the Creative Learning EXCHANGE

Volume 1, Number 2 - Fall 1992

Brattleboro Union High School - A Start Down the Road

In 1984 a number of people had a vision of systems thinking being used in education. A variety of factors came together to make Brattleboro Union High School, Brattleboro, Vermont, a fertile ground for the initial thrust. It had a committed citizen champion in Peter Büttner along with his wife Marianne. It had an excellent teaching staff interested in educational excellence and a supportive administration. It was near the center of system dynamics with the resources of the department at MIT. Lastly it was near Dartmouth and the staff was in contact with those who were developing a user-friendly system dynamics software - STELLA.

Brattleboro was the first, and by being the first, successfully led the way for a national movement which is now evidencing itself throughout the country. The chronology of those early years is interesting and perhaps will give others a flavor of what it took to launch a systems thinking initiative in a school system:

Summer '84- Peter Büttner, David Kreutzer and others met at MIT. Peter was told about the development of STELLA. Meetings were held that summer to discuss the possibility of a network to connect systems thinkers and develop curriculum. The project was titled the Systems Thinking National Education Project.

Fall '84- Science teacher Charlie Butterfield took a one year sabbatical from Brattleboro to take courses at Dartmouth. He came into contact with Barry Richmond and the software he was developing, STELLA, and became excited about system dynamics. The original group plus others had another organizational meeting.

Winter '84-'85- The project tried to get Macs through Apple and were unsuccessful. Another meeting generated the idea of a one-day workshop.

Spring '85- An introductory workshop was held at BUHS. John Sternman and David Kreutzer from MIT were presenters. BUHS faculty, administrators, and students were invited. The assumption was that a one day workshop would provide teachers with sufficient background to begin to develop curriculum. One day proved not to be sufficient.

Summer '85- An introductory course of five days with University of Vermont credit was arranged with High Performance Systems and David Kreutzer collaborating on the course. BUHS faculty, students, board members, educators, and business people attended. David Clarkson, another teacher at Brattleboro, received funding to go to the International System Dynamics Conference.

Fall '85 -A repetition of the introductory systems thinking course was offered. The decision was made to apply for an Excellence in Education grant for teacher release time.

Winter '85- Brattleboro School District funded one Macintosh. Larry Richardson, acting science chairman, applied for Windham Foundation funding for more Macs.

Spring '86-Systems Thinking in Education Project progress meeting.. Windham grant came through with $3,000 for Macintoshes.

Summer '86- Excellence in Education grant materialized in late July. Tony Cline from ETS visited a class by David Kreutzer and through him made contact with the Brattleboro project. Brattleboro Union High School became the charter member of the STACI project.

Fall '86- ETS was instrumental in getting BUHS a lab full of Macs. Chris O'Brien, David Clarkson, Charlie Butterfield and Larry Richardson all started to work on incorporating STELLA into their courses.

Fall '86-'89- During the implementation phase of this project, Charlie Butterfield worked on using STELLA in his chemistry classes; Larry Richardson explored its use in biology; and Chris started in physics. Of these three Chris is the one who has found STELLA compatible with his courses and teaching style.

David Clarkson tried a different approach by creating a course called *Wars and Revolutions.* Among the students who took the course were

Brattleboro continued on page 3

UP-DATES...

George School

The George School, a Friends' High School in Newtown, Pennsylvania, has had teachers working in the systems thinking area for more than two years. Teachers in the science department have been working on units from their curricula which lend themselves to using STELLA models. Each of them is trying to take their classes into the computer lab between 3 and 9 times a year using STELLA to generate interaction with the material in a new and constructive way. They are enthusiastic about the empowerment the students feel from the use of STELLA.

Some of the models they are currently using in the classroom include a predator-prey model, a model of chemical reactions, an island model (relationship of biodiversity vs. size), one model in cellular biology, and a ozone-cfp model. In hydrology, their ninth grade course, many of the students have been introduced to STELLA through a model of an open system vs. a close system and a drain pipe system. They are exploring the possibilities in an elastic collision model and a genetics model.

The chairman of the math department has used STELLA and the computer lab for both his calculus class and his math drop-out class. By utilizing the abilities of the calculus students to help him develop a piece of curriculum, he was then able to use it to teach the students who have a fear of math. A creative and educationally sound use of both the technology and the capabilities of students!!

Once they have recovered from the theft of most of their computers, the teachers hope to be back on track using models throughout their school year.

The systems thinking coordinator at George School is Polly Abdul Jawward.

FROM THE EDITOR. . .

The Creative Learning Exchange is busy these days. I am receiving about ten inquiries a week for materials, both from people who have not contacted me before and from those of you seeking additional materials. I am eagerly awaiting *your* feed-back. Is there a lesson or curriculum you found successful- or not so successful? What insights have your experiences given you? We do not all have to re-invent the wheel. Please be in touch with me so that I can tell others about what is going on with you. By sharing what each of us is doing we can build on collective experience rather than on just our own isolated experience. I look forward to hearing from you.

Lees Stuntz, Editor

Ridgewood Public Schools

Ridgewood New Jersey is a school system in northern New Jersey with six elementary schools, two middle schools, and one high school. About a year and a half ago, the director of MIS, Richard Langheim, and a fourth grade teacher and critical thinking specialist for the district, Tim Lucas, happened upon the *Fifth Discipline* and STELLA at about the same time. It "all came together". They felt that the systems thinking piece was the next most logical sequel to their critical thinking program in the district- the one that pulled it all together.

In the year and a half, they have devised a number of in-service courses to help introduce systems thinking and STELLA to their colleagues. They are having a great deal of luck in the elementary schools and there is some interest being shown at the middle school level. *There will be a more in depth description of what is going on at Ridgewood in the Winter issue of the Exchange.*

STACI^n Project

The Educational Testing Service (ETS) became involved with the Brattleboro project in the summer of 1986. Later they got Apple computer to contribute computers to a consortium of schools in the San Francisco Bay area in February of '87 and STACI^n was born. Early on in the process they realized the importance of giving the teachers their own computers to help them become comfortable with them.

Ellen Mandinach and Tony Cline have headed up this Systems Thinking Project for five years now. For these first five years, the resources have gone into the teachers, helping them become conversant with what systems thinking entails. Now they are ready to start on the assessment phase. They are seeking to discover what organizational impact systems thinking has, what is the impact on the children's learning and what happens as the dynamics of the students with their teacher changes. They are going to involve the teachers in their assessments.

A lot has been invested in the schools involved in the STACI^n program. Many questions can be answered by closely following what is happening in them. *A more in-depth look at what is going on in the STACI^n program will be in future issues of the Exchange. The front page article is on the first STACI^n school- Brattleboro Union High School.*

Brattleboro Union High School - A Start Down the Road

continued from page 1

those who had taken the introductory workshop from MIT and High Performance Systems. Utilizing these students with a background in modeling, the first year of Wars *and Revolutions* was very successful.

Reflections-

Comments gleaned from those involved the Brattleboro project during these three years yielded some interesting insights. Much of what follows in this section is from Peter Büttner's history of the project.

A number of factors seemed to have played a role in the delays and unaccomplished goals of the Brattleboro project. There are content and pedagogical factors which are substantive matters likely to appear at other sites, and administrative and structural factors which may assume a different level of importance at other schools.

Content Factors

- Conflicts were evident between the goal of using the systems thinking and modeling to teach the same subject matter versus the goal of defining and teaching the new learning objectives. Curriculum at the high school level is traditionally focused on discipline-centered facts rather than thinking processes and interdisciplinary integration. The initial efforts of the science teachers were primarily focused on using system dynamics to support the present curriculum., which in turn introduced other problems.

  An exception to this was the *Wars and Revolutions* course which was an elective taught from a system dynamics perspective. One problem was that the modeling skills necessary for the course were not an integral part of it. The students had to acquire them from the science classes or from the guest appearances from MIT experts. When students not conversant with modeling took the course in the second year, this issue came to the fore.
- Causal loop and/or structural diagramming with or without computer simulation was an unresolved conflict. What are the appropriate uses for each method?.

Administrative and Structural Factors

- The lack of teachers from outside the science and math departments appears to have been critical, although not fatal to the project. Without the involvement of English and social studies teachers, the integrative potential of the systems thinking paradigm was only partially explored. Additionally, the erroneous perception that systems thinking and modeling are 'science' and only appropriate for those subjects was not broached substantially.
- Released time for teachers was not sufficient to provide time for creating, planning and additional training in modeling concepts and STELLA. During this period there was lack of time for specific curriculum development either with release time or summer time, causing a delay in implementation which may have helped to create some of the attrition factors in the program at this point.
- The timing of the funding, its delay and then curtailment had a substantial effect on the beginning years of the project. The Excellence in Education grant did not come through in time to use it for the summer of work necessary for a strong start. The cutting of the funds for the program after the first year, even with the ETS support in training at that point, was a depressing factor on the program.

Brattleboro Now

Chris O'Brien, who has been working in the systems thinking project the entire time it has been functioning at Brattleboro, consistently uses STELLA models and modeling concepts as a tool to explore the physical world in his algebra-based physics course. The science department started teaching a concepts-based physics course a couple of years ago at Brattleboro and Chris teaches that also. He did use STELLA as an adjunct in that course last year, but as a control he decided not to use it this year. He is finding that he is missing the rigor which it imposed. He may use STELLA at the end of the year. The exercises he has developed for his courses are cookbook-type exercises which work very well in using STELLA as a tool. He feels it is a whole different story to establish a problem and ask students to solve it with STELLA. However, there are students who take off and can do amazing things with STELLA within a few months.

Two other teachers have joined Chris in the STACI^{n} project at Brattleboro: Jake McDermott and Eric Achenbach. Jake is an earth science and general science teacher. His classes include many students who are difficult to teach. He is working with them using differing techniques to tackle complex problems. He is interested in pursuing the use of games such as SimEarth to help introduce systems thinking to his classes.

Eric comes at systems thinking from the computer end. His niche in the high school is that of computer expert. He has made STELLA part of the beginning programming course and for two years now has offered a course in systems thinking as a one semester

continued on page 4

A System Dynamics Approach to Rabbits

Excerpts from a report of the System Dynamics in Education Project, by Terri Duhon, Massachusetts Institute of Technology,

A System Dynamics Approach to Rabbits is a study of the structure of a rabbit population living in ten acres, introducing S-shaped growth and two related terms; loop dominance and dynamic equilibrium.

The Rabbit System and Its Components

Ten rabbits, five females and five males, are placed within an enclosed ten-acre field, cut off from predators and unable to escape. There are several facts relevant to the study of this system. Ideal living conditions for rabbits are about ten rabbits per acre of land with rabbits living an average of seven years. Every three months, females have a litter of five babies.

We must distinguish the different elements of the rabbit system and then make assumptions about the relationships among the elements. The most obvious elements are the rabbit population, births and deaths.

Population-Births Relationship

The relationship between the rabbit population and the rabbit births is characterized by reinforcement. The rabbit population produces a certain number of babies each year. The new babies are then added to the population and soon they begin to reproduce. The increased population in turn produces a larger number of babies in the next year. Thus, the population reinforces itself, continually, creating a positive feedback loop.

A representation of this positive feedback loop is the model in Fig 1. The three parts of the model are the rabbit population, the births, and the birth fraction. The birth fraction represents the fraction of reproducing rabbits times the number of babies each reproducing rabbit has per year. The number of baby rabbits per year is calculated by multiplying the birth fraction by the rabbit population.

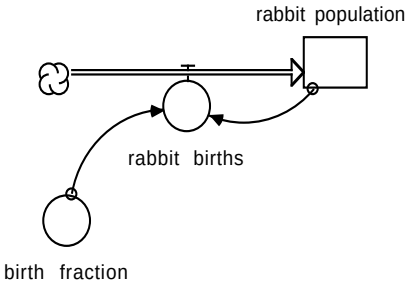

Fig. 1

The rabbit population and the birth rate are connected in a circular arrangement in the model, illustrating the positive feedback loop.

Population-Deaths Relationship

The relationship between rabbit population and rabbit deaths is characterized by decline. Every year a certain number of deaths in the rabbit population occurs, decreasing the population. At the same time as the population decreases, the number of rabbits dying also decreases because there are a smaller amount of rabbits left to die. This is a continual process.

Negative Feedback - Model

A representation of the negative feedback loop is the model in Fig 2. The three parts of the model are the rabbit population, deaths, and average lifetime. The average lifetime is used to calculate the number of deaths in the rabbit system.

The model connects the rabbit population and the deaths in a circle, illustrating the negative feedback loop. This loop works by continually draining the number of deaths from the popu-

Rabbits continued on next page

Brattleboro Union High School - A Start Down the Road

continued from page 3

elective. Last year's course proved to be intensive and exhausting. The students who took it were excited and stimulated but felt that the work it entailed could only be sustained for one semester, especially because the problems they were trying to solve did not have answers. Within the black and whit e world of high school- that was difficult to get adjusted to. The one student who wished to go on, did so in an independent study with Eric.

Chris, Jake and Eric continue to be an integral part of the ongoing STACI^{n} project run by ETS and attend their semi-annual workshops.

Ed. Note: Thanks and appreciation go to Peter Büttner, Chris O'Brien, Tony Cline and Ellen Mandinach for sharing their information and histories with me. A special thanks to Peter and Chris from all of us who care about systems thinking in education for their vision and their persistence.

I have available a number of copies of the two issues of the Brattleboro Bulletin, a newsletter put out by the Systems Thinking National Education Project. They are very interesting reading and informative. Please write and ask if you would like copies sent to you.

A System Dynamics Approach to Rabbits

lation. The deaths are calculated by dividing the population by the average lifetime. When run in isolation, population and deaths eventually reach zero.

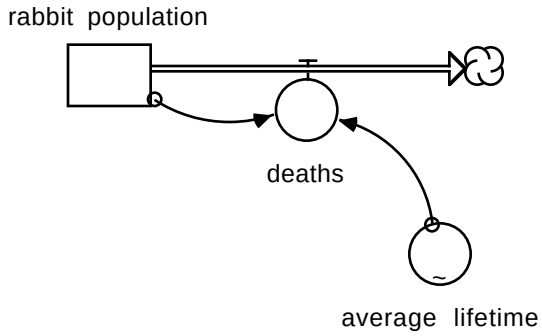

Fig. 2

Loop Dominance and Dynamic Equilibrium

When a positive and negative feedback loop are used together, as shown in Fig 3, the strongest loop is the dominant one. For one loop to be dominant, it must have a greater effect on the population.

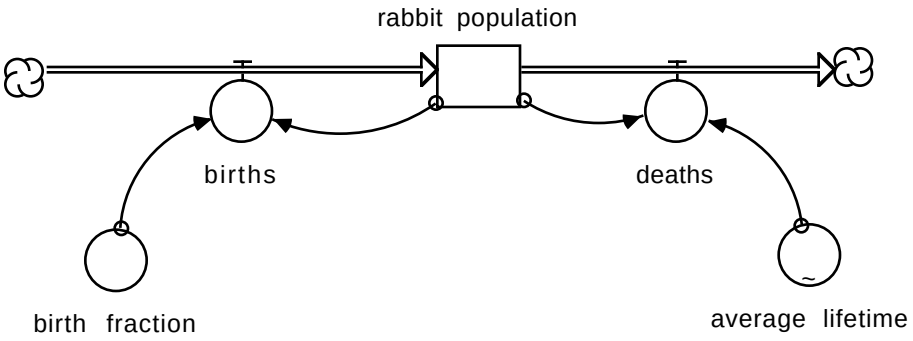

Fig. 3

Positive feedback loop dominance occurs when the rabbit births are greater than the deaths. The population behavior is then exponentially increasing. If, on the other hand, the rabbit deaths are greater than the births, the negative feedback loop dominates. The population behavior is then exponentially decreasing. The population behavior for Fig 3 is similar to the behavior of the loop which dominates.

When the birth rate equals the death rate, neither loop dominates, and the population is in dynamic equilibrium. It is dynamic because the individuals in population continue to change although the number of rabbits remains the same.

The Missing Element

Initially the system had ten rabbits living in ten acres. But, with the present model of the system, there would eventually be more rabbits in the ten acres of land than is possible.

The model has left out a major element in the rabbit system: the limited area given to the rabbits. This element will affect the number of rabbits in the system.

The Effect of the Limited Area

Ideal living conditions for rabbits are ten rabbits per acre. Under these conditions rabbits live for an average of seven years. When crowding begins to occur, the average lifetime begins to decrease. There is not enough food per rabbit to keep each rabbit healthy. Some die of starvation, while others are more susceptible to disease. From the close living conditions, disease is spread more easily. Many baby rabbits are stillborn, and others are born sick and don't live long enough to reproduce.

The limited area does not actually directly affect the average lifetime of the rabbits. It is the density of rabbits per area, that causes the change. Above ten rabbits per acre, the higher the density , the lower the average lifetime; the average lifetime decreases, and the number of deaths increase. As the population decreases there is a decrease in density. If the density is still above ten rabbits per acre, the effect of the limited area is still evident. Now the average lifetime is not as low because the density is not as high. Therefore, the number of deaths is not as high because the average lifetime has increased, and the population is smaller. As density continues to decrease, this process continues until the density is

Rabbits continued on page 6

A System Dynamics Approach to Rabbits

continued from page 5

below ten rabbits per acre. At this point, the density no longer affects the average lifetime and the average lifetime again becomes seven years.

The loops described above are modeled in Fig 3. The density and the area are two new elements which help to create a second negative feedback loop. The constant in this model is the area. It limits the number of rabbits that can live in the system. When the density is below ten rabbits per acre the average lifetime is a constant.

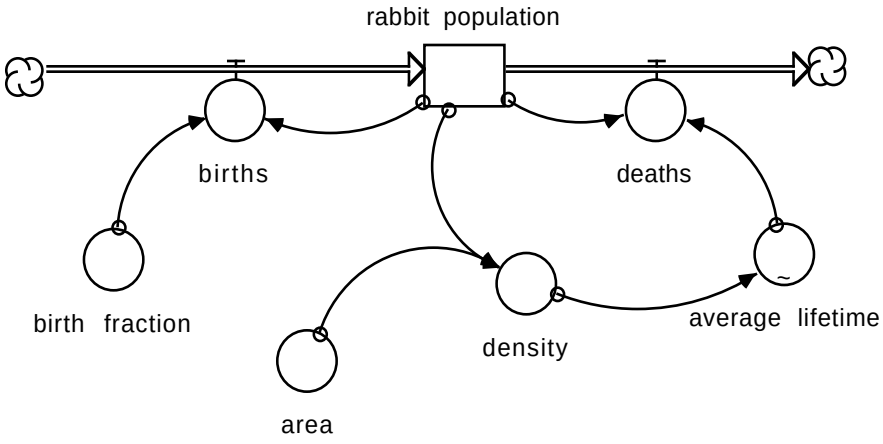

Fig. 4

Entire Model

Combining all of the loops that have been discussed, we can create a complete model of the rabbit system. We know the population behavior of each isolated loop for our system. Using loop dominance, we should be able to determine the population behavior for the combination of all three loops.

When a model was first created for the rabbit system, the illustrated behavior was not possible within the given ten acres. It was discovered that the limited area, an essential element in the rabbit system, had been overlooked.

The final model created is not an exact replication of reality. The relationships among the elements had to be assumed, and average numbers had to be used. They come as close to reality as possible, given the level of complexity.

A complete copy of this paper is available through the Creative Learning Exchange, 1 Keefe Road, Acton, MA 01720.

INTERESTED IN INVESTING?

All of us are interested in promoting the use of systems education in our schools. A number of you have asked if there is a charge for the services of the Creative Learning Exchange, or what you can send to help defray the costs of printing and mailing to you.

The Creative Learning Exchange will continue to send out materials free of charge to all those on the mailing list, regardless of their desire to invest at this time. However, 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 $25 is a reasonable amount for a year. All contributions are tax-deductible.

I am sending _____ to *Trust in Diversity* to help invest in the future of systems education .

Name_____

Address_____

Thank you!!

The Creative Learning Exchange
1 Keefe Road
Acton, MA 01720
Phone (508) 287-0070 Fax (508) 287-0080

The Creative Learning Exchange is set up as a project of *Trust in Diversity*, a trust devoted to encouraging exchanges to help people to learn through discovery. *Trust in Diversity* is a non-profit educational institution and all contributions to it are tax-deductible.