What is a System Dynamics Story?

John C. Mayer
University of Alabama at Birmingham

Before a student is allowed to tackle a System Story, we assume the student has developed some skill in manipulating STELLA, analyzing graphs, and designing models. This necessary background is acquired in several stages. Initially, students build Systems Dynamics models in STELLA following step-by-step instructions. Later they develop models to follow a specific description, though the descriptions get less and less detailed. In between, they are asked to build simple original models of systems they choose. From this foundation, the student needs to move on to developing original models of larger systems, by making reasonable assumptions about, and resolving inherent ambiguities in, the situation to be modeled. The System Story[1]concept is designed to help the student make the transition from being a follower to being a leader in System Dynamics model-building.

Below is a list of System Stories, each a scenario describing a situation to be modeled. The complete story is self-contained and provides all the data needed for the model. Though each story is developed in parts, so the model is built and validated incrementally, the story is **not** a set of step-by-step instructions. Moreover, some variations on the original scenario may require substantial rethinking of parts of the model development. Most of the stories listed are from Diana Fisher's book.[2] The stories *Peppered Moth, See Rock City,* and *Opportunity Costs* were written by GK12 Fellow James M. Malaugh as part of the EdGrid and GK12 Projects, and are included with this package. The story *Mosquitofish* is based upon a project now starting among UAB mathematicians and biologists.

The student will build a model, and write a 5-10 page technical report, based on one of the System Stories. Students may ask their colleagues and their mentors, for help in constructing and understanding their model. However, the student is expected to produce independent work on the model, and write the report independently. A timetable is given for the start of the project, the preliminary model review, and the final report. The completed model and report will be graded according to the Scoring Guides[3] of which each student will have received a copy. The student is also given an MSWord template for the report. Before writing the report, but when the model itself is complete, the model (diagrams, equations with units and documentation, graphs, and tables) is turned in for a preliminary review by the mentors. The Model Scoring Guide will be applied for a preliminary score. Suggestions for improvement, if needed, will be given.

A list of the currently available System Stories follows, with a brief description of each and a difficulty number, currently ranging from 1.00 to 1.10. We encourage students having considerable success at previous STELLA assignments to choose the more difficult stories as a challenge. Difficulty is a consideration in grading. The raw grade a student earns on the model and on the story will be multiplied by the difficulty factor given below for each story. The adjusted grade is the one that is used to determine the student's course average. This enables us

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[1] The concept of a System Story is credited to Diana M. Fisher, and appears in her book *Lessons for a First Course in System Dynamics Modeling*, Summer Creek Press, Tigard, Oregon, 1998.
[2] One source is on-line, HPS-Inc, the publisher of STELLA.
[3] Model and Report Scoring Guides are available with *Lessons for a First Course in System Dynamics Modeling*.

to grade all work to the same standard, even though some stories are more difficult to model and to report on well.

System Stories List

Lost Lake (difficulty 1.02). This scenario involves monitoring the water level in a lake. Stream runoff and precipitation feed the lake. Evaporation drains it. Additionally, the water is being used to supply a nearby town.

See Rock City! (difficulty 1.03). This scenario explores the earth's rock cycle. Magma crystallizes to igneous rock, igneous rock weathers to sediment, etc. The distribution of rock types over geological time is modeled. The meteor strike is bit tricky to model.

City Growth (difficulty 1.05). This scenario assumes that construction of new buildings in a city is a useful indication of the city's economic health. Building, population, and housing subsystems are developed and put together.

Peppered Moth (difficulty 1.06). This story was developed from a real case of natural selection in action. The rise and fall of the English peppered moth population as a result of industrial pollution is modeled. The population of moths is represented by subpopulations of different genetic make-up. The Hardy-Weinberg Principle of genetics figures significantly in constructing the model.

Dam Model (difficulty 1.07). This scenario involves keeping the water in a hydroelectric dam at a certain level. The dam must not overflow (a disaster!), and it must meet electrical demand. A controlled spillage for fish complicates matters.

Pronghorn (difficulty 1.09). This story was developed from a real study of antelope around Bend, Oregon conducted by a wildlife biologist. The pronghorn story is an age-specific population story incorporating death rates influenced by predators, weather, and hunting. The model can be tested against observed population counts. There is more than one reasonable way of making the model, but exploring use of a different kind of stock is beneficial.

Opportunity Cost (difficulty 1.10). Companies not only have costs of production, but costs associated with maintaining an inventory (in the warehouse). Firms often hold inventories to buffer short-term changes in production or demand. But in doing so they forgo the profits they would earn by selling the inventory as it is produced. Loss of profit is the "opportunity cost" of the title. The goal is to find the optimal inventory to maximize profit. The mathematical difficulty in this model lies in managing potential oscillations.

Mosquitofish (difficulty 1.10) This story is developed from a current study of mosquitofish population dynamics at UAB in cooperation among mathematics and biology students and professors. Mosquitofish are small "bait" fish and a live-bearers. There main food are larvae of insects, and adults are liable to mistake their young for insect larvae, so they are cannibals. The objective of this system story is to understand how cannibalism can act a as population control mechanism. This project may be done in Excel, Maple, Matlab, Mathematica, or Stella. (The description assumes Stella but is modifiable.) Extra credit is possible by carrying out some of the more difficult further explorations.