

The Creative Learning Exchange

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OBSERVATIONS AND INSIGHTS FROM THE IMPLEMENTATION OF THE FOOD WEB CURRICULUM

Excerpts from a report of the System Dynamics in Education Project, by Christopher H. Prince, Massachusetts Institute of Technology, System Dynamics Group

Our goal here at the System Dynamics in Education Project is to help develop curriculum and support materials that are centered around system dynamics. A fundamental change in the focus of education should shift away from lecturer-centered learning, where the teacher is seen as the one who possesses all of the knowledge. The new focus should center around the students. They should be encouraged to take charge of their own learning, and use the teacher as a resource person. Our curriculum units are designed to allow the students the freedom to explore on their own in groups of two or three students. It is in these small groups that the development of critical thinking skills takes place.

In our development of curriculum we have been fortunate to have an informal arrangement with educators at the Cambridge Rindge and Latin High School. We have implemented two separate curriculum units that use system dynamics models to transform the classroom into a learner-centered learning environment. The subject of this report is an eleventh grade ecology class. Tad Sudnick, a biology and ecology teacher at the high school, taught two separate periods of this particular ecology class.

In 1991, Tad Sudnick came to the System Dynamics Group with an

idea for a model for his ecology class. His original goal was to demonstrate to the students the difference in resiliency of a simple food chain and a food web with multiple branches.

The finished product at the end of the summer actually consisted of two models. There was one a simple three level food chain consisting of hawks, mice, and biomass. The final model consisted of four levels and environmental factors. We added snakes to the three level food chain to create a web effect and environmental factors that could be easily manipulated by the students: weather severity, DDT sprayings, and area infringement. Unfortunately, this was not as extensive a web as Tad had envisioned. The model did not contain enough species to sufficiently demonstrate the greater resiliency of a web over a chain.

Despite the fact that the model did not satisfy the original goal of the process, Tad still felt it would be useful. Over time, I realized that Tad's focus was shifting from wanting to use the model to teach the students about food webs to using it to teach some of the basic skills of system dynamics.

Once the model was complete, Tad and I began to develop exercises to use with the model. He focused on creating basic homework assignments

meant to develop students' skills so that they would be capable of using the model. He created exercises ranging from simple graphing to a situation with exponential growth. None of these materials actually used the food web model, and often they did not appear relevant to ecology. I focused on creating mini-models that demonstrated S-shaped growth, overshoot and collapse, and sustained oscillation, for use in the Mac lab. These exercises involved hawks and mice, but did not reflect the final model of the food web. Finally, we created exercises for both the simple food chain model and final food web model which included the environmental factors.

We set out on this experiment with high hopes, but we kept in mind the realities of the situation. These ecology classes were "low achievement" students for the most part. There were multiple disciplinary problems in each class, attendance was poor, and the class had a wide range of abilities. We thought that if this "worked" in these classes, then it could work anywhere.

Methodology of Curriculum Implementation

In the past this class had been taught just like any other high school class, with lectures, quizzes and tests.
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FROM THE EDITOR. . .

Welcome to the first edition of the *CL Exchange*. It is being created to do just what it says - Exchange. Although I hope to be able to impart information to you which is both timely and interesting, I would appreciate feedback about what you would like to read.

Ideas for articles, or better yet, articles themselves, will be gratefully accepted. There is interest in a regular column to keep people up to date on what is happening in school systems across the nation. Other ideas for future issues include annotated bibliographies and lists of people by portion of the country or interest area.

You will notice that the back page of this letter is a questionnaire. Please fill it out if you have not given me one already. If you have sent one in, please fill out the section which asks for ideas and/or names of others who would be good candidates for receiving this newsletter as well as other related mailings from the Exchange. Anything you can send me will help us all.

UP-DATES...

System Dynamics in Education Project

This project, headed up by Jay Forrester, uses the multiple talents of undergraduates at MIT to help clarify the intricacies of System Dynamics for utilization in the classroom. One of the major thrusts this summer has been the development of a Road Map for a neophyte to start learning what System Dynamics is. The first section of this is available from the Creative Learning Exchange. Each section will have an annotated bibliography with it to help guide the learner through the maze of literature. This, as with all projects produced by SDEP, is designed to elicit feedback for constant improvement of the process and the product.

Other projects this summer include finishing a Food Web curriculum packet, the Fishbanks packet and a few papers, such as a *Cooling Cup of Coffee*, to illustrate some simple or not so simple concepts.

Systems Thinking Project in the Catalina Foothills District, Tucson.

The Systems Thinking Project is going into the third year of its Waters Grant. There are special issues this year posed by its longevity. Since some

children have had exposure to systems thinking for two years there are now curriculum sequencing issues to be looked at.

The new high school will be in its first year with a ninth grade class. New teachers have been hired. Frank Draper will be giving them their introduction to systems thinking before school this summer. He, with the able help of William Glass, formerly with the SDEP, will be giving support and system dynamics help to teachers and students this year.

At Orange Grove Middle School, Principal Mary Sheetz and her associate Tracy Benson will each be working at the school three days a week and devoting the other two days to helping other schools start on their own metamorphosis into a Learning Organization.

For those of you interested in planning ahead, Frank Draper and Dr. Walter Doyle are organizing a Systems Curriculum Institute next summer at the University of Arizona at Tucson.

Please let me hear from you. Whom in your system should I call for your update?

FOOD WEB, continued

Our goal was to deviate by using system dynamics. Rather than have the students learn from a book or a lecture, we intended to let them see for themselves what happens to a food web when one of its species becomes extinct. By exploring and making changes to the model, the students will gain a greater understanding for the important ecological concepts inherent to food webs.

The primary barrier preventing a smooth transition to the new methodology was that the students had never heard of system dynamics nor STELLA. About half of them had never used a Mac before.

The first decision concerned how much of an introduction we would give them to STELLA and system dynamics. They would need basic skills in order to gain anything from using the model. Tad also felt that STELLA and system dynamics were valuable in their own right, that students should be exposed to the basic principles.

We decided that a step by step introduction was necessary. We began with simple graphing, moving on to study the STELLA symbols and their meanings. The students were later tested on their knowledge of these symbols and the terminology. (A major problem here is the evaluation procedure. The students simply memorized the stock and flow information so they could regurgitate it on the test - just what we were trying to avoid! See Section VII in the full text for alternative evaluation procedures.)

Following the STELLA introduction we embarked on a step by step process to prepare the students for proper interpretation of the information contained in the more complex models. We presented a constant inflow situation, a constant outflow situation, and a combined inflow and outflow situation. The introduction included in-class worksheets, as well as home-

FOOD WEB, continued

work. None of these topics directly related to ecology. This was a major problem for the students; they became very impatient with these proceedings.

Based upon these negatives, we decided it was time to make a change. We began to doubt our theory that the students must know everything that builds up to a model in order to gain anything from it. We had planned to go through simple positive feedback, simple negative feedback, and a combined positive and negative feedback situation similar to what we had done with the inflows and outflows. We had structured Mac Lab exercises that were thorough and, quite frankly, boring. Based on how things were going with dissecting the inflow and outflow situations, we decided to trash the idea of doing the same with the feedbacks.

In lieu of the step by step approach, we decided to give them a model that was more realistic and more complicated. We created a "rats in an alley" model that included positive and negative feedback.

The first day in the Mac Lab went quite well. The students were much more interested in the rats model because it had believable elements in it. They were also excited about being allowed to experiment with this small model on their own. While they investigated the model, they discovered equilibrium as well as situations where the positive feedback loop dominated and situations where the negative feedback loop dominated.

The debriefing was crucial. Tad used the overhead Mac to review and dissect what had been done the day before. The debriefing was led by Tad, but dominated by the students. There was exciting debate in the class for the first time. The students would argue over which loop would dominate or if it would be in equilibrium. After this experience, I felt that the students had gained a solid understanding of dy-

namic equilibrium. This was by far the most exciting and educational day of system dynamics to date.

The biggest lesson that we learned here concerned our methodology. By using positive and negative feedback situations in the more complex and realistic model, the students were more interested, and therefore understood the concepts better than if we had used the step by step approach.

If we had absolutely believed that giving them the end product first was the more effective method, we would have gone on to the food web model the next day. However, we were still skeptical about giving them something this complex (in retrospect, it probably would have been okay).

We intended to show them S-shaped growth, overshoot and collapse, and sustained oscillation. We demonstrated S-shaped growth in a simple model involving hawks and mice. After one day in lab with a guided worksheet, they seemed to understand the idea of a limiting factor that led to the S-shaped behavior. There was a certain degree of excitement in the class with some students who are normally totally disinterested becoming quite involved.

Actually, I doubt the students needed any of the build-up and instructional work in order to learn from the food web model. I think that we should have done the graphing skills and a brief introduction to the basics of STELLA, but then moved right on to the food chain. The debriefing sessions are key in bringing out the important concepts. Some of the most productive classes that Tad had during this unit were when he used the Mac overhead for the debriefing. The students were really into it because they had just done something similar the previous day in the Mac lab, and they 'bring something to the party' in the form of questions or insights based on their own experience with the model.

HOMELESS TWINS

Enclosed in this envelope you will find a paper entitled *Discovering the Homeless Twins: Education and Democracy, Authored for discovery exchanges by our total environment*. It is the compilation of a lot of peoples' ideas put together through the draftsmanship of John Bemis, who has been instrumental in initiating the effort to introduce the concepts of systems thinking and System Dynamics into the field of K-12 education. It is intended as a working paper. What are your ideas and thoughts? Do you find it helpful in seeing what is happening? What about it strikes you as germane? In what direction does it stimulate your thinking?

The Creative Learning Exchange has a special emphasis on systems thinking and System Dynamics as well as its adjunct computer modeling process. How does a working paper such as this help us relate to those concepts and concomitant actions?

Please send your reactions to us here. We hope this stimulates a spirited exchange of ideas.

Obviously, allowing them to begin by manipulating the food chain, and using debriefings to cover the main points has not been tested any more than the step by step methodology had been. However, based on this experience, I firmly believe that giving them a reason to need to know certain skills or sparking their interest first is the way to go. We should avoid the monotonous step by step build-up that bores the students and gives them reason to doubt the significance or relevance of learning all of the build-up material.

The full text of this paper as well as the Food Web Curriculum packet is available from the Creative Learning Exchange.

IF YOU HAVE NOT ALREADY SENT IN A QUESTIONNAIRE, PLEASE FILL THIS OUT TO JOIN THE CREATIVE LEARNING EXCHANGE NETWORK.

Name _____ Title _____

School District or Organization _____

Address _____

Street _____ Town _____ State _____ Zip _____

Phone _____ Fax _____ E-mail _____

How did you hear about the use of a systems approach in education? Please be specific. _____

What would your role(s) be in implementing a systems approach:

Teacher (grade and subject)? _____

Administrator? _____

Citizen Advocate (Parent, School Board, etc.)? _____

Have you personally used a systems approach in your classroom, or have you seen a systems approach used in your school or school district? Please be specific. _____

Have you developed any curricula that you would like to share? Would you like help with it? What kind of help? _____

The Creative Learning Exchange has reprints and packets of material to stimulate your thinking in the area of applying System Dynamics and systems thinking to curriculum. Would you like to receive a list of those materials?

Materials appropriate for starting out _____

Materials appropriate for introductory use? _____

Materials appropriate for those with a more detailed knowledge of System Dynamics and/or STELLA _____

Is there any reading material which you have found helpful? _____

Are there other activities or materials that you would like to see the Creative Learning Exchange initiate or distribute? Please be specific. _____

Do you have any ideas or information for me? I would appreciate ideas for the next newsletter as well as references to people who might like to be part of the network. Do you have information for the Up-Dates column? _____

FEEL FRE TO COPY THIS TO SEND IT IN OR GIVE IT TO OTHERS. THANK YOU. I APPRECIATE YOUR TIME! I WILL BE IN TOUCH WITH YOU.

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