-style-type: none"> <li>1. Divide the class into small groups (2-4 students).</li> <li>2. Instruct each group to open the selected model and conduct a feedback loop analysis using LTM.</li> <li>3. Using a text box on the Stella file, students will document: <ol style="list-style-type: none"> <li>a. Each feedback loop story (3 sentences at most) and its name (4 words or less) and polarity.</li> <li>b. Each point in time the dominance shifts and the loop(s) that are dominant (more than 50%) at that point.</li> <li>c. Explanation of model behaviour using a feedback narrative.</li> </ol> </li> <li>4. Walk around the classroom to provide assistance and ensure that students are on the right track.</li> </ol>
Presentations (15 minutes)	<ol style="list-style-type: none"> <li>1. Bring the groups back together after the group activity.</li> <li>2. Get volunteers to share their findings, with emphasis on their constructed feedback narrative.</li> </ol>
Conclusion (15 minutes)	<ol style="list-style-type: none"> <li>1. Summarise the key takeaways from the lesson: <ol style="list-style-type: none"> <li>a. The importance of understanding the feedback narrative of the model structure</li> <li>b. The importance of loop dominance, feedback loop interactions and shifting dominance for forming that narrative</li> </ol> </li> <li>2. Have students reflect on their experience with and usefulness of LTM for model analysis. <ol style="list-style-type: none"> <li>a. Reiterate the point that LTM cannot replace analysis; the steps here require you to think for yourself!</li> </ol> </li> </ol>

### Instructor Reflections

What went right and what went wrong? Why do you think it turned out this way? What have you learnt from this? How would you do things differently in the future?

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