

# Simplifying Learning Environments For Introductory Students

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## Abstract

*An interactive learning environment (ILE) appropriate for intermediate macroeconomics students has been simplified for students in introductory college and high school courses. Without changing the underlying model or the “flight simulator” options, the simplified instructional approach relies on feedback loop diagramming more than stock-and-flow diagramming. Interactive Vensim causal loop diagrams are embedded in a STELLA interface, using slide show and video software. In addition, students appear to learn more as model-users if they engage in preliminary model-building activities using simple word-and-arrow diagrams.*

*MacroLab* is a *STELLA* model and interactive learning environment (ILE) for teaching macroeconomics. Developed for college-level courses, *MacroLab* is currently used to teach distance education students at Virginia Western Community College. The ILE uses the *STELLA* “story-telling” feature to unfold a model of a national economy, one-sector-at-a-time, throughout the course. A recent modification enables feedback loop diagramming<sup>1</sup> to be used, in addition to stock-and-flow diagramming. When explaining a complex system in an introductory course, loop diagrams appear to be more effective in shaping mental models than the stock-and-flow approach. Similar benefits may be obtained in K-12 classrooms.

The feedback loop method is not always superior to the stock-and-flow method for communicating the structure of a system dynamics model. No feedback loop diagram, for example, can convey the “bathtub” imagery of a stock with an inflow and outflow. For complex

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<sup>1</sup> Alternatively called “causal loop diagramming.”

models, however, the simplicity of loops has some advantages. An ILE that can tell the “story” of a model using both stock-and-flow diagrams and feedback loop diagrams is a useful tool.

Feedback Stories in STELLA. As the model economy takes shape over a 16-week period, the stock-and-flow structure of *MacroLab* becomes complex. STELLA’s excellent story-telling feature does facilitate the presentation, but complex models require several stories. Moreover, the detail in some stock-and-flow maps can distract beginners, particularly as a model evolves during a semester. This is particularly challenging for distance education students who have to learn both system dynamics concepts and economics at the same time, without any classroom contact with their instructor. Moreover, in a face-to-face course taught last fall, I witnessed similar difficulties even while physically present to help the students.<sup>2</sup>

For introductory students, I now rely on an alternative approach that emphasizes feedback structure, using causal loop diagrams. While a formal assessment of the relative effectiveness of the two approaches has not been done, my impression is that current students find the loop diagramming easier to use, and they are developing stronger mental models of a national economy than did my previous students.

Feedback loop stories can be added to the *STELLA* interface, using a combination of simulation, presentation, and video software. *Vensim* is used to create the feedback loop diagrams. Then *PowerPoint* and *QuickTime* are used to convert the static feedback loops into annotated, interactive video that can be imported into a *STELLA* learning environment.<sup>3</sup> That enables the feedback structure of the model—complete with annotations—to be presented in a series of building-block stories.

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<sup>2</sup> Intermediate economics students would have less difficulty, of course, and I have maintained the stock-and-flow stories in *MacroLab* for that level of instruction.

<sup>3</sup> Apple’s Keynote presentation software also comes in handy, as explained below.

***Procedure.***

1. Use *Vensim* to create links and loops, such as figure 1. Copy and paste into presentation software, such as *PowerPoint* or *Keynote*.

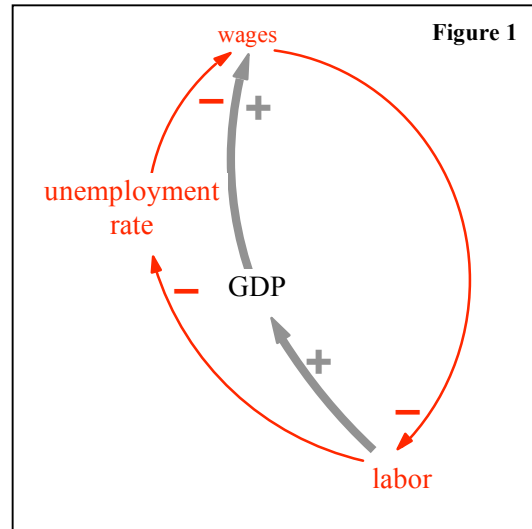
2. Use *PowerPoint* (or *Keynote*) to separate the links and loops into pages that “build” the story.

Ungroup the pasted picture of the links and loops, so that individual pieces can be selected and

deleted. If you want to tell the story of this feedback loop in four pages, then make four copies of this slide. Then selectively delete links so that each “page” has just the information that you want. Then add text to explain each slide. When you finish, it will look like the four slides on the next page (figures 2.1-2.4). The slide show will provide annotated images of an unfolding “story” of the links and loops of interest.

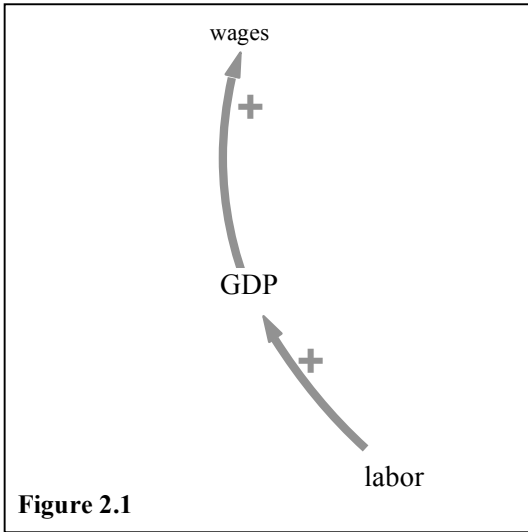
3. Use *Keynote* to convert the slide show into a *QuickTime* movie.<sup>4</sup> In *Keynote*, open the *PowerPoint* file. Then export the file in *QuickTime* format, choosing “interactive” and “full quality” when presented with those options.

4. Import the movie into a *STELLA* model. Create an information button, and select the “import movie” option. Then browse and select the file exported from *Keynote*. Clicking on the button will activate the movie. Click on a slide to advance to the next one.<sup>5</sup>



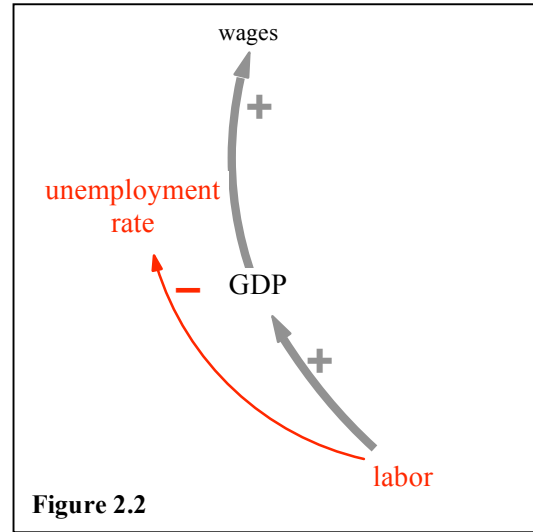
<sup>4</sup> *PowerPoint* files can also be saved in *QuickTime* format, but the resulting movie is not easily controlled after importing into *STELLA*. If *PowerPoint* movies imported into *STELLA* run automatically when opened, use *Keynote* to make the conversion to *QuickTime*. Another hint is to create a duplicate title slide because the movie “jumps” past the opening slide when opened in *STELLA*.

<sup>5</sup> Unfortunately, it is not possible to review previous slides.



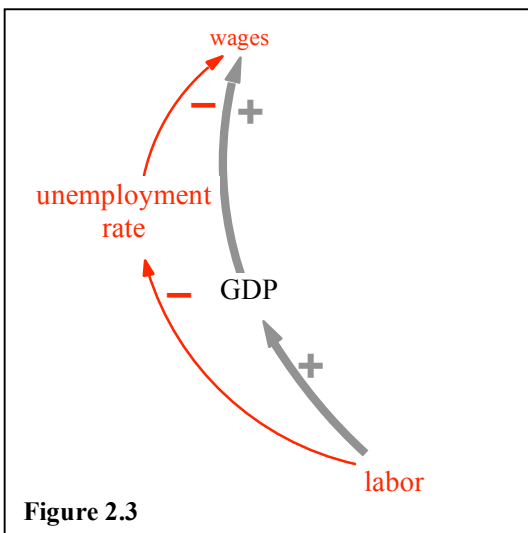
**Figure 2.1**

*A segment from the main reinforcing loop, showing that more employed labor increases GDP, and higher GDP means higher wages.*



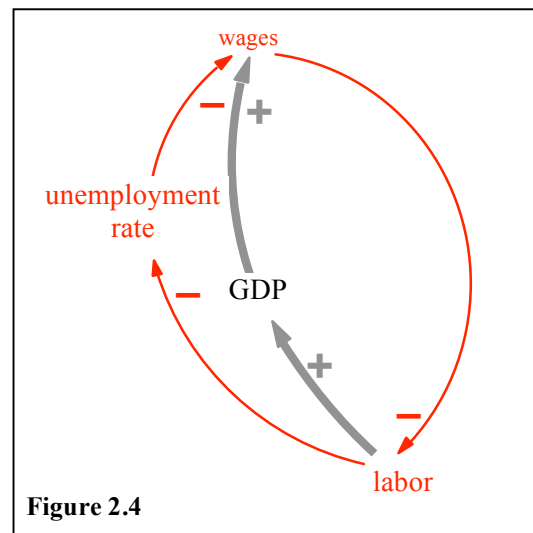
**Figure 2.2**

*As more labor is employed, the unemployment rate falls.*



**Figure 2.3**

*The link from the unemployment rate to wages is negative. If the unemployment rate rises, starting wages tend to fall, and that makes average wages lower than they otherwise would be.*



**Figure 2.4**

*As wages increase, less labor is employed. As wages decrease, more labor is employed. Thus, the link from wages to labor completes a counteracting loop.*

The end result is an annotated feedback loop story embedded in a STELLA interactive learning environment. It can be used as a stand-alone instructional device for beginners or it can be used in conjunction with the STELLA's "story-telling" feature that explains stock-and-flow diagrams.

Model-Builder vs. Model-User. Using *MacroLab* to teach economics raises the perennial question of whether students can learn much from a model without actually building it. Clearly, they would learn more if they could build it, but that is not a feasible option in an introductory economics course. The challenge, therefore, is to provide students with experiences during the course that are similar to some of the experiences they would have if they actually built the model. I have addressed this issue with small “hypotheses” assignments.

In the distance learning course, the hypotheses assignments are implemented via the online discussion board. Each hypothesis assignment asks students to draw a link between two variables. For example, the question might be: “What causes GDP to change?” Students have to draw a link such as “ $X \rightarrow (+) \text{GDP}$ ” and speculate what X might be (e.g., “productivity”), accompanied by a brief explanation of their hypotheses. The ensuing threaded discussion provides an opportunity for applauding insights, correcting misunderstandings, or (frequently) clarifying how to draw causal links. The benefits are two-fold. First, when the students later see those same variables added to a larger feedback loop structure, they already have first-hand experience with the diagramming method. Second, they have already been involved in discussions about the *ceteris paribus* relationships involving those variables. This preparation makes it easier to move on to consideration of larger, more complex structures.

Incidentally, such hypothesis-building early in the course coincides with textbook chapters that are introducing concepts (e.g., GDP, productivity, unemployment, and inflation) and focusing more on measurement and historical reference modes than theory. The hypotheses assignments require students to draw initially on their own experience and insights regarding the causes and effects of macroeconomic behavior. Most students are probably unaware that they are engaged in the early stages of model-building; they think they are “merely” offering educated opinions. Model building emerges, then, from the clash of simple ideas expressed by students

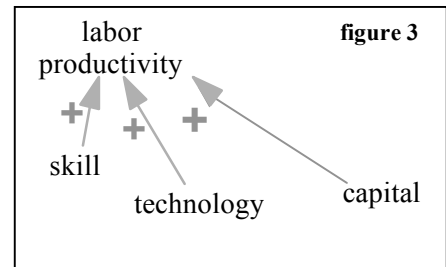
and instructor, rather than as a complex pre-ordained picture to be memorized. The table below illustrates an actual threaded discussion among students and instructor on the topic of productivity during a distance education course in macroeconomics, using *Blackboard's* Discussion Board feature.

<p><u>Instructor</u>: <i>What do you think "causes" the productivity of labor to change? As you did in the previous exercise, use the causal link language to summarize your hypothesis, and then offer a short explanation.</i></p>
<p><u>Kim</u>: <i>technology -----&gt; (+) productivity As technology improves companies can implement new equipment to increase productivity.</i></p>
<p><u>Ruth</u>: <i>absenteeism -----&gt; (-) productivity When there is an increase in absenteeism it causes a decrease in productivity.</i></p>
<p><u>Instructor</u>: <i>Good, Ruth. This could occur for two reasons. The absentee is still employed but not producing, and that brings down the average productivity for all workers. Second, the absentee (when at work!) may be required to interact with others to get work done, and being absent may cause the others to be less productive, too.</i></p>
<p><u>Tom</u>: <i>new techniques ---&gt; + labor productivity As new techniques for completing tasks are completed, productivity will increase since these new techniques take less time than the old ones.</i></p>
<p><u>Jenny</u>: <i>product demand-----&gt; (+) labor productivity When a product is in greater demand, for whatever reason (new technology, fads, price reduction, etc.) production will rise to meet the demand.</i></p>
<p><u>Instructor</u>: <i>You're misunderstanding productivity, Jenny. It is not the same as production. Production is output per year. Productivity is output per worker per year.</i></p>
<p><u>Jenny</u>: <i>human capital-----&gt; (+) productivity When companies send workers to learn new skills or improve on skills, then workers' productivity increases. Is this more what you mean?</i></p>
<p><u>Instructor</u>: <i>Absolutely, Jenny. By a "change in productivity," we mean a change in "output per worker" during some time period (such as year, month, or hour). Productivity improvements usually result from improvements in tools &amp; equipment due to improvements in technology, or in employee knowledge and skills. It could also result, as another student said, by reorganizing the work more efficiently.</i></p>
<p><u>Bill</u>: <i>capital -----&gt; (+) productivity When a company invests in new equipment, it makes the job easier, thereby productivity is increased as the worker can produce faster and with more ease.</i></p>

This particular threaded discussion had many more entries. The same process could be used in a regular classroom brainstorming session. By the end of the exercise, the basic reasons

for productivity growth had been identified: the quantity and quality (technology) of capital equipment and the skills of workers, including the way that work is organized.

Later, when “labor productivity” was added to a feedback loop version of the model, the issue of “what causes productivity to grow” had already been discussed (figure 3). It was, therefore, much easier to move ahead with the layout of the larger model.



More importantly, however, the students seem to develop a better intuition about the whole process of “theory-building” when this approach is used. It doesn’t substitute for actually building a model, of course. But building a model is often not a practical component of a classroom exercise, particularly if it involves a complex model that takes an entire semester to “build.” Students can participate in laying one-brick-at-a-time, however, and thereby have a better chance of claiming some ownership in the final structure.

Conclusion. Educators may be interested in the simplified instructional approach that relies more on feedback loop diagramming than stock-and-flow diagramming, plus the method for getting interactive *Vensim* loops into *STELLA* learning environments. They may also be interested in ways to provide at least some model-building experience to students who are primarily expected to be model-users when learning about a large complex system. This paper provides an overview of both efforts aimed at simplifying learning environments for introductory students. The author welcomes comments, suggestions, and questions.