the Creative Learning EXCHANGE

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A CONNECTED VIEW OF HISTORY

Leslie Skillings, Jr.

About fifteen years ago I was asked by my social studies department at Baldwin High School to teach World History. As a result of this request, I have created, over the years, a very different and very interesting course that I call, ***A Connected View of History***. The teaching strategies in the course are founded on brain and cognitive learning theories in their approach to the student. These strategies, plus the structure of the course, help the student make mental connections between the past, present and future. The course is structured **topically** rather than the typical **chronological approach** found in most history courses. I made this shift in approach early-on because it became clear the first time I tried to "cover" world history in a year that it was not possible to do so and also do justice to the students or the course content. I decided to cover less but in greater depth. Early in this evolutionary journey one of my students asked me, "Why do I have to learn this stuff? What's it good for?" These questions got me to ask additional questions about the structure of the course and the textbook. It was clear, to me, my students were not going to become little historians as a result of this course. Then, I asked myself, what would they need to become successful in the world that they were about to inherit? Critical systemic thinking skills was my answer. ***A Connected View of History***, I think, challenges students to think critically and systemically about the present and future through the vehicle of study of the past.

Time-Space Relationships

After those initial discussions about class rules and grading (or "sorting" as Alfie Kohn calls it), I ask the students to write a short essay on whether or not the course should be called **History** or **Herstory.** This helps me assess how well my students write and defend a point of view. The best answers over the years have argued for **Ourstory**. Of course the story is larger than just the human story; it's a story of relationships between themselves and the environment in which they find themselves embedded.

My **Large Numbers** activity helps students think about very large numbers such as a million, billion and trillion through a number of exercises. (e.g., calculating your age in seconds. High school juniors are just over 1/2 billion seconds old. How many years would it take to pay-off the national debt at a dollar a second?)

I use the **Washington Monument** and a **US. Postage stamp** in a spatial relationship that compares the known distances of the monument (555') and the thickness of the stamp to the time in each of three epochs of history:

***History** continued on page 5*

Using System Dynamics to Enhance the Learning Potential of Dyslexics

James Rieley, Chris Soderquist, and Melissa Rieley

Using systems thinking theories, concepts, and tools is valuable not only for exploring the dynamics of business, social, and environmental issues, it can be used effectively by individuals to explore some of their everyday concerns. For example, a parent of a dyslexic child can use systems thinking to deepen their understanding of what their child is going through, and become better able to communicate the child's experience with others, especially teachers. This can be critical if the child is to be able to optimize their learning experience in a traditional school environment.

Dyslexia represents a basic linguistic deficit in the integration, execution, and learning of language functions that are required to carry out the primary skills of reading and spelling words, and doing mathematical computations. In some cases, there are deficits in thinking, talking, reading and writing by way of "sentence units," as well as attaining the intended comprehension that these sentences represent. These deficits set up a critical tension that is structural in nature.

In the education system in this country, there are systemic structures

***Dyslexia** continued on page 4*

Updates. . .

Carlisle Public School

How can we take what we are already doing and make it better? That, says Alan Ticotsky, is his job as systems thinking mentor. Throughout the year, Ticotsky will spend time in every elementary classroom teaching lessons to students and teachers, applying the concepts and tools of systems thinking to our curriculum.

In grades 1 and 2 they played the Friendship Game. In a "pretend" game, friendship spreads as one friend becomes two, then four, then eight, and so on. It is a very rich lesson for kids: If you're a friend and you make friends, it can grow. This idea fits into our Open Circle curriculum, but acting out a model of the behavior makes it easier to understand. Also, even little kids can begin to grasp the concept of exponential growth.

In grade 3, students study the water cycle. "This is a perfect place for systems lessons," says Mr. Ticotsky. Students look at a causal loop diagram of the big picture, but they also look at the parts to see how they fit together. They discuss how changes in one part of the system affect the whole system. When students do their experiments with evaporation, they use behavior-over-time graphs to record and predict water levels. They also use stock and flow diagrams to explain how the water level in a pond depends on the streams flowing into and out of the pond.

Fourth graders will use systems tools to explore plot and character development in the novel *Maniac McGee*. Graphing helps students read more thoughtfully and express their ideas more precisely. It is always fun to see the variety in how kids interpret what they read. The discussions are lively. This is really fun for the kids," says Mr. Ticotsky, "and for me!"

In the Middle School, students in Sara Bysshe's seventh grade science class use a STELLA computer model of yeast population dynamics to really understand a classroom lab experiment. First, the students culture yeast cells at room temperature. They examine the cells under a microscope and carefully record their data as the yeast population grows and finally collapses when the food runs out in three days.

Then they go further. Applying what they have learned about cell growth, the students predict precisely what happens at other temperatures, as you approach boiling or freezing, for example. In teams, students make their predictions on behavior-over-time graphs; then they run the simulation to test their assumptions, explaining any discrepancies. "We could never try other temperatures in our own little lab, but with the model, students can manipulate the variables until they really understand," says Ms. Bysshe.

Updates *continued on page 10*

From the Editor . . .

Happy New Year! The conference is building momentum now as the program becomes more definite. This is our main focus for the first half of this new year, a year we hope will be one of joys, successes, and growth for all of you. To that end, if there is anything we at the CLE can do, please get in touch.

Lees Stuntz *(stuntzln@tiac.net)*

New Materials Now Available from the CLE or the Web Site

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

SYSTEMS EDUCATION

DYSLEXJR ***Using System Dynamics to Enhance the Learning Potential of Dyslexics.*** James and Melissa Rieley and Chris Soderquist

Co-authored by a dyslexic high shcool student, this paper is a discussion of how systems thinking can help deepen the understanding of—and help explain the experiences of—students with dyslexia. [Systems Education, K-Adult] (50¢)

SOCIAL STUDIES

CONNECLS ***A Connected View of History.*** Leslie Skillings, Jr.

A description of the World History course and teaching strategies the author created for his students at Baldwin High School in Wailuku, Hawaii. [Social Studies, Implementation, High School] (50¢)

INTRODUCING SYSTEM DYNAMICS INTO THE TRADITIONAL SECONDARY CURRICULUM: THE CC-STADUS PROJECT'S SEARCH FOR LEVERAGE POINTS

Diana M. Fisher and Ron Zaraza

Teachers are among the most "conservative" professionals. While they may be extremely creative in their classrooms, and tremendous risk-takers in the way they work with students, they remain staunchly conservative and protective of their subject matter. Tradition has defined what the appropriate content is in a Global Studies class, a Literature class, or an Algebra class. Any changes in instruction that threaten a teacher's ability to present the great bulk of material they feel they must cover will be met with resistance. Every change in education is met by the question "How can I add . . . when I'm already having a hard time covering the syllabus?"

Attempts to bring systems thinking and system dynamics into the K-12 classroom have faced the same problem. Teachers are pressed for time and skeptical about changes that may appear to add new topics to an already full curriculum. When such new ideas are outside their own professional content expertise, they are nervous about their own mastery of the material as well. Traditionally, educational innovations have emphasized positive change in outcomes: Students will learn better/faster/more. Yet most educational innovations, even though less "foreign" than the introduction of systems concepts, are only slowly and often incompletely implemented. Better/faster/more simply isn't enough to insure acceptance. Successful integration of systems concepts into the curriculum will suffer a similar fate unless the unique capabilities of systems work can be made obvious. While systems thinking and dynamics can help students learn content better/faster/more, the truly impressive advantage of systems work is the way it allows students to ask better and more important questions. That results in learning through "conversations", through thoughtful involvement of students. The opportunity to experience such learning is a powerful force in convincing teachers to begin to use systems. However, the initial entry into the use of systems remains a stumbling block.

During the four years the CC–STADUS (Cross-Curricular Systems Thinking and Dynamics Using STELLA) Project has trained teachers in the development of models and curriculum for K-12 classroom use, the more than 160 participants have gained a wealth of experience in how system dynamics can be introduced to students in both single discipline and cross-curricular environments. It has become clear that single-subject use is the easiest way to introduce systems ideas to both teachers and students. Further, it is clear that there are certain natural "entry points" into the traditional courses.

Each subject includes topics that are natural systems topics. Those topics constitute leverage points, topics that clearly show the potential of dynamic modeling. Introduction of dynamic models at those points opens up both the discipline and system dynamics for student inquiry. The advantages of dynamic models in addressing the topics are dramatic and obvious. Thus, those topics should be emphasized in training of teachers as they begin to use system dynamics. The power of these basic models presents a compelling argument for the introduction of systems into courses. Too often complex and detailed models are presented to novices as an example of the power of dynamic modeling to build knowledge. Those complex models are often intimidating and tend to obscure the real power of dynamic modeling: Even simple models can have a major impact on student learning. These simple but powerful models provide the real leverage that can attract teachers to modeling.

Within the sciences, each field has distinct topics that can be used to introduce system dynamics. Two approaches are being used by CC–STADUS teachers in physics. The first focuses on the basic mathematical definitions of the concepts of motion. Physics has often been referred to as "the study of rates". The language used to describe flows in systems is identical to that used in defining basic concepts of motion. The ideas of position, rate of change of position (velocity), and rate of change of velocity (acceleration) can be easily developed through simple models. These models provide exposure to two of the four basic model structures, linear and quadratic, that CC–STADUS training focuses on. Dynamic models provide a visual reinforcement of the concepts normally introduced algebraically. These models may then be expanded to deal with all the other basic concepts of motion.

The alternative physics approach utilizes models illustrating the concepts of impulse, momentum, and the conservation laws. Effectively, these models introduce physics through Newton's laws of motion. The emphasis is less on developing models that are analogues of mathematical relationships and more on physical concepts. This allows an alternative approach to developing physics in secondary schools, one usually restricted to college students with advanced mathematical training.

Integration *continued on page 8*

The Learning Potential of Dyslexics, continued from page 1

in place that manifest themselves in the need to "complete the book" by the end of the semester or school year. This implied need to "keep the class moving" can set up a tension between the school "need," and the learning needs of a dyslexic child. Teachers and the methods that they use are not at fault in most cases, it is the "teaching system" that generates the tension. As we have learned from the structural tension models put forth by Robert Fritz (Corporate Tides, Berrett-Koehler, 1996), tension seeks resolution. In figure 1, this can be seen.

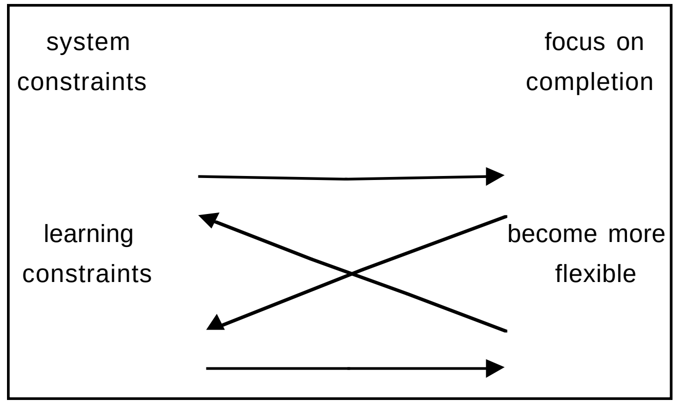

Figure 1

As the tension that is set up by educational system constraints increases, the resolution is found in focusing the classroom experience on completing the material on a specific timeline. As the tension that is set up by a dyslexic's learning constraints increases, the resolution is found in having the educational experience become more flexible. However, the more flexible the educational experience becomes, the more it increases the tension of the system—and the more the educational experience focuses on completion, the more the tension of learning constraints increases. Unfortunately, there is no way to resolve structural tension, and in this case scenario, it is the dyslexic's need for flexibility in learning that is usually overrun by the system.

The dynamic relationships of this interaction can be seen in figure 2. As dyslexics have unsuccessful learning experiences, their level of frustration increases, which has a negative effect on learning itself. By creating flexibility in the educational system, people suffering from dyslexia have a better opportunity to realize their potential. To help illuminate the learning tension that is experienced by dyslexics, system dynamics modeling tools can be used.

Dyslexia results in frustration felt by the student who requires flexibility in teaching formats. By developing a system dynamics model, we can better understand the tension between the two needs and see the effect of increasing the flexibility in teaching methods as it relates to the level of learning in a dyslexic.

Applying systems thinking to this problem requires a systems thinking paradigm. How does this process work operationally? In the upper left-hand corner of the model, one can see the operational definition of how dyslexia (and likely other learning disabilities) impacts learning. The inflow of information is written as a flow. Each of us receives information in a variety of ways. This information needs to be processed. A stock represents the information to be processed. We can either process it correctly (get

Dyslexia *continued on page 11*

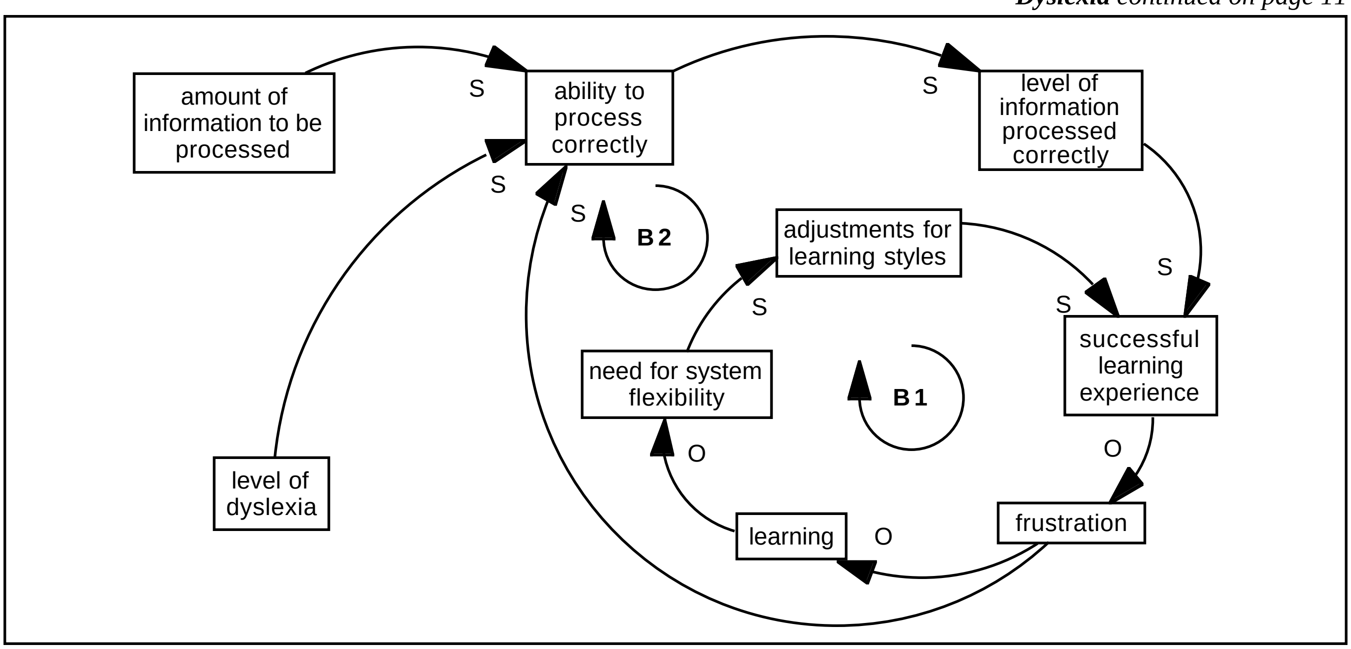

Figure 2

A Connected View of History, continued from page 1

the Hunter/Gatherer Epoch, the Agricultural Revolution, and the Industrial Revolution. The height of the monument corresponds to the time of the Hunter/Gatherer Epoch. The thickness of the paper in the stamp perfectly balanced on the pentacle of the monument represents the 8-10,000 years of the Agricultural Revolution. The thickness of the ink on the face of the stamp represents the time of the Industrial Revolution—the epoch we in the United States just left. A majority of jobs in this country are no longer found in manufacturing. Presently, only 17% of jobs in the United States are in manufacturing. This is expected to drop to 2% by 2025. We have become a service/information society.

Can't you just picture in your mind that stamp perched at the top of the Washington Monument on a windless day? When you use this activity with students, have fun with it. The more dramatic the better. These three epochs will be looked at in greater detail in the remainder of the course.

To place the Washington Monument/postage stamp into perspective, I use a section of Wes Jackson's *New Roots for Agriculture,* and have my students create two calendars to represent all of the earth's five billion year history. The first calendar covers all of earth's history represented by a calendar year with the student's name, date and period in the block that would have been for December, which I have my students put on the back of the 8 1/2 x 11 sheet. December is full of entries and needs more space to write things taken from the selection I call **The Long View of History**. I have the students locate the monument on their calendar. As it turns out, that's around December 11. Oil as a fossil fuel only appears in the last six seconds before midnight on December 31. This activity serves as a reality check for the students while helping them gain perspective on their place in the cosmos.

The final activity in this unit deals with map distortions. The Mercator Projection is the most common map projection used in education and also one of the most distorted. As Korzybski said, "The map is not the territory." The maps we use shape our view of the world and the Mercator projection gives us a very distorted view of our world.

Buckminster Fuller's Dymaxion Projection, on the other hand, is the most accurate map projection, because it holds all distortion uniform throughout. I have my classes first locate twenty-five places on a Mercator projection map and then the same twenty-five places on a Dymaxion projection map. They find the second projection strange at first.

After they complete the two maps, I have them break into groups of two or three and then they play with a Dymaxion projection wood puzzle of the world. I ask the groups to first make a land view, then a water view of the world and finally a southern hemisphere view of the world with the puzzle. This is fun, hands-on and it challenges the student to think about his/her world in very different ways.

Note: These and other materials can be obtained from the Buckminster Fuller Institute, 2040 Alameda Padre Serra, Suite 224, Santa Barbara, CA 93103.

Hunter/Gatherers (H/G)

If we move beyond the noise of names, dates, and places in the traditional historical approaches, there is an underlying basic structural lesson we can learn from modern hunter/gatherers like the !Kung of the Kalahari Desert. The question we need to ask and answer is how were H/G societies successful for hundreds and hundreds of thousands of years. Our study of the !Kung and other such groups have shown that **sharing** of food along kinship lines was/is a survival strategy for long-term success. These non-violent egalitarian people lived in harmony with each other and their environment.

To model these groups students could use a simple teeter-totter in balance with the H/G on one end and the environment on the other. The model could then be extended to the Agricultural Revolution as sedentary people begin to shift the balance in their favor and to the detriment of the environment. Agriculture changes polycultures of the H/G into monocultures (e.g., cereal crops) for the use of humans and their domesticated animals. As birth spacing between children from the H/G epoch dropped from 4-5 years to 18 months for sedentary societies, sedentary population growth took off. The world's population at the dawn of agriculture is estimated to have been 4 million. The world population would not reach its first billion until 1850, and is presently just under 6 billion, with the addition of over 90 million per year.

The Industrial Revolution, when coupled with agriculture to create agribusiness, lifted natural limits through the use of chemical fertilizers, pesticides, herbicides, fossil fuels, water pumps and machinery. The singular focus of this approach was extremely successful in the short-term, not sustainable in the long-term, and blind to the environmental damage that this success brought, while allowing world population to skyrocket to present levels, with doubling times for world populations as brief as 35-40 years. The teeter-totter was totally shifted for the use and benefit of industrial populations. Globalization opens the third world's resources even further for the benefit of industrial population and to the detriment of the populations and environments of third world countries.

I was taught, as I assume most of you reading this were, that human

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A Connected View of History, continued from page 5

history was one steady climb from the hunter/gatherers' abyss via the agricultural and industrial revolutions to the present. The time-arrow ↗ was moving up and to the right. Recent work in a new field called **paleopathology** has brought this traditional view into question. I set my students up at this point. I first ask them to write a brief essay defending the move to agriculture as **a step forward** or **a step backward** for humankind. I follow this with a quick hypothesis assignment where they are asked to list the physical evidence they would expect to find to support agriculture as a step forward or backward. They bite on this hook, line and sinker. A typical hypothesis goes something like this: I would expect to find that early farmers **lived longer, had better teeth, were taller and showed no dietary deficiencies that would be manifested in the skeleton.** As it turns out paleopathology has shown that early farmers lost a full foot in height, and lived shorter lives than typical hunter/gatherers found in the same areas and around the same time periods. Early farmers showed poorer teeth, chronic malnutrition and vitamin deficiencies related to a high starch, low protein diet. The skeletons of early farmers also showed the effects of heavy stress on their skeletons related to the workload of farming. The evidence also points to sexism, class distinctions and the origins of organized warfare. This shakes students' biases to the core. (*See Jared Diamond's article "The Worst Mistake in the History of the Human Race" in Discover, (1987): pp. 64-66.) Also, SUNY has published books in this field.)*

I move from this "good news" on to a study of agriculture in the past, present and future. At a deeper level, the student will look at **land degradation** resulting from agricultural practices we can still find in use today. These practices result in lowering the fertility of the soil by wind and water erosion, water logging, salting, silting and desertification. It should be remembered here that the fastest growing land classification in the world is the formation of deserts. One of the screen savers I use on my computer over the three televisions in my classroom is: "Forests Precede Civilizations; Deserts Follow Them." As we look around the world today the dominate model of farming, grazing and forestry is degrading soils and replacing them with deserts.

In the futures portion of this unit, I look at alternative practices to the traditional agribusiness approach (e.g., Fukuoka's One Straw Revolution, Bill Mollison's Permaculture, and other environmentally friendly approaches). This must be done or the course gets too negative.

The course also traces the history of metals using a video series called: ***Out of the Fiery Furnace***. Smelting metal required early peoples to have the ability to amass high temperatures over long periods of time. Metals technology probably was an outgrowth of pottery making and they both were responsible for **deforestation** in the areas where they were practiced. Metals technology was chosen as a gauge of technological sophistication of a given society in time/space.

Near the beginning of the course I introduce and set the due dates for a ten page paper called **The Next Sixty-five Years of Your Life.** The purpose of this paper is to help students make the connection between decisions we are making as a society now, and the future impacts those individual and group decisions will have on them. The paper can also serve as a draft plan for students—where they are going, and what it will take for them to get there. The final draft of this paper is due around May 1.

With the recent interest in AIDS, I replaced the unit on warfare with a **History of Disease.** In this topical format it is easy to add, replace, or change materials presented in the class. It's also helpful if you're not teaching to pass standardized tests. I tell my administrators I don't have standardized students so why should I give them standardized tests?

Clive Ponting in his ***Green History of the World*** has an excellent chapter eleven, "The Changing Face of Death," which ties the domestication of animals and their diseases to the many common diseases found in human populations. Jared Diamond's Columbus celebration article in October, 1992, Discover, pages 64-73, "The Arrow of Disease," explains why the old world gave its diseases to the new and where the old world got them from in the first place. To teach this unit you must have these two articles. It's not hard to find articles about new drug resistant diseases or new diseases. The popular press has been full of these in recent years. This would be a good assignment—for the students to bring in an article from the web or print media on disease.

My new addition to this unit is the **Epidemic Game** simulation. Thanks to the Systems Group at MIT and their Road Maps, I get to play the simulation game with all my history classes and kill them off. I'm the game master (say that very carefully in front of high school students because they hear something very different) and I'm the only one alive at the end of the game. The students love this simulation game. This is a good unit to lengthen if the student interest is there.

The final unit of the course is called: **World Views: Different Paradigms Through Time.** We assume that people in the past and present look(ed) and thought about the world they live(d) in pretty much the same as we do. Wrong! The goal of this unit is to help the students understand their own view of the world by looking at different people's views over time. Also, im-

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Systems Thinking and System Dynamics in K-12 Education

A study supported by The Waters Foundation—School Year 95-96—by Mary Scheetz

The Spring 1997 issue of the Creative Learning Exchange newsletter featured Mary Scheetz's study of twelve school districts around the country which are integrating systems thinking and system dynamics into their programs. In that issue (Volume 6, Number 2) we included the summary from the Carlisle, MA, Public Schools. Our Late Fall 1997 issue (Volume 6, Number 4) held the summary from the Harvard, MA, Public Schools. Following is the summary from the Lawton Elementary School, in Ann Arbor, Michigan.

LAWTON ELEMENTARY SCHOOL
Ann Arbor, MI

Setting

The Ann Arbor Public School District encompasses a 125 square mile area, serving the City of Ann Arbor and all or parts of eight surrounding townships. It is ethnically and economically diverse. The school district runs one preschool, 20 elementary schools, 5 middle schools, 2 comprehensive high schools and 2 alternative high schools, and serves a student enrollment of 15,275. Lawton School is the largest elementary school in Ann Arbor with an enrollment of 530 students. Its ethnic and economic diversity parallel that of the school district as a whole.

School Mission Statement

The Lawton School Community believes that all students are unique, valuable and able to learn. Toward that end, the staff, parents, and students of Lawton School, in cooperation with the community, are committed to offering learning opportunities which will enhance each student's ability to be self-assured, to participate effectively in a democratic society, to be creative problem solvers and life-long learners. We will accept as evidence of the accomplishment of these goals, academic test scores, the level of student participation in meaningful activities, and the stated opinions of Lawton families and staff that these goals are being achieved.

Goals/Philosophy Of Project

The primary goal of this project is to utilize the tools and concepts of systems thinking and system dynamics to improve instruction and learning for all students with special attention being given to developing elementary applications. Learning and improvements at the organizational level are also goals of the project and are addressed through additional applications of the tools and concepts of systems thinking and system dynamics in decision making, problem solving and planning situations.

History Of Project

During the 1990-91 school year, a group of administrators within the Ann Arbor Public Schools began meeting informally to share ideas and discuss implications for systems thinking and organizational learning in the Ann Arbor district. Participants were quick to identify the parallels between the business applications and their own experiences in schools. They were convinced that the concepts of organizational learning and systems thinking had great potential for the improvement of their organization and the learning of students.

Writing to MIT's Center for Organizational Learning resulted in the group being directed to Orange Grove Middle School in Tucson, AZ. In the spring of 1991, the Superintendent of Schools, an elementary school principal, and two external consultants made a visit to Orange Grove. During that visit it became obvious that figuring out "what Orange Grove was doing" would take a serious investment of time and energy, so the idea of an extended visit was explored. A mini-sabbatical was arranged for the elementary principal in the fall of the 1991-92 school year.

The month of October, 1991, was spent at Orange Grove, observing, reviewing written documents, talking with the Waters Grant Project staff, learning about evolving organizational structures, and building relationships for future work. Later that year, arrangements were made for representatives of High Performance Systems, Dartmouth, NH, to come to Ann Arbor to train several groups of teachers, administrators, Board Members, and business leaders in basic systems thinking concepts. A smaller subset of people was trained to use STELLA. This group continued to meet on a regular basis throughout the 92-93 school year. Several simulations were developed as a result of this work and were piloted at Angell Elementary School. While very labor intensive, the initial experience convinced all involved that systems thinking simulations were an appropriate instructional tool to use with upper elementary aged students (grades 3-5).

The initial training was followed up with several overview presentations on basic systems thinking and organizational learning concepts for other audiences within the school district. These extended across the instructional and business services divisions. Everywhere the concepts were shared, people expressed a strong level of interest in the ways in which these tools could strengthen instructional and organizational effectiveness. The unspoken assumption at that time was, if people were interested in the concepts, they would work to apply them in their own work, and in the work of their departments or buildings. Several building level administrators attempted to do this. Concurrent with the curriculum work, School Improvement Teams were working to apply systems thinking con-

***Ann Arbor Schools** continued on page 9*

CC-STADUS's Search for Leverage Points, continued from page 3

Grant participants have developed a broad physics curriculum around both types of models. The graphical representation of concepts provides an alternative approach to developing an understanding of basic physics. That, however, does not provide a compelling reason for using systems in physics. These models do, however, provide a good base for models that deal with real problems of interest to students but not normally addressed because they cannot be solved using the traditional mathematical tools at their disposal. Non-constant accelerations (their car!), motion with air resistance (sky diving), and non–constant mass problems (the flight of a rocket) are all problems that students ask about. The ability to discuss these and similar problems provides the motivation or leverage which convinces teachers to bring systems into physics. Once these mechanics/kinematics models have been used, expansion to electricity, magnetism, and radioactive decay becomes obvious and simple.

Biology presents its own obvious starting points. Regardless of the course emphasis, almost all secondary biology courses deal with population growth and ecology. Both are excellent leverage points. Traditional study of these topics has been qualitative. Dynamic models provide a way to include quantitative work as well. The study of the reproduction of micro-organisms allows the introduction of the concept of exponential growth. Simple exponential growth models allow students to explore a wealth of problems discussed in biology. As their experience grows, students or teachers add complexity, placing different controlling factors in the model. They may also link models that affect each other. This opens up the possibility of exploring ecosystems. Using simple models focusing on a single organism and its food supply (an herbivore and the plants it eats) or a simple predator–prey model (wolf-moose), students can explore the relationship by changing rates, variables, and population sizes. Ultimately students begin to understand the concept of a biological system from experimentation with models.

It is the quantitative nature of this work, as well as the opportunity to experiment, that provides the motivation for biology teachers to begin using models. Discussion of exponential growth is compelling when graphs and tables can be easily generated. The structure of an exponential growth model provides insight to the process, facilitating understanding. The reality that there are limits to growth can be easily seen working with models. Understanding why and how those limits apply can be explored with models. They move discussions from the "hand–waving" to the real, because the variables can be manipulated. As the models are expanded and linked, students can truly explore and experiment with the interactions of an ecosystem, something simply not possible without dynamic modeling. For many biology teachers, that capability alone provides sufficient motivation to begin using systems in their classes.

Chemistry has presented more of a problem. The field seems ideally suited for dynamic models, with the same emphasis on rates seen in physics. However, successful models have been few. While some models have been attempted, most are either too complex for easy student use or too narrow in their focus. For some models, particularly reaction rate models, accurate data is virtually unobtainable. The only models that have seen substantial use have been heat flow models. While thermodynamics is certainly an important part of chemistry, thermodynamics models are not strong motivators, do not provide the leverage needed to broadly attract chemistry teachers. The true leverage point in this discipline would almost certainly be accurate, easily understood reaction rate and equilibrium models. Until such models become available, use in chemistry will remain limited.

The Social Sciences are an area where a large amount of successful work has been done using dynamic models. Introductory work is often based on the same type of exponential growth/population models used in Biology. Often focused on comparisons between industrial and third-world nations, these basic models dramatically present information. Many teachers have become interested in using models in their classes simply through exposure to these models. These low-complexity models provide all the leverage needed to motivate use. These simple models provide a basis for discussion that can evolve into very detailed and sophisticated concepts, even with no further modeling. When the initial systems can be changed to include linked systems and the many modifiers on systems, including impact of disease, wars, emigration and immigration, a depth of understanding of the system can be developed that goes far beyond traditional classroom experience. The possibility of such work, based on simple models, makes social science teachers eager to use models.

Like physics, much work in mathematics focuses on rates. Concepts from slope through the second derivative can be easily described by the rates used in systems models. An entry point for models in mathematics is the use of a motion detector in conjunction with dynamic models of motion. The motion detector can be used to produce a graphical and a conceptual view of functions from their rates of change. A model can be introduced to generate the same patterns. The structure of the model gives clues to the pattern's causes. The models then allow students to explore problems and applications that involve the functions. This allows

Leverage Points *continued on page 10*

Summaries of ST/SD Projects in K-12, continued from page 7

cepts in planning and decision making efforts. In addition, a variety of individual efforts were underway to use organizational learning concepts within staff and department level groups.

In the spring of 1994, the Superintendent of Schools left the Ann Arbor district. A strong source of encouragement for the potential of systems thinking/organizational learning concepts and commitment to a continuation of the related staff development activities on a wide scale was lost. A transition period to develop the support of the new administration was necessary.

A small group of teachers and principals representing about four out of the twenty elementary schools in Ann Arbor have continued to work on developing applications useful to their settings. Representatives of this group have participated in each of the annual systems thinking conferences for educators and have met on a monthly basis in an informal study group. The greatest concentration of efforts has taken place at Angell School (during the 1990-1994 time frame) and Lawton School (during the 1994-1996 time frame). Work has been motivated by experience with elementary aged students leading to a belief that young children are capable of the kind of thinking necessary to understand key systems thinking concepts such as interconnectedness, circular causality, and behavior over time.

During the 95-96 school year, a renewed sense of excitement about the potential for improved effectiveness through meaningful application of systems thinking and organizational learning tools has occurred. Several key events spurred this interest and energy. They include support from The Waters Foundation and workshops for administrators and teachers. While most of the classroom applications are occuring at Lawton School at this point, organizational applications are occuring in a variety of settings, including applications to a district-wide special education/general education restructuring effort. Plans for the coming school year are to continue the work currently in progress—to work with volunteer teachers to develop helpful curricular applications of systems thinking tools and to use systems thinking and organizational learning tools as appropriate in building level planning and learning processes.

Quotations from Project Participants

Notable Results

• "We are still at a very early stage in implementing these applications, so our results are very limited. At this point our experience has been limited to use of several computer simulations and behavior-over-time graphs. We have used these with various groups of students in second through fifth grades. Each group has been heterogeneous in terms of academic performance. What has struck me in each situation is the high interest level of all of the students, their ease in use of the tools, and their facility in making logical interpretative remarks relevant to the experience at hand."

• "Because these tools are new to everyone involved, a true sense of inquiry is present in a way that differs from most other "learning activities" at school. I have seen students remain highly engaged for longer periods of time than in other activities."

• " We are also at a relatively early stage in implementing organizational applications; however use of simple tools such as stock/flow diagrams has made thinking explicit in a way that has allowed us to surface and begin to deal with critical issues that had been bogging us down without ever being named. A much wider group of people are becoming verbal participants in staff meetings. I also believe that the same sense of real learning that is observable in classroom settings through use of "new" tools is also present in staff meetings and other organizational meetings where the new tools are used."

Individual Learning

• "If we are all born natural systems thinkers, as many are fond of saying, wouldn't it make sense to support and nurture that kind of thinking from the earliest ages, as opposed to saving it for middle and high school?"

• "Young children can understand concepts of systems thinking. They enjoy building meaning from use of systems thinking tools."

• "Systems thinking tools can help groups make their thinking more explicit and thus surface hidden issues. Without surfacing these issues we cannot have an accurate picture of our system. When we make plans with inaccurate pictures, we are almost certainly doomed to ineffective efforts."

• "To develop the capacity to create fundamental changes at the classroom, school, and/or district level, several kinds of support are critical:

a. Ongoing staff development—From my experience this should include regular opportunities to work with people learning the same concepts; periodic opportunities to network with people working on similar initiatives in different school/school districts; and periodic consultation and/or mentoring from those with greater experience or expertise.

b. Easy access to tools such as computer software, telecommunications, books, etc."

Challenges

• "The challenges were of two types: financial and emotional. As a building

Ann Arbor Schools *continued on page 12*

A Connected View of History, continued from page 6

plied in this unit and the rest of the course is the appropriateness of their view since history is really the study, as one archeologist puts it so beautifully, of "the people that blew it—the losers, if you will." History is the study of failure at least at a very basic level. It's fair to ask, what didn't these earlier civilizations see that lead to their downfall? Systems Theory teaches us that a system gives us warning signals before it fails. Did they ignore the warning signs? Is Global Warming a warning signal for us? In a very small unreadable book, ***Survival of the Wisest,*** Johnas Sauk many years ago proposed a simple thesis that those things that lead to a society's success on the way up ➚ would lead to its failure on the way down ➘. I think he was saying we fail to appreciate just how our success alters our reality, and because we fail to see this we keep doing what made us successful in the past, even when the reality has changed.

The Future History term paper, final course matrix, course evaluations and reading each others' views of the future brings this to a close. The format gives the teacher and student a lot of flexibility limited only by their own imaginations.

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Search for Leverage Points, continued from page 6

students to use a conceptual perspective, rather than traditional methods.

This process can be repeated wherever problems are presented in which the independent variable is time. Thus, each new topic becomes a potential leverage point where models can be used to address the topic conceptually before, or in parallel with more traditional treatments. The problems can be modeled, expanded, and explained by the students, significantly enhancing their experiences and demonstrating the relevance of mathematical study to other disciplines.

Perhaps the most unusual work done by the CC–STADUS project has been the work done in literature by Tim Joy and a few others. The whole idea of using systems in literature seems odd to some. However, the plot of a book is essentially an interplay among characters, in short, a system of interactions. One of the things literature teachers want students to do is analyze and understand those interactions and the motivations behind them. They want students to write about them, and discuss them. The discussion part is the difficult piece. Usually only a few students are truly engaged. Dynamic models can provide a structure for generating those discussions and involving more students.

Using very simple models, Tim has pioneered work in which students trace character development through changes in specific traits. Using the authoring level of a STELLA model, students are presented with a succession of events and quotations from the book. Students are asked to adjust the level of the trait before the model resumes. This adjustment is accompanied by written justification based on passages in the text. In the course of running the complete model, students generate a graph of the character's behavior. These graphs are displayed in class. Students then are asked to explain or justify their interpretations as displayed in their graphs. The result is an animated, sometimes passionate discussion. The potential for that level of student involvement serves as a strong motivator for Literature teachers. It provides enough leverage to involve teachers. Additionally, the "Savage Instincts/Lord of the Flies" models introduce students to the use of systems at a level that is accessible to virtually everyone. Discussion and further student modeling bring students more fully into the understanding of dynamic systems.

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Updates. . . cont. from page 2

Eighth graders use modeling in a slightly different way in an interdisciplinary physics of motion unit with science teacher Jim Trierweiler and math teacher/mentor Rob Quaden. Again starting with a hands-on experiment and data-gathering, teams of students roll cars down ramps to see how far the cars go depending on the angle of the ramp. They plot their data, write an equation for the line, and make predictions for other angles.

This time, however, they take their data to math class where they actually build a STELLA computer model of the system as a class to better understand the behavior. Obviously, the steeper the angle, the further the distance, but why? And what makes the car stop, exactly? In modeling, there is no room for fuzzy answers; the pieces have to fit together. Back in science class, how does this apply to other physics of motion experiments and to life?

Adding system dynamics to these lessons has a surprising effect on our students. The students asked better questions, and many more of them. And they seek the answers because they want to know. The learning becomes more learner-centered, with the teacher as a guide. That is an outcome worth nurturing.

Debra Lyneis, lyneisd@cle.tiac.net ❖

The Learning Potential of Dyslexics, continued from page 4

the right meaning) or process it incorrectly (jumble the meaning up). What defines dyslexics is that they incorrectly process a greater amount than others do.

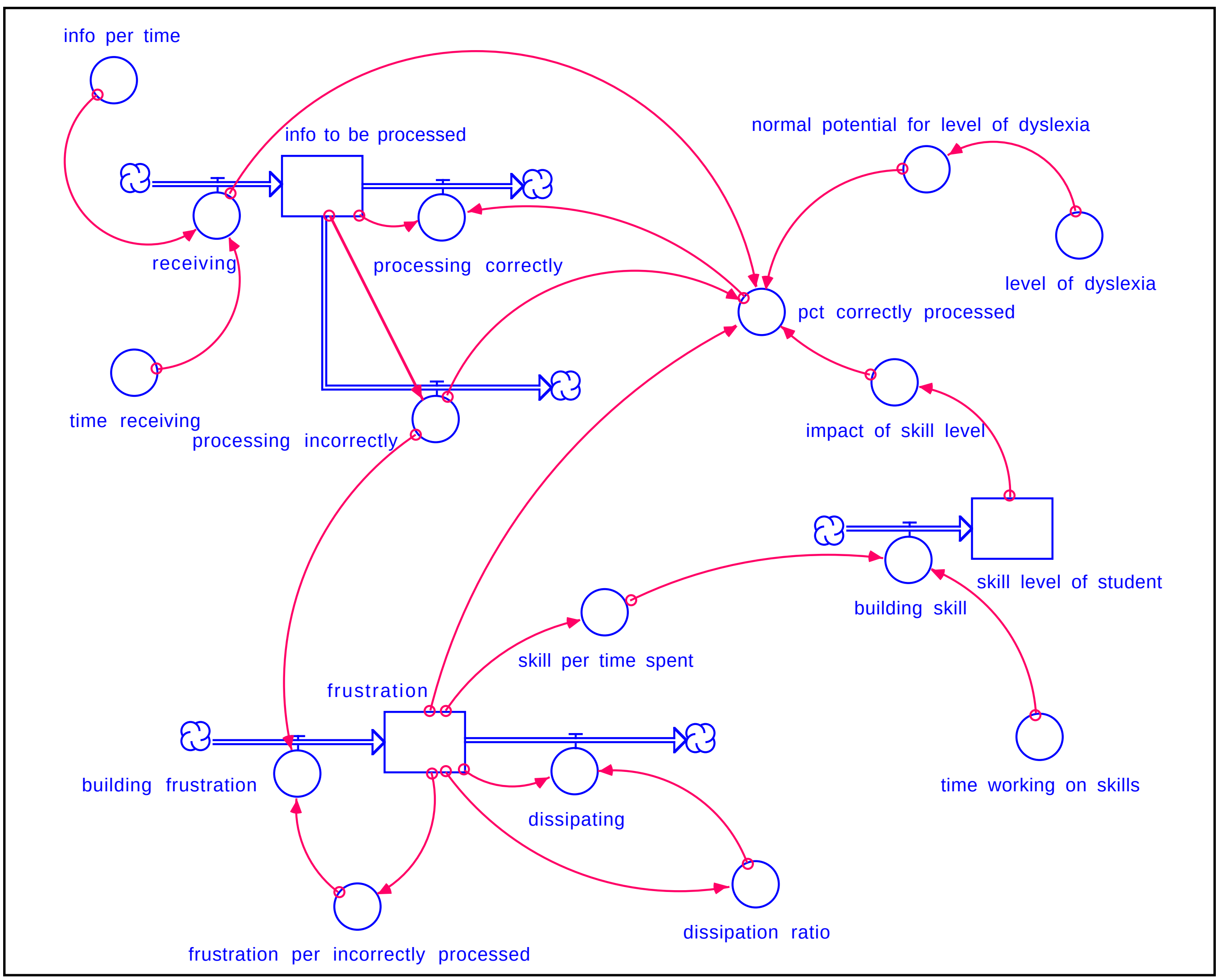
This amount, or percentage processed incorrectly, is influenced by their level of dyslexia, the coping skills of the student, the amount of information they are receiving (high levels of arriving information likely will impact their ability to process), and their frustration. The goal of working with the student is to build his skills. But if there is no concern as to the amount of processable information given to a student, he will be overwhelmed beyond his skill level. Worse, if their stock of frustration does build, the student will find it difficult to improve their skill level. More difficulty leads to more frustration, which leads to more difficulty. This can be a reinforcing loop—a vicious cycle.

So, as a parent, what can you do with this information? Well, being fluent in the systems thinking language and paradigm, you can take a model similar to the one below and share it with your child's teachers. The use of systems thinking modeling will not cause your child's dyslexia to cease being a problem, but, working with the teacher and school, you can build a clearer understanding of the dynamics at play in your child's learning process. This can improve the potential for learning to occur for your child. Additionally, you can develop some specific action steps that can result in building your child's skills. Understanding and using systems thinking concepts, theories, and tools can do all this.

James Rieley directs The Center for Continuous Quality Improvement at Milwaukee Area Technical College, and works with organizations to help them better understand how to become more effective over time.

Chris Soderquist works for High Performance Systems, Inc. and consults with organizations on system dynamics modeling using ithink.

Melissa Rieley is a high school junior who is working to better understand her dyslexia. ❖



Summaries of ST/SD Projects in K-12. . . continued from page 9

administrator, I found it very difficult to garner financial resources to keep this work in progess once the Superintendent who initiated this work left the school district. Just getting money to send people to summer conferences was a major undertaking. I believed then, and continue to believe now, that exposure to the work of others engaged in similar undertakings and the opportunity to discuss problems and successes with those who have relevant experience is one of the most powerful learning tools we have available to us. Had we been cut off from this resource I do not believe our work would have continued at even its slow pace. While we were ultimately able to access some district resources, this took a great deal of time and effort, and the expenditure of many political chits. Without the generous support of the Waters Foundation, our participation at educational network events would most likely have ended last year."

- "The emotional strain was one of isolation. For those of us who had been involved from the beginning in efforts to learn about systems thinking, we went from being part of a large scale learning initiative which had the full support and involvement of the central administration to being a small scale informal study group which had limited support. It was difficult to maintain the necessary focus to promote continued learning under those circumstances. Without the encouragement and support of colleagues in the broader educational network, I do not think our efforts would have been sustained."

- "I believe the biggest challenge for the future will be to find the time to do the ongoing staff development that I believe is required to lead to lasting, fundamental change in our instructional practices, the ways in which we design programmatic structures, and the ways in which we interact with one another."

Please note: The entire text of the article from which this piece was excerpted is available from the CLE and the web site (http://sysdyn.mit.edu/). The 8-character title is SUMMARMS.

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