Road Maps

A Guide to Learning System Dynamics

System Dynamics in Education Project
Road Maps

System Dynamics in Education Project
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Welcome to Road Maps!

Many books and thousands of papers cover the field of system dynamics. With all of these resources available, it is difficult to know where to begin learning about system dynamics. The System Dynamics in Education Project at MIT is putting together Road Maps to help sort through this vast library of books and papers. Road Maps is a series of self-study guides that use modeling exercises and selected literature to provide a resource for learning about the principles and practices of system dynamics. In its present form, Road Maps is not meant to be a teaching curriculum for classroom use.

The Spiral Learning Approach

A new concept is usually not fully mastered after reading about it only once. Also, learning usually involves building one’s understanding up from one level to a higher level. For this reason, Road Maps utilizes a spiral learning approach, in which each new concept is repeatedly reinforced in successive chapters. This repetition moves upward along a spiral as more advanced concepts build upon basic ones.

In constructing this spiral, Road Maps has been divided into chapters. The end of each chapter marks the completion of a particular subset of concepts, with the next chapter building on the material just learned. Each chapter comes as a separate document so the reader can request them as needed.

Organization

The Road Maps series begins with Road Maps One, which introduces the concepts of causal loops and circular feedback in systems. In addition, some of the applications and history of system dynamics are presented.
Road Maps Two takes you through your first system dynamics model, and introduces computer simulation and the concept and methods of graphical integration. Two basic elements of system dynamics models, the stock and flow, are presented. You will need a computer and STELLA™ software for this and subsequent chapters of Road Maps.

Road Maps Three presents two of the most common structures in system dynamics: the first-order positive and negative feedback loops. Systems exhibiting exponential growth and decay are examined, and the idea of loop dominance in systems is introduced.

Road Maps Four introduces generic structures and discusses the use of computer simulation games in teaching system dynamics. After playing the Fish Banks game, you will construct a model of the scenario and learn about the tragedy of the commons. Using your computer model, you will simulate and analyze several policies for this system.

Road Maps Five probes the structure of system dynamics models, emphasizing some important features that you may not have noticed, and explains the spread of an epidemic. Road Maps Five also introduces testing for model validity in the system dynamics context. How do you know that your model is a good representation of the real system?

In Road Maps Six, the dynamics of economic supply and demand are explored and more modeling exercises are provided. Also, oscillatory systems are used to show the transferability of structures. More modeling exercises sharpen your modeling skills and develop intuition about systems.

Road Maps discusses the principles and characteristics of systems, explores the interrelationship between structure and behavior of dynamic models, provides guidelines for good modeling practice, and discusses the applications of system dynamics. From Road Maps One on, the spiral of learning returns to these primary areas several times by introducing more advanced material while building on fundamental concepts. After completing Road Maps, you should have a strong working knowledge of system dynamics, have developed intuition about the fundamental principles of systems and be ready to explore the application of system dynamics in any area of interest.
How to Use Road Maps

First, you need to determine where you should begin in Road Maps. Some readers have had more background in system dynamics than others. This introduction should help you find a good starting point in Road Maps.

Road Maps explores several topics in system dynamics through selected readings and exercises. Before each reading or exercise is a short description of the reading and its most important ideas. After each reading or exercise, we highlight the main ideas before moving on.

Each chapter in Road Maps contains readings that introduce and strengthen some of the basic concepts of system dynamics. Other readings focus on practicing the acquired skills through various exercises or simulation games. Most of the chapters conclude with a prominent paper from the literature in the system dynamics field.

We present the fundamental concepts of system dynamics as *System Principles* in Road Maps. These principles are enclosed in boxes that highlight them from the rest of the text to emphasize their importance. The progression of system principles in Road Maps allows you to revisit each principle several times. Each time a principle is revised in Road Maps, you will build upon your previous understanding of the principle by learning something new about the principle. The system principles are the core of Road Maps around which the readings, exercises, and papers are built.

As part of the spiral learning approach that we use in Road Maps, many concepts will be briefly introduced early on and then explained later in greater detail. Road Maps contains a number of series of papers that are spread out over successive chapters. Each of these series focuses on a specific topic in system dynamics or the developing of a particular skill. The series start out with a simple paper, and progress to further develop the idea in subsequent chapters.

Things You’ll Need for Road Maps

**STELLA II Software**

In order to complete Road Maps Two and subsequent Road Maps, you will need to have access to STELLA II. STELLA II is currently available for both Macintosh and Windows, but the Road Maps guides and most of the readings and
exercises included in Road Maps are written for STELLA II for the Macintosh, so be aware of this as you go through Road Maps. If you have any questions about STELLA, contact High Performance Systems (see Appendix). Ask about prices for educational use.

A Computer
To run STELLA on a Macintosh, you will need an Apple Macintosh computer (Macintosh Plus or higher) with at least 2 MB of RAM, a hard disk and System 6.0.4 or higher. If using System 7, you will need at least 4 MB of RAM.

To run STELLA for Windows you will need an IBM PC-compatible computer with a 486-class processor or 386 Enhanced mode running Windows 3.1 or greater. You'll need at least 4 MB RAM, a hard disk with a least 5 MB free space, and a 3.5-inch high-density floppy drive.

In either case, if you plan on continuing to model, it may be a good idea to have access to a computer with more memory, hard disk space and a faster processor.

Books
1) Kauffman, Draper L., 1980. Systems I: An Introduction to Systems Thinking. (Road Maps 1)
   To order a copy of this book, contact Pegasus Communications (see Appendix).

   Portland, Oregon: Productivity Press, 388 pp. (Road Maps 2 onwards)

   Portland, Oregon: Productivity Press, 562 pp. (Road Maps 2 onwards)

   Portland, Oregon: Productivity Press, 285 pp. (Road Maps 3 onwards)

   If you have any problems in getting the above three books, contact Productivity Press (see Appendix).

   Post Mills, VT: Chelsea Green Publishing Co., 300 pp. (Road Maps 5)
To order a copy of this book, contact Chelsea Green Publishing Co. (see Appendix).

Good luck with Road Maps!
System Dynamics in Education Project

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Appendix: Names and Numbers

- To obtain additional copies of Road Maps, please visit our System Dynamics in Education home page on the World Wide Web at:
  
  http://sysdyn.mit.edu/

  If you do not have access to the World Wide Web, you can buy paper or disk copies of Road Maps through:

  Lees Stuntz
  Creative Learning Exchange
  1 Keefe Road
  Acton, MA 01720, USA
  Phone: (508) 287-0070
  Fax: (508) 287-0080
  Email: stuntzln@iac.net

- For information on the System Dynamics in Education Project, please visit our home page, or contact:

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  Fax: (617) 252-1998
  Email: nlux@mit.edu

- To inquire about educational prices for STELLA II software, please contact:

  High Performance Systems
  45 Lyme Road
  Hanover, NH 03755, USA
  Phone: 1-800-332-1202 (product inquiries)
  (603) 643-9636 (customer support)
  Fax: (603) 643-9636
  Email (for customer service, tech support and product questions): support@hps-inc.com
  WWW Site: http://www.hps-inc.com/

- Although Road Maps is written specifically around the STELLA II software, two other software applications are suitable for use with Road Maps, assuming the user is willing to make some interpretations and translations:

  Powersim for PC:
  Powersim Corporation
  12030 Sunrise Valley Drive, Suite 300
  Reston, VA 22091, USA
  Phone: (703) 391-2779
  Fax: (703) 391-2768
  Email: powersim@powersim.com
Vensim for PC or Macintosh:

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Ventana Systems, Inc.  
149 Waverley Street  
Belmont, MA 02178, USA  
Phone: (617) 489-5249  
Fax: (617) 489-5316  
Email: vensim@world.std.com  
A free “Personal Learning Edition” of Vensim can be downloaded from: http://news.std.com/vensim/

- If you have any questions about obtaining books required for Road Maps, please contact their respective publishers:
  
  Chelsea Green Publishing Co.  
P.O. Box 130  
Post Mills, Vermont 05058  
Phone: 1-800-639-4099

  Pegasus Communications, Inc.  
Order Dept.  
P.O. Box 120 Kendall Square  
Cambridge, MA 02142-0001  
Phone: (617) 576-1231  
WWW Site: http://www.pegasuscom.com/

  Productivity Press  
P.O. Box 13390  
Portland, OR 97213  
Phone: 1-800-394-6868, (503) 235-0600  
Fax: 1-800-394-6286  
WWW Site: http://www.ppress.com/

- Road Maps HELP line: If you are having any problems with the material in Road Maps, or if you have any helpful comments or suggestions, please email:

  rm-help@sysdyn.mit.edu  
outlining your problem. We will respond as soon as possible.

- To join the K-12 Discussion Group for educators interested in using System Dynamics to teach, email Nan Lux, discussion group administrator, at nlux@mit.edu