the Creative Learning EXCHANGE

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The Systems Thinking and Dynamic Modeling Conference

The second Systems Thinking and Dynamic Modeling Conference was held at Wheaton College in Norton, Massachusetts, July 17-19. It built on the work of previous conferences—the first ST&DM conference in Concord, Massachusetts, as well as several conferences held previously in Tucson, Arizona, sponsored by the Waters Grant Foundation and the Catalina Foothills District. This summer a coterie of experienced educators were joined by internationally known system dynamicists to help create a three day conference for learning and exchanging of ideas and information on systems education.

The conference had an excellent start with a general overview given by Mary Scheetz. Mary has traveled throughout the country in the past year visiting many school districts where systems education is being utilized. She presented an overview of what is happening in systems education across the country and how teachers and students are reacting to it.

She was followed by a keynote address—"Muddling through Models"—by Michael Goodman, author of *Study Notes in System Dynamics*, and vice-president for Innovation Associates in charge of the Systems Thinking practice. Michael gave an excellent presentation on the sequence of models which we all use—or could use—from our own mental models through physical models, systems thinking models like causal loops, up to computer simulation system dynamic models such as those which can be created using STELLA II, PowerSim, and VenSim. His entertaining and well received talk gave the participants a good framework for the learning available during the rest of the conference.

David Kreutzer's afternoon talk reinforced the definitions of causal loops, mental models, and simulation modeling, and also introduced the Fast Break technique of using hexagons to facilitate the exploration of patterns within discussions as a pre-cursor for using Systems Thinking modeling tools. In a brief encounter with Michael and David between sessions it was fascinating to see the amount of information exchanged about what had been covered by Michael for David to build upon. It was this concern for the learning of the participants which exemplifies the quality of the presenters. David's presentation was exciting and energizing to set the stage for the rest of the conference. He was still talking while being escorted out to catch a plane!!

The Wednesday afternoon and evening seminars gave conference participants a potpourri of interesting topics. The sessions ranged from a description of the highly successful initial System Dynamics Fair (SyM Bowl), to a discussion of using mapping and mod-

Conference *continued on page 3*

Reflective Learning Journals

by Dr. Carol Ann Zulauf, Suffolk University, Boston, MA

Continuing in the spirit of contributing to our exciting field, I've written an article capturing the insights and key learnings that students undergo when learning to think systemically. Their thoughts, questions, and learnings were captured in their own Reflective Learning Journals, from which this article was written.

So what's it like to learn systems thinking? I became intrigued with this question last semester during my Systems Thinking course at Suffolk University. Here was a new class of Graduate students learning this new way of viewing the world. As we were discussing some key point with causal loops, I stopped short in the middle of an explanation, and asked my students what it was like for them to actually go through this process of learning and thinking. What struggles were you having? What private questions and moments of insights were you experiencing?

I had asked them if they would try to capture those moments of insights, challenges, struggles in a Reflective Learning Journal. The majority of the students jumped at the opportunity to reflect on their own learning journey. Only a few declined because it wasn't on the initial syllabus (hmmmm, whatever happened to spontaneity and flexibility??? This was a learning insight for myself: Should I leave an open

Journals *continued on page 9*

Updates. . .

Los Alamos

I work as a science education program coordinator at Los Alamos National Laboratory. My job is to design and implement teacher education programs that utilize the Laboratory's unique technical expertise in ways that benefit teachers and students in the region.

For the past two years I have been coordinating the TEAM program-Teacher Environmental Assessment and Modeling-a program for high school teachers designed to promote interdisciplinary scientific investigations around the theme of water quality in the Rio Grande watershed. The program consists of a four-week summer institute and three follow-up workshops.

Updates *continued on page 8*

From the Editor. . .

Two events—the summer Conference and the death of a premier citizen advocate for systems education, Gordon Brown—give us pause to consider how far the introduction of the concepts of system dynamics and systems thinking into K-12 education has come. People like Gordon Brown in the Catalina Foothills District, as well as many others globally, have worked hard in their individual communities, schools and school districts to promulgate the concepts of systems. At the conference, it was evident that many people are exerting their considerable talents toward the same end, and being more effective with each year. There was a growing excitement at the conference, that I, for one, wish Gordon had been with us to experience.

I would like to pay tribute to Gordon Brown, and all the others who are following in his footsteps to improve the education in K-12 schools, and consequently improve the world for the generations to come. Thank you for your time, energy, and love.

For those who wish to write a note of condolence to Jean Brown, Gordon's widow, her address is: Mrs. Jean Brown, Santa Catalina Villas, 7500 N. Calle Sin Envidia, Apt. 1204, Tucson, AZ 85718

Lees Stuntz (stuntzln@tiac.net)

Gordon Stanley Brown (1907-1996)

Gordon Stanley Brown, friend, advisor, mentor, and pioneer died on August 23, 1996. Brown came to the Massachusetts Institute of Technology in 1929 from his native Australia. Throughout his long career, he innovated in education. As director of the MIT Servomechanisms Laboratory from 1941-52, and with his book *Principles of Servomechanisms,* he launched the field of engineering feedback systems. When Brown became head of the MIT Electrical Engineering Department, 1952-59, he transformed the faculty from the age of power to the era of electronics. As Dean of Engineering, 1959-68, he exerted national leadership in modernizing engineering education. One of the engineering buildings at MIT is named in his honor.

Well after retirement, Brown became the moving force, a "citizen champion," to bring system dynamics into K-12 education in the Catalina Foothills District of Tucson, Arizona. By knowing the high-leverage points, and using them in a timely sequence, he met with and encouraged teachers, administrators, school board, and public. He arranged for computer gifts from industry. Not only for Gordon's influence in Tucson, but also for his pioneering of the concepts of feedback systems, we who are now working toward system dynamics as a foundation for pre-college education owe him a debt of gratitude.

In 1989 friends and admirers established the Gordon Stanley Brown Fund in recognition of Gordon's contribution to K-12 education. The fund supports released and summer time for teachers so they can prepare for distribution the system dynamics teaching materials that they have used in classrooms.

On a personal note, Gordon was my mentor at MIT, as he was for many others, and was substantially responsible for helping me develop my career. Feedback system theory that I learned in his Servomechanisms Laboratory became the foundation for the field of system dynamics.

Gordon was a part of my life for over 50 years. He was proud of his "marriage bureau" and the many couples that met through him. My wife, Susan, and I are one of those lucky couples. He will be much missed by us and many others.

Jay W. Forrester

1996 ST&DM Conference, *continued from page 1*

eling with parents and teachers, to a systems approach to introduction of systems education.

During the next day-and-a-half the talents of many competent educators continued the description of the tools of systems education, as well as discussion of the application of the tools in schools and classrooms. There were educators spanning the gamut of K-12 as well as experienced administrators describing the usefulness of the tools of systems in learning organizations.

Thursday and Friday were punctuated by two inspiring Keynote addresses. Dennis Meadows, developer of Fish Banks, LTD., a National Diffusion Network exemplary educational program, as well as other games which include systems thinking principles, gave a talk on "Use of Gaming as a Tool in Education". It was both fun and inspiring. His broad-based knowledge of techniques to illustrate teaching systems principles through gaming was informative. He kept everyone awake from 8-10 after a long day of sessions!!

The conference ended with an inspirational speech by George Richardson, former editor of the *System Dynamics Review* and Professor at SUNY in Albany. He gave us many interesting and pertinent examples of the power of the systems tools in understanding our complex social systems—and consequently why we should be teaching our K-12 students to understand the world from a systems perspective. It set the reason for creating systems education in perspective.

A conference like this requires the generosity, time and energy of many people. The excitement at the conference was palpable. When the next conference convenes in the Boston Area in 1998 it is hoped that many of the participants at the conference will be ready to contribute their own stories from the journey of introducing K-12 students to the world of systems.

Conference Sessions and Presenters

Introduction and Brief Overview of Systems Education in K-12. Mary Scheetz
Keynote: "Muddling Through Models". Michael Goodman
Keynote: Hexagons and Causal Loops. David Kreutzer
Open House: A System Dynamics Science Fair. Ed Gallaher
System Dynamics As a Common Language for Humanities and Sciences–CP Snow's Two Cultures. Tim Joy
A Systems Approach to Introducing Systems Education–A Dynamic Systems Organization for Falmouth's Public Schools. Gus Root and Grant McGiffin, Falmouth ME.
What Does Systems Education Look Like in the Classroom? Jim Trierweiler, Rob Quaden and Deb Lyneis, Carlisle, MA
Demonstration of Curricula Developed in the STACI^N Project. Doug Cardell
Using Mapping and Modeling with Parents and Teachers to Build a Learning Organization. Tim Lucas
Using a Variety of Simulation Software: Model-It, MicroWorlds Project Builder, and STELLA. Kathryn Verzoni and Shari Jackson.
Teaching Systems Education to Pre-Service Teachers. Albert Madwed
System Dynamics in K-12, An Overview from a Writer's Point of View. Allen Boorstein and Andy Smith
Ongoing open computer lab: Interdisciplinary curricula. GIST (Glynn Integration of Systems Thinking) Project with help from Waters Grant, Catalina Foothills School District, Tucson, Arizona, and CC-STADUS from Portland, Orego;. English and social studies curricula. Tim Joy, Paula Ghiglieri, Dorothy Johnson; Science and math curricula. Ron Zaraza, Diana Fisher, Al Powers.
Non-Computerized Systems Tools in the Classroom. The Waters Grant Project Mentors
All Day or Half Day Modeling Workshop. Jeff Potash and John Heinbokel.
Using ST Tools to Build a Learning Organization. Tracy Benson, Joan Yates
Fish Banks As a Tool for the Classroom. Dessa Dancy
Road Maps: What Is It and What Can You Use It For? SDEP Students
Using Systems Thinking and Dynamic Modeling in the High School Science and Math Curriculum. Diana Fisher and Larry Weathers
General Introduction to ST Tools for Students. Steve Kipp
Teaching Modeling to Kids. Scott Guthrie and Diana Fisher
Working with a School System: From Hexagons to a Model Don Seville & David Packer (GKA)
How Does Systems Thinking and Dynamic Modeling Fit into English and the Humanities? Tim Joy and Paula Ghiglieri.
The Game of Stratagem. Dennis Meadows
Using ST Tools in Teacher Evaluation and Student Assessment. Tim Lucas
Follow–Up from Fish Banks with the Tools from SDEP. SDEP Students
Why Don't Hispanic Students Go to College? Lori Melman, Juan Grenidge, Janis Contreras
The Usefulness of ST Tools in the Elementary School. Nan Gill
Introducing a Systems Education into the High School Curriculum. Will Costello
Keynote: "Use of Gaming As a Tool in Education." Dennis Meadows
Scenario Matrix As a Tool to Help Develop Robust Strategies. Mary Scheetz , Nan Gill
Using Systems Thinking Tools with At-Risk Students. Ron Zaraza
The Use of Systems Modeling in the Curriculum at the Biosphere. Josh Tosteson
Slinky Theory. Waters Grant Project
Keynote: "Useful Insights from Systems Thinking and Dynamic Modeling." George Richardson

Getting Started: Five Lesson Plans to Help Teachers Introduce System Dynamics to Their Students

Cathy Greene Curry, B.A., M. Sc. in Ed. © 1995

(Preparation of this report was supported by the Gordon Stanley Brown Fund administered by the System Dynamics Society.)

Presented here are Cathy's Introduction and the first two lessons. The entire report is available from the CLE or the SDEP Web site — http://sysdyn.mit.edu/

After reading through Road Maps 1 to 4, I realized that everything I had read made me extremely eager to start using System Dynamics with my students. However, I quickly found that going from Road Maps to the classroom was not going to be an easy task. Most often, new curriculum ideas are supported by four or five initial lesson plans to help get the teacher started. I proposed to create these start-up lesson plans and here they are!

The following five lesson plans, complete with class assignments and homework assignments, will take teachers and students through the necessary steps in any new learning method. The plans begin with an extremely simple lesson on systems in general. Students will begin thinking about systems they know and the factors that affect systems. From this general start, the lesson plans begin to encourage students and teachers to make diagrams or models of systems that they use or see everyday.

Once the students have the confidence that comes from familiarity, they will start using the language and shapes of System Dynamics. Learning the definitions for “stock” and “flow” and learning to associate those terms with shapes from Stella are the next necessary steps. After the students have a few definitions and have experimented with drawing simple models, they will learn to assign numerical values to stocks and flows. When the students are comfortable and confident with the more simple beginning concepts, the concept of feedback is introduced.

Recognizing feedback takes practice through analyzing different systems and determining how to best model those systems. Exercises and practice are necessary until the teacher feels that the students are comfortable trying to model more complex systems. Finally, the teacher will introduce the STELLA software and demonstrate to the students how they can model using the computer and actually watch a system working.

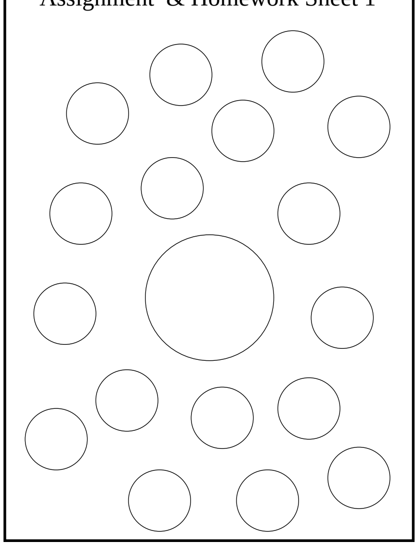
The lesson plans that I have created will take a teacher and his or her students through all of these steps and bring them to a level of confidence at which they are eager to begin looking at more subject-specific modeling.

Please note that these lesson plans assume the teacher is already familiar with the concepts introduced in Road Maps. These lessons are intended to complement Road Maps.

Lesson Plan One

Materials Needed:
A blackboard and chalk
Copies of the accompanying assignment sheet (2 per student)

Assignment & Homework Sheet 1



Anticipatory Set: At the beginning of class, put the title “System” on the board.

Objectives: By the end of the class, the students will have:

1. accumulated a written list of different systems operating in the world.

2. spent time thinking about the different parts of simple systems that work together.

3. gained some experience working cooperatively with their classmates.

4. gained an understanding that they will spend the next 5 or 6 classes learning about systems with the goal to apply what they have learned about systems to the subject of that particular class.

Method:

1. With the title “Systems” on the board, ask the students to give examples of systems they know. Write all responses on the board under the title. Ask the students why they think their suggestions are examples of systems.

2. After a sufficient list (perhaps 20 items) has been written down, add a few items of your own that students would not generally think of as systems (i.e.., a bank account, a cup of coffee cooling, water in a bathtub, etc.)

3. Building on their confusion or surprise that you think a simple thing like a bank account is an example of a system, explain to the students why you have started the class as you have.

a) Explain that almost everything that changes or works is actually a system.

b) Explain that too often in school or in life we learn about one part of something and move on. We need to learn to look at all parts of a system and how they work together to really understand something. Even relatively simple systems can produce complex behaviors.

c) Discuss examples of instances in life where being able to understand all parts of something changes attitudes, actions, and opinions (e.g., the environment, conflict, paying taxes).

d) Explain to the class that in the next few classes, you will be attempting to teach them to look at all parts of systems and how the parts work together so that you can start applying this type of learning to your subject.

4. Choose an easy, concrete example from the list on the board. With the class, list all of the related factors that make the system work (using the format of the assignment provided. The students may be a little amazed at how many factors are involved that they would not normally consider.

5. Divide your class into groups of four.

6. Pick some examples of simple systems from the board and assign one to each group. The best examples to start with are concrete ones to which the students can easily relate and that are also easy to draw (e.g., bank account, bath tub, etc.).

Assignment:

Give each student an assignment sheet. Explain that the assignment is to choose one of the systems not already done and write the name of the central element of the system (e.g., "bank account") in the largest circle on the assignment sheet (just as you did together on the board). Have the groups fill in the remaining smaller circles (as many as possible) with any elements they can think of that are involved in that system.

Explain that each member of the group should have an accurate and complete diagram because you will decide at the end of class whose diagram you will be collecting to be marked as the group's mark.

Have each group pick a spokesperson who will explain the group's results.

Give the students a set amount of time that they will have to discuss and work on filling out the assignment sheet.

Check for Understanding:

When the set time has expired or the students seem to be done, have the students return to their seats. Have each group's spokesperson explain her or his group's results to you and the rest of the class.

Closing

Recap what you did this class. Ask the students why you did this assignment today. Explain to the class where you plan to head for the next five classes.

Independent Learning

For homework, give each student another assignment sheet. Have each of the students take one of the examples of systems on the board (that was not presented in class) and repeat the assignment using the chosen system.

The instructions for the assignment sheet are as follows:

1. Choose the main element of the system and write its name in the largest circle.

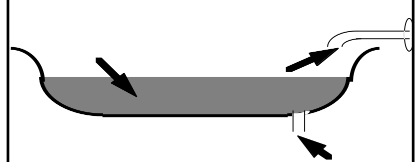
2. Think of every possible factor that affects the central element and write the names of those factors in the smaller circles.

Lesson Plan Two

Materials needed:
A blackboard and chalk
An overhead projector
Overhead pen/marker
Acetate copy of Bathtub Example
Copies of Bathtub Example for students
Copies of assignment sheet for students

Lesson Plan 2

The Bathtub Example



Assignment 2: Stocks and Flows
Below is a list of stocks and flows. Using the definitions you have of stock and flow, determine for each example whether it is a **stock** or a **flow**.

1. Inventory of a store
2. The balance in a bank account
3. Babies born in the U. S. in a year
4. A country's debt
5. Incoming orders in a store
6. The speed of a car on the highway
7. The amount of exhaust a car emits
8. The tons of garbage in the dump
9. The number of cars on the road today
10. Blood pumped from heart to body
11. The air pressure in a tire
12. Withdrawals from a bank account
13. Your present weight
14. Gas you are pumping into your car

Anticipatory Set: Set up the blackboard so there is room for four students to go to the board and draw their examples of parts of systems prepared as homework for Lesson Plan One.

Objectives: By the end of this class, the students will have:

1. spent time analyzing the parts of systems that their peers had analyzed out of class time.

***Lessons** continued on next page*

Five Lesson Plans*, continued from previous page*

2. been exposed to examples of the parts of systems that their peers have examined.

3. been told that the work they did last class and the work they will be doing for the next set of classes will be referred to as “System Dynamics.”

4. written definitions of the terms “Stock” and “Flow” in their notebooks.

5. labelled a diagram of a bathtub with terms used in System Dynamics.

6. spent time determining whether examples on their assignment sheets are stocks or flows.

Instructions:

1. At the beginning of the class, pick four students to put their examples of the assigned homework (from Lesson Plan One) on the board.

2. Ask the rest of the class to be thinking of any parts of the systems being drawn on the board that might be missing or should be considered.

3. As a class, examine each of the parts of the systems on the board. Ask the class if they notice any similarities among the systems. Discuss their comments and observations.

4. Explain to the students that before studying any new topic, it is essential to be informed of the language or terms used. Explain that the term “System Dynamics” refers to the work they did last class on systems and the work that they will continue to do in understanding how systems behave. Write “System Dynamics” on the board. It might be necessary to explain to the class the meaning of the word “dynamics.”

5. Explain to the students that they are also going to learn two new terms today— Stock and Flow. Write those two words on the board.

Method:

1. Hand out the copies of “The Bathtub Example” to each student. Place your acetate of “The Bathtub Example” on the overhead projector so that the whole class can see it.

2. Explain to the class that using a bathtub to help explain the terms Stock and Flow will help them later when they will be asked to determine the stocks and flows of more complex systems.

3. Ask the class what they think the term stock means. Write a good definition at the bottom of the drawing of the bathtub. Have the class do the same. Ask the class what they think a flow is. Write a good definition of flow at the bottom of the drawing of the bathtub. Have the class do the same. Stress the importance of understanding the differences between the two. (Examples of definitions for the two terms can be found at the end of this lesson plan.)

4. Ask the class where they would label the stock and flow of the bathtub. Label the overhead drawing of the bathtub putting the word “stock” in front of the arrow pointing at the water in the tub. Write the word “flow” in front of the arrow pointing at the taps from which the water is flowing. Tell the students to label their drawings also.

5. Ask the students (unless already noted) if there is another flow to consider. Label the drain area at the bottom of the tub as a flow also. To clarify the two flows, you can label the water coming from the tap “InFlow,” and the drain area at the bottom of the tub, “OutFlow.”

6. If there does not seem to be any problem in understanding what they have just done, hand out the assignment sheet that lists different examples of stocks and flows to each student.

7. Explain to the students that the ability to use the definitions of stock and flow and identify stock and flow correctly is crucial to understanding a system.

8. Explain to the students that they are to get into groups of three or four to determine whether the examples on the sheet are stocks or flows. They will work together and discuss the assignment, but each will have his or her own copy of the assignment completed.

Check for Understanding

After the students seem to have finished the first couple of examples, take the first few up orally together to see if the students have understood the concepts of stocks and flows.

Closing:

Review what you have taught this class. Explain to the class the importance of knowing the difference between a stock and flow for their future success with modelling and understanding systems. Tell the class that next day they will be looking at the symbols for stocks and flows used to create System Dynamics models on the computer with a program called STELLA.

Independent Learning:

In any remaining time, let the students work at finishing all of the examples. If there is not enough time, the students should take the assignment home for homework.

Definitions:

A stock is an accumulation of something (food in your stomach, dollars in a bank account, blood in a heart).

A flow is an action or movement (a rate of change). If there is a flow of something, there must be an associated build-up or depletion of a stock.

Note 1: Stocks and flows are inseparable. There is not one without the other.

***Lessons** continued on page 11*

Diana Fisher Talks about Systems Education

Our perspective—the NSF CC-STADUS project (Cross-Curricular Systems Thinking and Dynamics Using STELLA)—takes a view that is more closely aligned with Dr. Jay Forrester than Dr. Senge. Our project trains teachers in math, science, and social science (including some English teachers) to design computer models using a broader systems perspective. Two of us in the project also teach System Dynamics Modeling classes to high school students. We feel it is the building of the models that provides the understanding of the system, that the larger picture, the social impacts, and the identification of leverage points are most effectively taught in a hands-on building environment. It's more fun for the students too. They get very involved in what they build. If you read their papers you can see they are taking in the larger view, interconnections, and need for validation of what they design.

Although I think the ideal situation would be to provide these opportunities for students in a school system that is designed as a learning system, most of us will not have the luxury of influencing those changes at this point. This does not discount what can be done in an individual teacher's classroom. The classroom can still provide systems experiences for the student in a traditional school system.

Our modeling classes touch on quite a few of the points (in varying degrees) in the Scans Report on Systems. Students learn how some technological systems work. They can distinguish trends and predict impacts on system operations. They can identify some of the deviations in a system's performance and get pretty good at correcting malfunctions. Not only can they modify existing systems (models), they develop new systems models for problems of interest to them.

If you are trying to include a systems component of "What Work Requires of Schools" and do not include a building/modifying model component I believe it is a BIG mistake. (Please excuse the bluntness of this remark. But if you could see the papers and the models that students have produced over the last four years you would understand better the emotion behind the statement! I have been a teacher since 1969, and have taught from grade 7 through graduate university courses. I have seen systems modeling students think through problems I did not understand as well as I thought I did. I started to understand some physics (my college minor) phenomenon more clearly when I built STELLA models to replicate the behavior. I teach mathematics now from the systems behavior perspective. Although my class would appear traditional on many days, students now design STELLA models (as well as equation representations) of some of the word problems. They study functions primarily using their behavior-over-time and rate-of-change characteristics. This perspective provides a natural link to more realistic applications for the math classroom.)

Our discussions to date have revolved around the need to articulate the following:

A: a simple definition of a system (every teacher thinks of "the system" and is immediately turned off).

B: the inter-dependency of individuals in an organization to get work accomplished.

C: the inter-relationship of an individual's actions on a larger community.

D: the ability to recognize a system, and to understand the need to use techniques other than linear, analysis-type techniques in approaching it (eg. problem solving).

For "A" I include below information developed by Dr. Ed Gallaher, research pharmacologist at the VA Medical Center, and professor at Oregon Health Sciences University in Portland, OR. This is part of a document he created to help bring "outsiders" up-to-speed so we can communicate with them on various systems issues. I have used it with consultants who are helping my students design a model in their (consultant's) area of expertise.

What is a "System"?

A System is a group of interacting and interdependent objects, classified into "quantities" that increase or decrease over time, and "rates" that cause changes in the "quantities." Systems often contain one or more feedback loops.

Examples of Systems

(Q=Quantity; R=Rate)

Personal Finance: Bank accounts (Q), investment equity (Q), salary/month (R), interest income/month (R), expenses/month (R).

Ecology: Fish population (Q) , births and deaths/year (R), harvesting/year (R), migrations/year (R), food supplies (Q), predators (Q), predation/year (R).

Industrial: Inventory (Q), production rates (R), deliveries/month(R), cash flow/year (R), advertising expenditures/month (R).

Biological: Body temperature (Q), sweating/minute (R), shivering/minute (R), exercise/minute (R), air temperature (Q).

Urban: Jobs (Q), housing (Q), taxable income/month (R), migrations/month (R), homeless population (Q).

Our CC-STADUS Project has a web page that contains some examples of materials that teachers have used in their classes. It also contains a lot of teacher-made models and curriculum that has been developed by our project over the last 3 years. The models are in both Mac and IBM format. The address is *http://www.teleport.com/~sguthrie/ccstadus.html*

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Updates. . . *continued from page 2*

This year we are taking the program up one level and introducing systems thinking/modeling (using STELLA) to the participants. The summer institute will focus primarily on the use of STELLA in the high school classroom to model riparian systems.

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Concord-Carlisle: a Student's Perspective

Al Powers, a chemistry/physics teacher at Concord-Carlisle Regional High School writes:

I thought you might enjoy the following comment one of my students added to a recent STELLA report.

STELLA has been little less than essential to my understanding of chemical reactions, especially those dealing with equilibria. It has allowed me to have first hand experience dealing with all of the aspects of a chemical reaction; many of which I wouldn't have even realized existed. It also illustrates them as they happen. As put by another student, STELLA was what really made realize that it all happens at once. I am a very visual person and without STELLA I don't think that I could really ever comprehend all of the aspects of a chemical reaction, as they naturally occur. I think that STELLA should be used much more than it is presently. It doesn't replace the labs, but provides the information that the labs fail to show. One can only truly get an understanding of chemical reactions by doing the lab itself AND engaging in STELLA.
Sarah Henrick, CCHS '98.

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SD from the UK

In an interesting email discussion a few weeks ago, Adrian Boucher wrote the following note on using system dynamics with children. Forwarded by Nan Lux, Administrative Office, System Dynamics Group, Sloan School of Management, E60-383 (30 Mem. Dr.) MIT, Cambridge, MA 02139 Office: (617) 253-1574, Fax: (617) 252-1998, (nlux@mit.edu)

...Let's start with the notion of helping really young learners to appreciate what SD can offer. The Creative Learning Exchange publishes a really excellent periodical which summarizes classroom use of SD and provides some really neat adventures into simple modeling. Last year, for example, there was a super piece on getting students to "discover" Newton's Law of Cooling, using a cup of coffee as the motivation. The CLE has a great resource pack entitled Road Maps which takes the beginner (of any age) through the first faltering steps of modeling toward some really profound ideas: conservation of non-renewable natural resources such as fish (Fish Banks Game). One example which really appealed to me was the problem of finding the solution(s) to the interception times of two bodies possessing different velocities. The context was a passenger running to catch the train as it left the station. Conventional analysis solves a quadratic equation. The SD solution was much more insightful. More delights are included in the Road Maps series. Contact: Lees Stuntz, Executive Director: *stuntznl@tiac.net*

My good friend David Riley at the University of North London, Dept. of Geography, 166-220 Holloway Road, London N7 8DB (Tel: (+44) 171 607-2789) has done some great work in modeling hydrological processes with secondary school students in the UK (using a HyperCard shell and STELLA. He also developed a STELLA/HC model of the Gaia Hypothesis (Loveluck) as part of the Apple UK "Renaissance" Project a few years back. I don't have an e-mail address for David.

The K-12 discussion list organized by the System Dynamics in Education Project at MIT is a fantastic source of examples, good ideas and good educational practice in using the SD and systems thinking tools to foster understanding. Contact: Nan Lux: *nlux@mit.edu*

There is (was?) an interesting attempt to get SD approaches adopted in US schools, by the US Educational Testing Service. The reports are in:
Mandinach, E and H F Cline (1994): "Classroom Dynamics", Lawrence Erlbaum Associates, Hillsdale, NJ: ISBN: 0-8058-0555-9.

Now, what is the "something" that students learn? In my view, it is that a number of dynamic processes have common features (e.g. exponential growth/decay) which occur in a range of contexts both within an academic discipline, and (possibly more importantly) across subject boundaries. What SD and ST are able to offer is a way of looking at these in general (or do I mean generic?) ways and comparing the structure of the processes rather than the specific mathematics and/or problem parameters. Senge (The 5th Discipline, 1990) provided a simple taxonomy of common processes and archtypal structures. {OK he's not the only one to do this, but for the sake of brevity.} Others have developed STELLA (and PowerSim) implementations, for example Gene Bellinger: CrnBlu@aol.com

The debate in the SD literature is whether it is a good idea or not to try

Updates *continued on page 10*

Reflective Learning Journals, *continued from page 1*

space on subsequent syllabi for opportunities I see emerging???)

Well, what emerged was captivating. The following excerpts provide a glimpse of the key insights, thoughts, and feelings which were experienced by students in the process of learning systems thinking. They have been taken verbatim from their Reflective Learning Journals, with their permission for publication and sharing.

Systems Thinking Debate

This evening we started our class off with a great debate about systems thinking. Someone made an inference that "this was nothing new...in fact...that in the words of King Solomon, '...there is nothing new under the sun...' Yes, but the cure for all cancers is under the sun, but where the heck is it? Someone needs to discover it, the way I believe Senge, et al. discovered this way of thinking. So, this IS new; it hasn't, until now, been recognized, written about, studied, so that we can try to be conscious of this way of thinking in all parts of our life. Which leads me to address the second of our great debate questions, "Does our society, do our businesses, do our families, etc., think systemically?" My answer is no, not 100% of our institutions...probably only a fraction, but it is out there; and we are trying.

I think our organization is made up of many systems thinkers...I just didn't know it until now. Although not everyone in my company has the awareness, I do think that I have been lucky to work with systems thinkers. As I talk to my classmates, I realize that not everyone works for a company with systems thinkers. So our businesses on the whole do not think systemically. If they did, then I would have been able to archetype the problem [we discussed in class]. Improvement efforts would be "systemically" thought out. It is exactly like a circle of dominoes—you know that if you push one over, it will hit the very next one. What is so hard about understanding that the 50th domino will also get knocked over, thus collapsing the system? Society *for sure* does not think this way.

An Immediate Application from the Classroom to the Workplace

I was having lunch with 3 other team members the other day listening to one member, John, discuss an issue that we continuously face, and all of us had perplexing looks on our faces, asking, "How could we have avoided that?" John ended up spending 10 times the amount of time he should have spent on a request that warranted not a lot of attention, and still solved it with the wrong people, and was, in turn, penalized for it. We could have argued that it was the account executive's anxiety that caused him to waste so much time, or that the spec was too senior for what the project really needed, or that John didn't have all the information necessary to make a good decision. The real reason was that he did not escalate the request to a manager in time. I pictured in my head the causal loop of our problem. Every time this exists, it is the same causal loop!

I am only beginning to think like this. I feel that I have a great deal to learn still in the area, but the fact that I am beginning to pull it into all areas of my life makes me quite excited.

Some other Snippets of Thoughts...

To be honest, this looping turned out better than I thought it would when I started it. It also came from a "flash of insight" rather than hours of thought (which I put into the first one)...I am beginning to see a looping around this fundamental and simple variable.

Another student shared some of her initial struggles with making a transition from the "traditional" way of learning to thinking systemically.

When searching for a solution to a problem or an issue, I habitually break problems apart. I reflect on one fragment at a time. I found this isolation of the problem works well in certain situations, yet contains weakness in others. Due to the fact that Systems Thinking forces you to approach the "problem" as a whole, I discovered a new, yet difficult, approach to problem solving. This approach was difficult for me because I never really focused on an issue in its entirely. As a very detailed and structured person, I always believed that it was more effective to look at one specific segment at a time. However, I have learned to look at the "big picture" when problem solving...I thought it looked strange to look at the "whole picture." It resembled viewing something in a completely different way for the first time (i.e., me as a brunette). (This student is a blonde!!).

Even though I could continue for quite a while, I will leave you with some final insights from one student who so eloquently summed up her experiences and thoughts:

Systems Thinking showed me that we are our choices and everyone needs to prioritize in order to avoid stresses in life.

...Systems Thinking stretches beyond the bounds of organizational learning. If understood, it can impact on every situation in your life. You begin to see things as they really are. Kind of a reality check. You will understand that perhaps your key leverage points necessary to change your own way of thinking could be your own emotional development.

My Own Reflections

I found this practice to be extremely worthwhile as I continually imagine new ways of interacting and designing learning experiences that stretch my students, and all the while, having them enjoy the process also. What I found particularly gratifying was that some of the students who were in my Systems Thinking course have requested that they keep a Reflective Learning Journal in other classes! Now, there is an example of wanting to continuously learn!!

Special thanks to the following Graduate students at Suffolk University who shared their experiences with us: Deborah Alton, Christine Roth, Elizabeth Sullivan, and Peggy Weeks.

Updates. . . *continued from page 8*

continued from page 8

to model real life complexity by relying on archetypes (as laid out in the STELLA/ithink manuals), or whether it is better practice to model from first principles. David Lane wrote a good paper on this for the International SD Conference at Stirling in 1994. Sorry, can't lay my hand on the precise ref. The Proceedings of that Conference also contain a paper by Wolstenholme and Corben on the same point, but with a differing perspective.

Last, but not least, George Richardson's excellent survey of systems development (Richardson, G P (1991): “"Feedback Thought in Social Science and Systems Theory”, University of Pennsylvania Press. ISBN: 0-8122-3053-1) provides a tremendous insight into the developments of the methods and their applicability in a wide range of contexts.

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CC-STADUS

This is passed along to you to get you curious about what's going on...if you don't already have a pretty good idea! Timothy Joy (Oregon) is responding to a few earlier comments by Gene Bellinger (Virginia) during an active email discussion about how to help system dynamics be successful on a email group I call “system-dynamics.” Email me directly if you would like to find out how to join this list of 500+ people. Sorry if this is a dupe for some of you! Nan Lux (nlux@mit.edu)

On May 6th, Tim wrote: Gene B states: *As sort of a general thought on the state and pace of SD acceptance, isn't SD just on the down side of a “Success to the Successful” Archetype? As Brian Arthur stated it in economics terms, “He who has gets.” And, it's not SD that is successful, in the largest percentage. It will be an up hill struggle to get to 50.000...001% and then it will just be a landslide.*

The first 18 -24 months of my SD association and work reminded me of days at the monastery—times of mystery, illumination and solitude. No one knew what I doing, why I was doing it. One of my colleagues even said, “you

***Updates** continued on page 11*

CORRECTION

In the last issue of the newsletter, somehow the meteor graphs for figures 5A and 5B in **Modeling Physics: System Dynamics in Physics Education** by Horst P. Schecker, did not print in their entirety. They are here reproduced, with apologies to all, and thanks to those of you who pointed out the mistake.

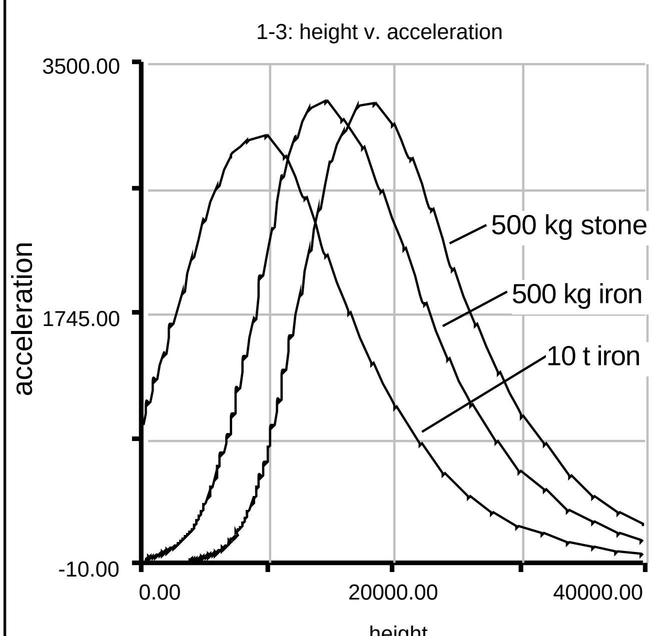

Figure #5A Deceleration of different types of meteors predicted by the model. Values of several hundred g are reached (compare: -10 m/s^2 = 1 g is the acceleration of a free falling body).

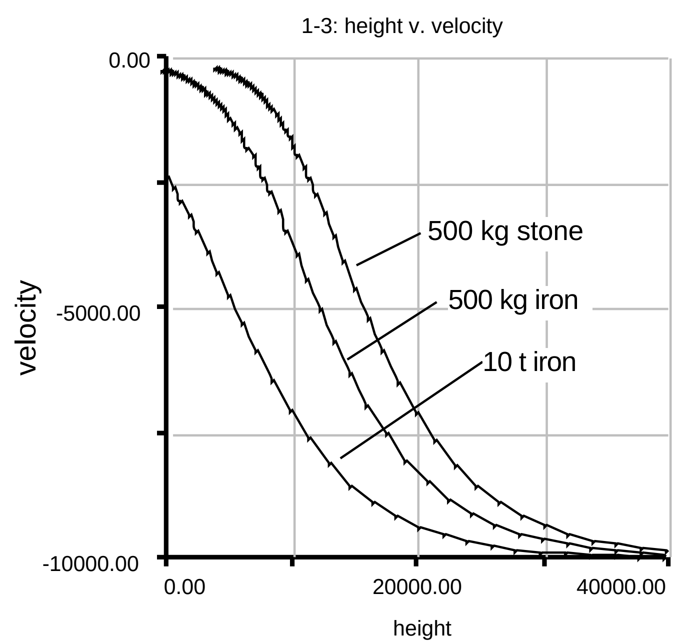

Figure #5B Velocities of different types of meteors. The stone meteor slows down from -10,000 m/s at a height of 40,000 m to nearly 0 m/s at ground level. The big iron meteor still has an enormous kinetic energy when it hits the ground.

used to be a writer, now you're a computer nerd."

In the last eight months, I have a hard time keeping track of regular school work; we are swamped with requests for ideas, clues, help, anything relative to system dynamics. On a number of occasions recently, I have thought I could not get more inquiries, and each time more things happen and open up. Watch the next academic year.

...yet I know I am doing little more than planting seeds that will hopefully someday sprout when the time is right. They need support systems, so I introduce them to this list, and the Learning Org list, the Whole Systems list, etc.

We must pursue with an impatient patience or a patient impatience. In Tucson '95, Jay Forrester said we have to be ready commit our careers to this. As Ed Gallaher says, forget the colleagues; teach the kids. They'll know.

Students still ask sometimes, "Why are we doing this in English?" There it is—Descartes is hard to let go of. As long as students (and people generally) see what happens in schools as discrete acts of intellectual activity, then we are in for a long, long haul. That framework must be broken.

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"I must Create a System or be enslav'd by another Man's. . . I will not reason and Compare; my business is to Create."
—William Blake

Acton-Boxboorough

Dorothy Johnson, English teacher at Acton-Boxboorough Regional Junior High School writes a few thoughts on why systems thinking works in her classes:

BOTG (Behavior-Over-Time Graphs —still a biggie with me) - Concrete representation of student thinking (The kids LOVE it when I issue each group an overhead transparency for their graph and explanations.) that leads into a student-run discussion. BOTG's provide a means for students to own not only the story, but the presentation of it. The decision of where to place each particular point on the graph generates rich discussion in the group. Then explaining and defending, sometimes changing in light of peers' arguments, brings students to a deeper understanding of a work than other strategies tend to.

STELLA - A tool that gives students a concrete means to explore their thinking and to test its validity. As they create models, students think through the relationships inherent in a piece of literature.

Dorothy Johnson
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Germany

Hello,
My name is Walter Hupfeld. I am a teacher in Germany and I am interested in system dynamics since several years. Because I didn't know [about] a Windows-based tool like Stella, I wrote my own program named ***Dynasys*** for modeling and simulation dynamic systems. It is especially for education proposes; that means the program includes only the necessary functions. You can have a look and download the German version of ***Dynasys*** from my Homepage. (http://members.aol.com/whupfeld.)

I also started an English translation, that you also can download, but I didn't translate all error hints yet. Now I am looking for someone, who [would] like to help me in finishing the translation. If you are interested, please have a look at the program and perhaps send me an email.

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You too can join the K-12 Discussion Group
(k-12sd@sysdyn.mit.edu)
To join contact Nan Lux: ***nlux@mit.edu***

Five Lesson Plans, *continued from page 6*

Note 2: The units of a flow always represent rates of change. In the case of a bank account, eg, the deposit of money is an inflow. In modelling a bank account, one could create a "Monthly Deposits" inflow, indicating that the model assumes deposits happen on a monthly basis. In this case, the units of the flow would be dollars/month. Other examples of units for flows could be miles/hour or gallons/minute.

The units of a stock always represent a total accumulation, independent of the rate of change. For instance, a bank account is an accumulation of dollars. The rate at which dollars flow into and out of a bank account (measured in dollars/month) affects the total amount in the account, but that amount is always measured in dollars. Other examples of units for stocks could be miles or gallons.

This article, code named 5LESSOCC, is available in its entirety from the CLE or the SDEP Web site — http://sysdyn.mit.edu/

NEW MATERIALS ON SYSTEM DYNAMICS

The following documents are from the new version of Road Maps, now available from us or the SDEP Web site http://sysdyn.mit.edu/

BEGIN2JW ***Beginner Modeling Exercises Section 2: Mental simulation of Positive Feedback (D-4487).*** J. Whelan
Simple exercises on positive feedback systems. From Road Maps 3. ($1.00)

BEGIN3HZ ***Beginner Modeling Exercises Section 3: Mental Simulation of Negative Feedback (D-4536).*** H. Zhu
Simple exercises on negative feedback systems. From Road Maps 3. ($1.50)

BEGIN4AC ***Beginner Modeling Exercises Section 4: Adding Constant Flows (D-4546).*** Alan Coronado
Simple exercises on introducing a constant flow to positive and negative feedback systems. From Road Maps 4. ($1.50)

BEGIN5LS ***Beginner Modeling Exercises Section 5: Mental Simulation of Combining Feedbacks in First-Order Systems (D-4593).*** Laughton Stanley
Simple exercises on systems producing S-shaped growth. From Road Maps 5. ($1.50)

DYNAMIRS ***Dynamic Simulation Models: How Valid Are They? (D-4463).*** Raymond Shreckengost
An outline of several tests that can be applied to a model to test its validity. From Road Maps 5. ($1.00)

GENER1SA ***Generic Structures: First Order Positive Feedback Loops (D-4474).*** Stephanie Albin & M. Choudhari
An introduction to the generic structure in positive feedback systems. From Road Maps 4. ($1.00)

GENER2SA ***Generic Structures: First-Order Negative Feedback (4475).*** Stephanie Albin
An introduction to the generic structure in negative feedback systems. From Road Maps 4. ($1.50)

GENER3MG ***Generic Structures: S-Shaped Growth I (D-4432).*** Marc Glick and Terri Duhon
An introduction to the concept of generic structures, along with examples of such a structure. Assumes knowledge of STELLA software and simple system dynamics structures. From Road Maps 5. ($1.50)

GENER4CC ***Generic Structures in Oscillating Systems I (D-4426).*** Celeste Chung
Two real-life scenarios illustrating the transferability of an oscillating structure. From Road Maps 6. ($1.50)

GRAPH1AO ***Graphical Integration Exercises Part 1: Exogenous Rates (D-4547).*** Alice Oh
An introduction to graphical integration of constant flows and step function flows. From Road Maps 2. ($1.00)

GRAPH2KA ***Graphical Integration Exercises Part 2: Ramp Functions (D-4571).*** Kevin Agatstein & L. Breierova
Graphical integration of linearly increasing and decreasing flows. From Road Maps 3. ($1.50)

GRAPH3KA ***Graphical Integration Exercises Part 3: Combining Flows (D-4596).*** Kevin Agatstein & L. Breierova
Graphical integration of combined inflows and outflows. From Road Maps 5. ($2.00)

MODLX1JW ***Modeling Exercises, Section 1 (D-44421).*** Joseph G. Whelan
First in a series designed to utilize and enhance the modeling capabilities of the reader, this paper outlines the importance and the process of model building. From Road Maps 6. ($2.00)

MODLX2JW ***Modeling Exercises, Section 2.*** Joseph Whelan
This paper is the second in a series. The first (MODLX1JW) outlines the process of model building. This paper contains two separate modeling exercises and their solutions. STELLA software required. ($2.00)

SUP&DW-M ***Economic Supply & Demand.*** J. Whelan and K. Msefer
A discussion of supply and demand in the framework of system dynamics, this paper includes how to model supply and demand and also presents exercises to help improve system dynamics modeling skills. From Road Maps 6. ($2.00)

INTERESTED IN INVESTING?

If you would like to invest in our effort here at the Creative Learning Exchange, your contribution would be appreciated. You may donate any amount you wish; perhaps $50 is a reasonable amount for a year. All contributions are tax-deductible.

I am sending ________ to *The Creative Learning Exchange* to help invest in the future of systems education.

Name____

Address____

Thank you!!

The Creative Learning Exchange, 1 Keefe Road, Acton, MA 01720

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