the Creative Learning EXCHANGE

Volume 7, Number 4 - Fall 1998

Teaching a Conventional Class (Global Studies) In An Unconventional Manner Using STELLA

Scott Guthrie and Megs Patton

Ever since being introduced to STELLA, I have used it in my science classroom to teach a unit on ecological issues in my Earth Science classes. In doing this, I meet my stated goal of teaching the students how the system we are investigating works. I also meet my hidden goal of getting the students to "ask the better question"[1], to really see what the key pieces or leverage points of the system are and how they have large effects on the system as a whole.

As a core team instructor during the CC-STADUS/CC-SUSTAIN Summer Institute, I (and the other team members) began to notice that, while the science models being built by the science trainees as part of their work were interesting, the social science trainees models were by far more interesting and loaded with potential for student inquiry. Science models, with the exception of those designed for biology, were problem-focused, while social science models tended to be broader in scope and impact.

After some discussions with our building administrators, some work "away from it all" at the Waters Center for System Dynamics in Vermont, and funding for a co-teacher for the class (me) from the Waters Foundation, Megs Patton and I managed to develop a course in Science, Technology, Society and World Issues. This is an Honors course in global studies, covering the typical subjects of a global studies course (political, economic, religious, and social systems of the U.S. and of countries around the world) and adding a twist: the students build, use, and refer to simple STELLA models of the system being studied. The assumption is that the model will direct student attention to, and promote further research on, the critical points of the system being studied. We're still in our first year of teaching this course, but the results are beyond our most optimistic expectation.

A "Brief" Description of the Course: What We Did

For this course the students were given a notebook in which to write their musings, research, actual assignments, tests, and STELLA doodles. One of the key features of this course, unlike a "normal" global studies course, is its open-endedness: other than the first quarter (8 weeks), we were in no rush to get through any "vital" subjects, so we were able to devote as much time as necessary to each subject to cover it

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Systems Thinking Education for K-12 in Taiwan: The His-Fu Cultural Foundation Requests Your Help

Richard Tu

The His-Fu Cultural Foundation is a part of the Megatop group of Taiwan. Since 1992, we have been in contact with Professor Showing Young, founder of the Systems Thinking and Organizational Learning Lab in Taiwan. From them we have learned about systems thinking, system dynamics, and how to become a learning organization. This paper outlines our program, about which we eagerly anticipate input from other systems educationists.

1993 attended 1993 MIT Learning Organization Conference.

1993 completed a"Systems Thinking Training Course" for 60 future managers.

1995-1996 developed internal lecturers for introducing the fifth discipline to the other members.

1996-1997 began building a learning infrastructure by developing the reading forum for all of the managers.
Reading assignment:
The Fifth Discipline
The Fifth Discipline Fieldbook

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Updates. . .

Summer Conferences

Since this newsletter is being writ ten before the school year starts, the major update we can share concerns the conferences which have been held this summer. Our conference, held in Durham New Hampshire at the end of June, was well received. The New England Center furnished us with a setting in the midst of trees, affording a delightful feeling of outdoors and spaciousness within the buildings, as well as food to supply us royally for 2 1/2 days (and probably many days beyond!).

The sessions displayed the variety of activities which the K-12 community has to offer in systems thinking and dynamic modeling. All of us were happy to catch up with old friends and share our enthusiasms with new ones. There was an increased use of technology, both computer and visual display technology, at this conference. The conference two years hence in the Portland, Oregon vicinity should provide an interesting challenge to us to have the technology desired by the presenters made available!

The three keynote speakers, George Richardson, Peter Senge and Jay Forrester, each contributed toward our thought in their own inimitable styles. One of the joys of running a conference like this is the willingness of the world-class figures in the field of system dynamics to give of their time and energy. George, Peter and Jay were joined by their friends and colleagues, Dennis Meadows, Barry Richmond and Jim Lyneis to present addresses and be present with the other attendees at the conference.

The International System Dynamics Conference was held in July in Quebec. There was a substantial presence of K-12 educators at the conference. We are looking forward to both learning from and teaching the System Dynamics community in our future exchanges. We all have so much to learn together!

Here at the Exchange, the result of both of these conferences is that have a lot of new material to review and organize. We are slowly going through the new papers and the presentations for the two conferences. You will be seeing them appear on our List of Materials, and in this newsletter over the next few issues. So many people are doing so much!!

From the Editor . . .

Welcome back to the school year. Since this is not a year that the CLE is running a conference (the next one will be in the Portland, Oregon area in the summer of 2000), we will be concentrating on working on our List of Materials and getting it all into digital format as well as keeping our new CD-ROM up to date. The preliminary planning for the next conference has begun. We have decided after this year's good experience that someplace that feeds and houses us well is a must!

We would like to hear from you all this year. I am always available via e-mail, and the K-12 listserve is a great way to have an international discussion about the issues which are facing K-12 educators.

Lees Stuntz *<stuntzln@tiac.net>*

The CLE Has CD-ROM Available

The Creative Learning Exchange is very pleased to announce that we now have a CD-ROM available for purchase. We have been working toward this goal for some time, since we believe that it is the fastest and cheapest way to exchange all the systems education ideas and curricula.

The CD includes:

Models and Documents
Complete List of Materials
Categorized Lists of Materials
CLExchange Newsletters
1998 ST&DM Conference Handouts
Acrobat Reader (PC and Mac)
STELLA 5.0 run-time (PC and Mac)

The CD costs $25.00, and may be ordered from Andi Miller, Creative Learning Exchange, 1 Keefe Road, Acton, MA 01720.

Phone: 978-287-0070 email: milleras@cle.tiac.net
Fax: 978-287-0080

Teaching a Conventional Class In An Unconventional Manner

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adequately (in our opinion, not our students' opinions). This very open-endedness, frowned upon in most schools, is vital, as it allows adequate time for student directed research and investigation. All of the models produced by the students are expected to work, except the most complex (the revolution models), since these models would take a year or more to develop, and we do not have that much time.

These are the key course components for our first year:

First Quarter

- Four weeks of instruction in the basics of STELLA. Cover the differences between *stocks*, *flows*, *converters*, and *connectors* and explore the behaviors of linear, exponential, quadratic model structures and their graphs.
- Play the Fishbanks game. Profit oriented students such as ours will wipe out all of the fish by turn five or six.
- Discuss what went wrong and what should be done to save the fish. The students made many suggestions here, ranging from taxation and permits, to fish farming.
- Build a STELLA model of the Fishbanks game as a class.
- Examine the model, checking to see if the class solutions would actually work by modifying the model to test them. Many of the solutions proposed before constructing the model were abandoned immediately by the students without testing because they could see that they were influencing a part of the model that had no impact on the number of ships or fish caught. Many new suggestions were made. The eventual "best" solution decided upon by the class was fish farming, since everyone "should have the right to make a profit." However, this led to the new question of how this would effect the genetic diversity in the fish species. This idea was explored later by a student group as a potential ecological disaster issue.
- Assign daily model presentation dates to students. This is similar to a "current events" assignments, with the added requirement that the student must choose a current event in which a system is prominent and present a sketch of a model (not a working model) that describes the system in question. After a five minute presentation of the issue and model by the student presenter for the day, the rest of the class would spend five to ten minutes in discussion on the issue and the model.
- Research and examination of other "ecological" disasters of student interest (constructing STELLA models of the systems affected). Many students chose to explore the effect of virulent non-native species such as kudzu in the U.S., rabbits in Australia and New Zealand, and rats in the Pacific Islands. Others chose to explore the spread of exotic diseases among the human population (Ebola, Dengue Fever). The models the students developed at this point exceeded our expectations. The level of complexity of the models of the issues that the students wanted to explore required some teacher assistance.
- Build a model of post collegiate life earnings, including standard of living requirements. Students had to do a lot of research here not only on the salary range of their chosen field of work, but on all of the costs associated with the lifestyle they expected to lead. This unit is very similar to an entire personal finance course.
- As the students researched their intended lifestyles we took time out to watch and discuss a "food for thought" film *Affluenza*. This film greatly disturbed the students who had never given their habits of consumption much thought.
- Discussion on "realism" of their completed models.

Second Quarter

- Revolution: What is a revolution (brainstorming session)? The students decided that political and social revolutions are caused by unmet needs or perceived injustices and that technological revolutions were caused by rapid change in "the way things are done."
- A brief overview of the French Revolution (students resist study of the American Revolution vigorously) through film and teacher presentations. In the brainstorming session on the probable causes of the French Revolution, the students identified social unrest (class warfare), the economy, the philosophical thought of the day (Voltaire, Locke, and their compatriots), the recent success of the American Revolution, and the availability (or unavailability) of leaders.
- Group research projects in subject areas that were identified as being important in the brainstorming session.
- Groups present their reports (and supporting models). Both the models and the reports are examined for "reasonableness" by their fellow students. The models here are not intended to be working models (more on this later). Lots of discussion.
- Class attempts to build a reasonable model incorporating the separate student models built for their group reports. The class discussions using the "big picture" model ended in concluding that the main cause of the revolution was economic. The money problems of the noble class caused them to sell off their estates to the growing middle class who, in turn, cut off the right to free pasture for the peasant class. This, along with poor crops and rising population, drove food prices too high for the peasants, making them eager to rebel against the nobility.
- Brainstorming on other revolution topics. Individual student's research, and modeling of a second topic of revolution (and written report with a presentation) but these topics were not restricted to political revolutions. Among the topics were the Information, Industrial, Agricultural, Green, Vietnamese,

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Conventional Class, Unconventional Manner, *continued from page 3*

Russian (Communist), Russian (anti-Communist), Cuban, and Iranian revolutions; the Civil War (War Between the States), and the War of the Roses.

- Student models are examined for similarities. The students decided that most revolutions are triggered by economic events, usually involving the perceived lack of economic opportunity.
- Reflection and discussion on the similarities between shortfalls in student "standard of living" model and causes of revolution. At this point, I brought an article on the growing disparity in the distribution of wealth in the U.S. This led to a discussion of whether or not a revolution in a democratic society must be violent or if a revolution can be caused by voting.

Third Quarter

- Examination of the reasons for immigration to the U.S. (legal and illegal). Discussion, research assignments (based on the discussion) and model building. The students focused on quality of life and economic disparity (get rich quick) issues.
- Food for thought film: *El Norte*, a story of a brother and sister who illegally immigrate to the U.S. and their adventures here. This film caused a vigorous discussion and some independent (non teacher assigned) work on the differences in the perceptions of what constitutes poverty around the world.
- Reflection on how causes of immigration (conditions in U.S. vs. elsewhere) relate to revolution. Once again, the students focused on the lack of economic opportunity.
- World Population growth research, discussion, and model building, followed by doing the same process for individual countries (all three "worlds" represented). The students were fascinated by the model behaviors for countries that show a declining population, such as Italy.
- Population growth controls discussed, researched, and modeled, along with research and discussion on how the individual countries view their population growth. Some students questioned the sanity of the leaders of some high growth, low resource countries that see their high population growth as being beneficial to their country.
- Interactions between population and natural resources for various countries researched, modeled and discussed. Interactions between world population growth, world-wide levels of Greenhouse Gasses, resource distribution, and industrialization were also researched, modeled and discussed at this point.
- Food for thought film (and model): *Mahenjo Daro*, where the need for bricks was driven by population growth and led to de-forestation, which led to more destructive flooding, which led to the need for more bricks. . . . a classic self reinforcing growth curve. The students built a model of this situation.
- Agriculture and population interactions for various countries researched, modeled, and discussed. The models were used in discussions of dietary needs and whether these needs could be met world wide (eradicating famine).
- Food for thought film: *Soylent Green*, a future world where overpopulation and pollution have ruined the food supply, forcing us to "recycle" our dead into crackers for human consumption (we added some comic relief with a *Soylent Green* modeling assignment).

Fourth Quarter

- Serendipity at this point: The Sierra Club "Immigration" vote! Discussion and modeling of the pro and con arguments. This was a fantastic opportunity at this time. Because of the modeling we had done with population growth and resource/food distribution, the discussion was highly animated and frequently punctuated by students going to the board to draw a model of their argument. The students decided that both world and U.S. population growth must stop (and possibly the populations must decline) to protect the environment and that the anti-immigration argument would only result in a short term reduction in the growth of the destruction of the environment in the U.S. and not slow the destruction of the world environment.
- Case studies of countries in bad situations for different reasons (post revolution and economic): Cambodia/ Kampuchea/ and Indonesia. Including research, discussion and models (again).
- Food for thought film: *The Killing Fields* and media articles, CNN and BBC reports on the Indonesian economy. The "secret agenda" item here: getting the students to think about what are the key considerations for running a country.
- Last three weeks: Introduce *Stratagem* game, its roles, and discuss how they may interrelate. Build a model of the game as a class, seeing if our discussion was on target. Play the game. Discuss how things went after play completed.
- Reflect one last time on how the things that we studied are connected.

This is the basic outline of the course, an intense year of learning. Throughout the course, our use of STELLA to model the situations we studied was the key to student learning. The rigor and precision imposed by model construction using STELLA gave the students a feel for what the proper relationships between things were in ways that loop diagrams cannot. For example, no models turning people into cars survived the scrutiny of the class even without help from the teachers. Units were preserved and cause-effect relationships were well thought-out. The discussions that resulted when using the models as a base for understanding rarely fell into the category of wishful hand-waving. When they did, the other students directed the discussions back to the realm of logical arguments rather quickly by pointing out that what the

student was saying could not be supported by the model. The immediate desire that the students had to add modifications to the models they built and were discussing, and to explore their ideas in even more depth was interesting and frustrating. It was interesting in that they were functioning as their own teachers, learning without our input, direction, or control. This was student directed learning at its best. It was frustrating in that these were missed opportunities for learning, since we had to cut these sessions off after a day or two in order to cover a minimum of material over the course of the school year. If they had been allowed to do everything they wanted, the class never would have gotten beyond the Revolution unit.

Plans For Next Year

Overall the class has been highly successful. However, as with all first attempts, improvements can be made. The biggest change that will be made will be to place the revolution unit at the end of the year in the fourth quarter. The amount of time the students needed to spend doing research on their topics after learning STELLA caused their modeling skills to atrophy substantially, forcing us to use a week and a half to bring them back up to speed at the end of that unit when they had to build their revolution models.

Also, we will work on filling in a glaring hole in student research skills that we discovered early in the year. As the preliminary research on the French Revolution began, we discovered that our students did not know how to use the library or the Internet for basic research. Rather than take the time to teach them how to do this (something we thought they should already know), we resorted to functioning as research assistants for the students. With three groups of five students each to a teacher, this was very exhausting. Next year, time will be taken at the beginning of the course to teach these skills, which should ease the burden on the teacher. Other than that, we wouldn't change a thing. The quality of the student work and discussions was a level above that of the typical accelerated Global Studies class at our school.

The student comments on the course at the semester break were also interesting. Several students complained that they signed up for a global studies course, not a science course. When pressed for details, we found that this was a reference to the STELLA modeling component of the class and to the "ecological" subjects covered early on. Later in the year, they admitted that they just did not see the connection between these subjects and global studies at the time (they do now). Also, some students complained that they seemed to be wasting time sitting around and doing nothing. These were students who did not have much experience in open-ended assignments and desired more direct teacher involvement in their learning. They learned to do without this. Near the end of the year, the student comments were quite positive, especially when looking over their notebooks: "I can't believe that I learned so much!"

Samples of student work will be posted for all to see at *www.teleport.com/~sguthrie/stswi.html.*

[1]*British Petroleum Is Not Jackson Middle School: Different Best Modeling Practices For Different Environments*, Tim Joy and Ron Zaraza, 16th International Conference of The System Dynamics Society Proceedings, 1998.

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Interesting References

Are you familiar with the Davidson Software product: The Magical Journey of the Zoonbeanies? Although it is a "math" program it is a terrific venue for teaching systems thinking constructs. I use it to teach systems thinking to my 2 & 6 year olds. They love it and "get" things like causal loops very quickly!

Brad Stearns

Another interesting set of papers on the topic of assessing systems thinking skills and their cognitive impact can be found at the following website:

http://www.tiac.net/users/sustsol/papers.htm

Greg Gunn

My website: http://home.earthlink.net/~tomfid/ contains:

- about 100 links to sites in system dynamics and other simulation and mathematical modeling disciplines

- about 100 links to climate change, energy, economics, and environmental policy sites (including my dissertation research on climate policy)

- a library of quality replications of classic models, like Forrester's Market Growth and Sterman's Economic Long Wave (more in the pipeline, too)

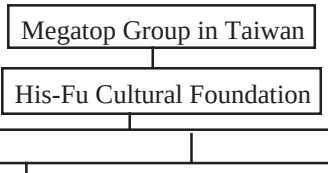
Tom Fiddaman

Systems Thinking Education for K-12 in Taiwan, continued from page 1

1997 attended a system dynamics course designed by Professor Showing Young.

1998 invited Professor Showing Young to design a course: "Systems Thinking—to facilitate top managers to learn how to design a new corporation."

Our Vision—To Become a Learning Organization



Objective	Adult Education	Community Education	K-12 Education
Vision	To enhance personal and organizational learning ability for managers and employees, and to introduce same to the public. To shape an outlook and perspective to fit the 21st century.	To re-engineer our community to become a learning community with increased inter-connectedness.	To give students a more effective way of interpreting the world around them. To help students gain a greater confidence for managing their lives.
Practice	Developing the "Fifth Discipline Teaching Team" to help with organizational training and to promote the 5th discipline to other organizations. Creating the 5th discipline course for adults to help them improve their learning ability. Communicating and interacting with other organizations to share this new management art and science.	Developing the "Fifth Discipline Scouts Team" to integrate our efforts with the community and young college students. Facilitating other communities to become learning communities.	Developing the ST Winter Camps for K-12 kids. Developing the ST Summer Camps for K-12 kids. Developing the advanced ST courses for K-12 kids. Facilitating kids to build a dynamic modeling ability. Contacting other system education schools to promote the 1999 ST Summer Camp—bring Taiwan's kids to the USA. Developing our teachers' ST&DM capabilities.

Our Vision of K-12 Education

"I believe we should give students a more effective way of interpreting the world around them. They should gain a greater and well-founded confidence for managing their lives and the situations they encounter."

Dr. Jay Forrester, Keynote address
June 1994 Systems Thinking and
Dynamic Modeling Conference

"Love to learn
Will to risk
Try it
Explore it"

Mary Scheetz
July 1996 Systems Thinking and
Dynamic Modeling Conference

A happy learning experience by playing games.
To enhance their creating ability.
To enhance their presenting ability.
To enhance their analyzing ability.
To enhance their ability to understand interrelationships.

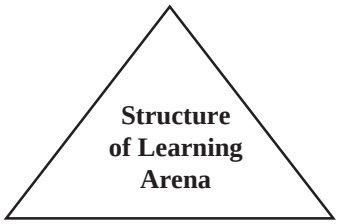
Thinking Education for
K-12 in Taiwan

A LEARNING PROGRAM FOR GRADES 3-6

Structure of Learning Arena

We followed Peter M. Senge's idea of building learning organizations, and Tim Lucas's concept of building a learning school by developing three core competencies. Thus, we designed the learning arena by building core competencies; understanding and practicing theory, method and tools; and developing innovative infrastructure.

Building Core Competencies:
- Aspirations—Goals of the soul
- Conversations—Talking the talk
- Dealing with complexity—Understanding interdependencies



Infrastructure (Summer/Winter Camps):
- Virtual World Games
- Experiment
- Role Playing
- Movie Discussion
- Case Study

Theory, Method, and Tools:
- Personal Mastery
- Mental Models
- Shared Vision
- Team Learning
- Systems Thinking— CLD's, BOTG's, Systems Principles, Systems Archetypes

Curriculum Structure

1. Team Building

Purpose: By building a team, we lead individuals into a partnership. Students can feel that they are connected with one another.

2. Find the Truth with an Open Mind

Purpose: After seeing some pictures and reading some stories, students will be interested to find the truth with an open mind. They will gain more confidence to explore the meaning behind events and open a new window for the real world.

3. Systems in My Life

Purpose: Students will learn how to identify systems by finding the interrelationships among the parts of systems. By playing an interesting game, students will discover a reinforcing feedback loop. We will invite students to talk about their feelings and become aware of their behavior. Finally, we will ask students to reflect upon their life to find some similar examples.

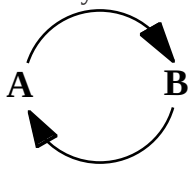
4. Understanding Cause and Effect

Purpose: Students will practice causal thinking, including short-term causality and long-term causality, helping them to widen their views of time and space. For example, students could begin a discussion of some social problems by writing down what happened, what caused the problem to happen, and how this problem affected the environment or themselves. This shows students that we all are in systems.

5. Building Causal Feedback Thinking

Purpose: 1. Introducing the cause-effect relationship symbol (A=>B).

2. Extending the cause and effect relationship. We begin to develop feedback loops by making an effect feed back to a cause. Thus, we can read the whole story with a circle symbol.



3. Recognizing single loop reinforcing or balancing feedback

4. Combining the reinforcing feedback loop or the balancing feedback loop with its behavior over time.

5. Reading and telling the systems story by using CLD's and BOTG's.

6. System Delays

Purpose: When we start to have a problem, we always find some solution or action to fix it. Actually, it does ease the problem symptom in the short term, but we also begin to accumulate some unintended consequences which may make the

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problem more serious. It is very important to understand delays and be comfortable with them.

7. Case Study

Purpose: 1. To practice event-oriented ways to tell a systems story.

2. To practice pattern-oriented ways to tell a systems story.

3. To use causal loops and BOTG's to understand systemic structure.

4. To change the story by breaking the loop or adding some arrows.

5. To find a better policy for some critical mistakes.

6. To introduce the insightful meanings of systems archetypes.

7. To practice drawing the CLD by using archetypes which reflect their own life.

A Game of Systems Thinking Education for Grades 3-6

The Fish Pond Story

Purpose

a. Understanding interdependence.
b. Discovering behavior over time.
c. Dealing with complexity—systems archetype of "The Tragedy of the Commons."

Scenario

Once upon a time, there was a fish pond. Everyone depended on the fish in the pond—for eating and to sell for profits. In this game we all play the role of the fishermen and begin to make use of the resources of this pond.

Every fisherman's family has a fishing rod, which is made of bamboo, fish "bait" and a magnet. Every fish is made of paper with a metal staple. Every fisherman's family can choose how many fish they wish to catch. Then we start to simulate the whole story.

But remember that if the number of fish in the pond drops to zero, everyone would starve. So be careful, and good luck. . .

Game Design

a. The initial value of the fish stock is 200.
b. There are 8 fishermen's families (8 teams).
c. The pond is open for one minute, and then closed and each team's fish are counted. At the same time, we begin to hatch new fish. Then a new round begins.
d. The hatch rate is 10%.
e. The new fish would grow up immediately.

Result

At the beginning, kids always want to catch more and more fish. But after some time, the numbers of fish are decreasing, and finally drop to zero. After this game, we invite students to think about how their selfish goal causes damage to the environment, and how we can improve this situation to avoid the tragedy of the commons.

Meaningful Insights

a. Discussing "Who makes this happen?"
b. Discovering and understanding the behavior over time graph (BOTG) of the stock (fish), and the teams' performance BOTG.
c. Developing the causal loop diagram (CLD) to clarify the interdependence.
d. Discussing the systems archetype "Tragedy of the Commons."
e. Thinking about what we should do if we play this game again.
f. Connecting the experiences of the real world with the game.

We Do Need Your Help!

Please give us some suggestions for our implementation of the experimental course for 3-6 graders which is outlined in the 2 previous sections. **Please send me any suggestions you may have:** Richard Tu
Doctoral Student
National Sun Yat-sen University
Taiwan
email: young@cm.nsysu.edu.tw

For the next step, we hope to design a Dynamic Modeling Course for grades 3-6. We want to use STELLA to help the students to learn. But there are some problems:

a. We must enhance our teachers' and students' English reading and speaking abilities first. Please suggest some ideas or materials about how to teach an elementary dynamic modeling learner. (Example: story books, other books, teaching methods, materials, textbooks, computer-based simulation games, etc.)
b. We need some teaching programs which have been used successfully to help us to develop a new course.
c. We need some successful examples of K-12 education which have been recorded step by step in books or formal reports.
d. We need some formal evaluation reports which have recorded some teaching experiments to help us research the results of our 3-6 grade teachers' programs.
e. Our teachers do not know enough about Systems Thinking and Dynamic Modeling. How can we utilize the systems teaching experience of American teachers? Can you recommend some teacher training programs which can help us find the right direction to go to train our teachers?

Thank you for your suggestions.

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The Idea: 1999 One-Month Systems Thinking Summer Camp for Grades 3-6 —Bringing Taiwan's Students to American Elementary Schools

Purpose: To enhance Taiwan's 3rd-6th graders global view and English ability, to learn systems thinking and dynamic modeling skills, and to develop a cultural exchange between the children of the 2 countries.

Description: In the summer of 1999, we hope to bring our teachers and students to visit an American systems education school. We want to create a 1999 Systems Thinking Summer Camp in the USA. In this tour, we would offer some English conversation classes, ST&DM classes, and sight-seeing.

Questions

Is it possible for you/your school to accommodate this tour in the USA?

Can your school offer classroom space for our planned activities?

Can you arrange for some teachers to design and teach the ST&DM program for our kids?

Can you organize some interaction between American kids and our kids for playing and learning?

Please get in touch with me to continue to work on these exciting plans for next summer.

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A Discussion about Teaching System Dynamics

This is an exchange from the K-12 discussion list in answer to a question posed by Jay Forrester after the ST&DM conference in New Hampshire in June.

Jay W. Forrester wrote:

So, I have a question for people on this list. What aspects of the present existing knowledge about system dynamics do you believe can not be understood by 8th grade (about ages 13 to 14)? Of what we now know about the dynamics of systems, which techniques, insights about systems, principles, and understanding of behavior can not be mastered before students get to high school?

Dr. Guenther Ossimitz wrote:

Some years ago I made a study about SD-skills with students aged 14 and 15. From that experience I think that the following issues are rather hard for that age:

the notion of time delays, esp. exponential delays and higher order delays (which are thought as an accumulation of several exponential delays). They can use them as a technical device, but it is really hard for them to understand the ideas behind it (e.g. the idea that an exponential leaking can be viewed as a "delay").

the notion of continuous models where dt is an "infinitesimal" time step (like in classical calculus); as well as concept of higher-order integration techniques (like Runge-Kutta 4th order).

the inner structure of very complex models that are not constructed by the students themselves! Students aged 14 can do rather complex things as far as these are their own ideas, but they are not so experienced in reconstructing the ideas others had implemented in a complex SD-Model (like World3).

Dr. Niall Palfreyman wrote:

Good point—this accords with my experience too. Although, I would say that learning to see the world from a viewpoint other than their own would in itself be a worthwhile goal for 14-year-olds.

Jim Hines wrote:

Concerning Guenther Ossimitz's interesting post about his investigation into the difficulties that 14 and 15 year olds have with SD:

A control group of adults would have been interesting. My guess is that adults have the same difficulties.

Dan Compton wrote:

A strong second to Niall's thoughts. Here are three examples of deep thinking discussions that I had with my 8 year old this last week.

Why do kings increase taxes on their people over time? There will come a time when a large enough portion of the population will decide it is better to be independent and forego the benefits of unity under the king's rule, and they will revolt and declare independence.

Why do people kill tigers if they are endangered? First it gets harder and harder to find big tigers and second

continued on next page

A Discussion about Teaching System Dynamics, continued from page 9

the tigers will become extinct; then nobody will have tigers.

What would happen if all the weeds in our yard were picked? How much time would it take every week to pick the new little weeds? Answer: Zero to a little bit. (He does not yet have a crisp sense of time, but he easily comprehends comparative growth through time.)

How much time would it take if the picking occurred only every month? Zero to kind of a lot of time. (It depends on the weather conditions.) How much time would it take if the picking occurred every year only? Answer: Lots and lots of time; more than all the times every week added together because the more weeds you have the faster they spread. I will never have to explain why weeding is done even though it looks like we can skip a week.

The complexity of the content is not the stumbling block to understanding. The cognitive capabilities seem to be present for systems thinking even when reading, writing, math, and telling time skills are not present. Our assumptions that a bunch of schooling needs to take place before we can think is wrong. I'm wondering if, for some, that schooling actually diminishes the ability to think.

While systems thinking and causal loops should be introduced before K, learning the modeling tools should wait until 10-14 yrs. That way making an SD model never becomes a replacement for thinking, but rather becomes a tool to manage the complexity of the problems not handled rigorously enough by causal loops.

Any more comments or additions to this conversation should be sent to the K-12 listserve k-12sd@sysdyn.mit.edu.

What Is a Modeler?

Excerpt from the system dynamics listserve:

Can anyone on this list point me at a description of the qualities that make a fine system dynamics modeler?

What separates an expert from a good modeler? By analogy, one characteristic that separates great concert musicians from good ones is their ability to interpret music—to amplify or adapt the composer's intent in ways that aren't captured in musical notation. What characteristics or abilities distinguish expert modeling?

Mark Shirley

1) Modelers see the big picture.
2) Modelers excel in visual spatial intelligence (H. Gardner).
3) Modelers are divergent thinkers.
4) Modelers enjoy thought experiments.
5) Modelers can't stay on task.
6) Modelers never finish a model; they are dragged away kicking and screaming.
7) Modelers think in parallel.
8) Modelers think with the symbols of the modeling system used.
a) C programmers model in C.
b) Einstein modeled in tensor notation.
c) Artists model in the symbols of their art (paint, clay, dance, music, chess pieces, diving board, etc.).
d) SD modelers model in causal loop and stock and flow diagrams. (But if the truth be known, the SD modelers already have a sophisticated symbol system they think with, and simply translate for the sake of standardization.)
9) Modelers are always modeling something.
10) Modelers do not have to have lists of ten.
11) Modelers are patient.
12) Modelers are strategic.
13) Modelers relish new ideas and can't wait to try them out on an old model.
14) Modelers don't charge enough for their models.
15) Modelers aren't as smart as they are gifted at being visionary and showing a
part of what they see in a model.
16) Modelers continue to learn from their models long after others have lost
interest.
17) Modelers honor the tools that bring life to their thoughts.

Dan Compton

Any more comments or additions to this conversation should be sent to the K-12 listserve.

THE K-12 LISTSERVE

A lot of information comes to us from the K-12 Listserve. There is always an interesting dialog to read or to participate in. You, too, can become a part of the K-12 Discussion Group.

k-12sd@sysdyn.mit.edu.

If you wish to join the listserve, write Nan Lux <nlux@mit.edu > or go to the system dynamics web site (http://sysdyn.mit.edu/) and register electronically.

<nlux@mit.edu>

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Many of our documents are available in four formats: on the Internet, on a CD-ROM, on a floppy disk, and in hard copy. A few are available only in hard copy.

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web page: >*http://www.adobe.com/*>
ftp site: <*ftp.adobe.com*>

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The Sense of the Goose

In the fall when you see geese heading south for the winter flying along in the "V" formation, you might be interested in knowing what science has discovered about why they fly that way. It has been learned that as each bird flaps its wings, it creates an uplift for the bird immediately following. By flying in a "V" formation, the whole flock adds at least 71% greater flying range than if each bird flew on its own.

People who are part of a team and share a common direction get where they are going more quickly and easily because they are traveling on the trust of one another.

Whenever a goose falls out of formation, it suddenly feels the drag and resistance of trying to go through it alone and quickly gets back into formation to take advantage of the power of the flock.

If we have as much sense as a goose, we will share information with those who are headed the same way we are going.

When the lead goose gets tired, he rotates back in the wing and another goose takes over.

It pays to share leadership and take turns doing hard jobs.

The geese honk from behind to encourage those up front to keep their speed.

Words of support and inspiration help energize those on the front line, helping them to keep pace in spite of day-to-day pressures and fatigue.

Finally, when a goose gets sick or is wounded by a gunshot and falls out, two geese fall out of the formation and follow the injured one down to help and protect him. They stay with him until he is either able to fly or until he is dead, and then they launch out with another formation to catch up with their group.

If we have the sense of a goose, we will stand by each other when things get rough.

The next time you see a formation of geese, remember...

It is a reward, a challenge, and a privilege to be a contributing member of a team.

Newsletter Subscription Information

The Creative Learning Exchange Newsletter is available in three different formats:

- On the web page at http://sysdyn.mit.edu/cle/
- As an attached file to an e-mail
- In paper via US mail ($15.00 outside USA)

Since we vastly prefer electronic distribution to paper because it is so much less expensive, feel free to e-mail us at any time when you would like to have an electronic subscription.

<milleras@cle.tiac.net>

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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

Words of Inspiration

Some people complain because there are thorns on roses, while others praise for having roses among thorns.

Faith sees the invisible, believes the incredible, and receives the impossible.

Letters...

Lees,

I first want to acknowledge all the contribution you make to the children of the world. And thanks for *The Exchange*; it has helped in my effort to get systems thinking along with CSL (Community Service Learning) into the Somerville K-12 curriculum.

Are you familiar with the Davidson Software product: *The Magical Journey of the Zoonbeanies*? Although it is a "math" program it is a terrific venue for teaching systems thinking constructs. I use it to teach systems thinking to my 2 & 6 year olds. They love it and "get" things like causal loops very quickly!

Brad Stearns
CSA, Communications Servies America

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