SYSTEMS THINKING
AND
SYSTEM DYNAMICS
IN
K-12 EDUCATION

A study supported by
The Waters Foundation
School Year 95-96
<table>
<thead>
<tr>
<th>Section</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>pages 3-4</td>
</tr>
<tr>
<td>Sample Quotations</td>
<td>pages 4-6</td>
</tr>
<tr>
<td>Participating Projects</td>
<td>page 7</td>
</tr>
<tr>
<td>Summary Format</td>
<td>page 8</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>page 9</td>
</tr>
<tr>
<td>Acton/Boxborough Districts</td>
<td>pages 10-12</td>
</tr>
<tr>
<td>Carlisle School District</td>
<td>pages 13-17</td>
</tr>
<tr>
<td>Catalina Foothills School District</td>
<td>pages 18-25</td>
</tr>
<tr>
<td>CC-STADUS Project</td>
<td>pages 26-29</td>
</tr>
<tr>
<td>Concord Middle School</td>
<td>pages 30-32</td>
</tr>
<tr>
<td>Concord-Carlisle School District</td>
<td>pages 33-37</td>
</tr>
<tr>
<td>Glynn’s Integration of Systems Thinking</td>
<td>pages 38-43</td>
</tr>
<tr>
<td>Harvard School District</td>
<td>pages 44-47</td>
</tr>
<tr>
<td>LaSalle College Preparatory School</td>
<td>pages 48-51</td>
</tr>
<tr>
<td>Lawton Elementary School</td>
<td>pages 52-56</td>
</tr>
<tr>
<td>Maumee Valley Country Day School</td>
<td>pages 57-61</td>
</tr>
<tr>
<td>Willard Elementary School</td>
<td>pages 62-65</td>
</tr>
</tbody>
</table>
Introduction

During the 1995-96 school year, a study was conducted in twelve school districts around the country that are integrating systems thinking and dynamic modeling into their programs. Educators were interviewed about their efforts to gain an understanding of systems thinking and dynamic modeling and the planning and implementation of instructional and organizational strategies that would incorporate the systems tools and concepts.

The settings for the projects involved in this study vary greatly. In each setting, the initial motivations for exploring potential uses of systems thinking and dynamic modeling were prompted by a variety of individual perspectives and circumstances. Some projects are just beginning and others have been in place for several years. Once the initial efforts were under way, continued efforts were varied and projects took on individual personalities. The summaries of the twelve projects involved in this study reflect one or more of the following types of applications of systems thinking and system dynamics:

• concentration on developing and improving classroom applications of computer modeling related to the dynamic concepts of systems thinking.
• development of formal training programs and the offering of workshops to teachers in their schools, their districts, their states, and even beyond.
• focus on a broad range of applications of systems thinking and dynamic modeling in both classes and in organizational planning, decision making, and reform.

No matter the approach taken or the amount of time that projects have been in place, there is a sense of purpose and commitment evident in all of the projects. All involved are convinced that the potential for systems thinking and dynamic modeling to affect learning is great and that we have just begun to scratch the surface of the possibilities. Given the uncertainties and the dynamics of the initial stages of innovation, the educators involved in these projects are working hard to maintain an attitude of respect for differing approaches as well as an eagerness to share whatever ideas, materials, and resources they have with anyone who is interested. The collegiality and collaboration that is demonstrated among the projects is rare in the world of education.

One of the elements found in all of the projects studied is a process of learning that is consistently described as challenging. The process often begins with acquiring the skills necessary to build computer models that enhance curriculum and instruction.
Depending on an individual’s technological expertise, model building can require a new set of skills and time to practice the skills in order to develop competency. However, the challenges seem to go beyond modeling skills and involve a realization that dynamic modeling is based on a “shift in thinking,” a new paradigm for planning instruction and in many cases, a new paradigm for decision-making and problem solving within the school or school district.

The strategies used to address the necessary “shift in thinking” differ from project to project. However, there is always some type of task analysis of the knowledge, skills, and perspectives involved in dynamic modeling and a conclusion that instructional strategies can and should involve tools and concepts that lead to the type of thinking required in dynamic modeling. In addition, the conclusion of educators involved in this work is that systems thinking/system dynamic tools and concepts can be incorporated throughout a K-12 education. A prevalent goal among the projects is a desire to contribute to producing students who are not only better able to understand and create dynamic computer models, but also who are able to apply this understanding in a variety of ways to a variety of situations.

Throughout the projects there are many people who love to learn, who are willing to test out new ideas, and who are extraordinarily willing to support the new ideas of others. Virtually every project began with one or more teachers who were introduced to dynamic modeling and who followed up by creating classroom applications. Classroom applications have often been accompanied by staff members utilizing systems thinking and system dynamics concepts in organizational situations as well. In some cases, teachers had to seek out training. In others, interested individuals or businesses in the community were supportive and provided opportunities for training. In all cases, a high level of commitment and a great deal of patience were demonstrated by the individuals who began the projects and who sustained their efforts over time in order to work through, and to help others work through, the challenges of change and learning.

Samples Of Quotations From Project Participants

The first set of quotation samples reflects the degree to which people in these projects are living the concept of being lifelong learners and the idea that great benefits can come from learning together. There is a strong belief that educators can create classrooms and schools that work better for students and for adults as well.

“Using system dynamics must fit in a curricular context, not just added, but within a planned framework.”

“To develop the capacity to create fundamental changes at the classroom, school, and/or district level, several kinds of support are critical: ongoing staff development, easy access to tools such as computer software,
telecommunications, books, etc."

“By not rushing we have been able to experiment with ‘how to’ make systems thinking and system dynamics meaningful to students and teachers. We have attempted to demonstrate how systems thinking and system dynamics can enhance what is already going on in classrooms, not replace it.”

“Learning is not easy, it takes time. It’s not a workshop; you pick up some of the concepts and use parts of it as you continue learning, trying, adjusting."

“It takes a lot of work and time and teacher training is very important as well as consistent practice. Learning together builds trust; is refreshing. All of this ‘together’ feeling fosters a spirit of cooperation.”

Those who use systems thinking and dynamic modeling in their classrooms are risk takers. They create environments and utilize instructional strategies in which there may not be one right answer and questions may be asked that surpass the teachers’ immediate knowledge or understanding. They take these risks gladly because they see the short-term learning results for students and the potential long-term results of developing skills and attitudes that will help students deal with the complexities of the world in which they live.

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

“Using systems thinking and dynamic modeling has changed the way I ask questions as a teacher.”

“When using system dynamics models, there is an immediate student interest and facility in learning. There is a willingness on the part of students to recognize and talk about complexity and interdependency of issues.”

“ This is like teaching someone to drive via ‘What do you think will happen if . . .?’ vs. ‘Stop! Don’t! Turn that way!!!’ ”

“It allows me to approach problems in classrooms that are beyond the normal scope of the course and the normal skills of high school students AND the results include greater student understanding.”

“Students’ thinking is shifting to a more analytical style. They are better able (and more inspired) to look for deeper meanings and cause and effect interrelationships.”

“I now look at math as change over time. It connects the functions, and
applications seem to be natural."

Many of the project participants don’t seem to be able to use systems thinking and dynamic modeling in the classroom without seeing implications for needed changes in the way we structure schools and the way we operate within those structures. It’s much like Deming’s idea that we have to change the way we think before we can change the way we work.

“Breaking down the barriers is slow but we can begin by training people in cross-disciplinary groups so that they have the experience of seeing what is possible when people work together.”

“Using organizational applications helps us to model behaviors we want from students, including being lifelong learners.”

“Support for systems thinking/system dynamics should be reflected in overall mission statements and system-wide goals. There should be a coordinated effort to steer the overall system in the direction of systems education practices and experiences.”

“Developing a common vocabulary through systems thinking is very powerful. . .”

“Prior to incorporating systems thinking, the administrators were clearly focused on their divisions, as opposed to their first focus being the school in its entirety.”

“I think there is a greater willingness on the part of my fellow administrators to weigh the impact of their decisions on areas other than those for which they are directly responsible.”

“This used to be a collection of classrooms - it’s now a school community. There’s a greater consistency, more shared ownership.”
Participating Projects

The following projects participated in the 1995-96 study. Educators from these twelve projects have communicated, collaborated, and shared resources for several years. At least thirty more projects are known to have started over the past few years. Several of them have been motivated and/or assisted by representatives from the projects listed here. Based on informal communications, it is assumed that a number of other projects have also started or perhaps have been in existence for years but have not been a formal part of the network that has been developing.

<table>
<thead>
<tr>
<th>Project</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acton Public School District and Acton-Boxborough Regional School District</td>
<td>Acton, MA</td>
</tr>
<tr>
<td>Carlisle K-8 School District</td>
<td>Carlisle, MA</td>
</tr>
<tr>
<td>Catalina Foothills School District</td>
<td>Tucson, AZ</td>
</tr>
<tr>
<td>CC-STADUS/NSF Project</td>
<td>Portland, OR</td>
</tr>
<tr>
<td>Concord Middle School</td>
<td>Concord, MA</td>
</tr>
<tr>
<td>Concord-Carlisle Regional School District</td>
<td>Concord, MA</td>
</tr>
<tr>
<td>Glynn’s Integration of Systems Thinking</td>
<td>Brunswick/ Glynn Co., GA</td>
</tr>
<tr>
<td>Harvard School District</td>
<td>Harvard, MA</td>
</tr>
<tr>
<td>LaSalle College Preparatory School</td>
<td>Portland, OR</td>
</tr>
<tr>
<td>Lawton Elementary School</td>
<td>Ann Arbor, MI</td>
</tr>
<tr>
<td>Maumee Valley Country Day School</td>
<td>Toledo, OH</td>
</tr>
<tr>
<td>Willard Elementary School</td>
<td>Ridgewood, NJ</td>
</tr>
</tbody>
</table>
Summary Format

Setting: Representatives of each project provided information about the community in which their school(s) are located. The purpose of this description is to provide a context for the project summary.

School/District Goals/Philosophy: Additional context is provided by the goals and/or philosophy of the schools involved in the projects. It should be noted that a great number of the school goals have direct connections with systems thinking and dynamic modeling.

Project Goals/Philosophy: The individual “project personalities” can be partially viewed through the project goals and philosophy. Each project has identified the goals that best suit the needs of students and staff at this point in time. The goals are also greatly dependent on the length of time that the project has been in place.

History of Project: The story of each project has been based on interviews and discussions with project participants. Evident in each of the histories are key people and events that stimulated the initial efforts and have served to sustain the projects over time.

Quotations: Participants from each project responded to the following survey questions: What do you believe have been the most notable results produced by the efforts to implement systems thinking or system dynamics in the classroom and/or the organization? For you, what have been the most important learnings that occurred because of the efforts to understand and implement the concepts of systems thinking or system dynamics in your classroom or your organization? From your perspective, what have been the most important challenges that had to be addressed and/or what are the most important challenges that still must be addressed? The responses reflect images and information about each projects that are not included in the more formal project history.
Acknowledgements

The projects described in these summaries have benefited greatly from the support that has been provided by many experts in the fields of systems thinking and system dynamics. Those experts and hundreds of K-12 educators owe a debt of gratitude to the pioneers of system dynamics whose belief in the value of systems thinking for all K-12 students and whose encouragement of the adults who work with those students have been crucial factors in both the beginning and sustaining stages of systems thinking and dynamic modeling projects in schools.

Dr. Gordon Stanley Brown (1907-1996), who pioneered the theory and practice of feedback dynamics and engineering control systems at the Massachusetts Institute of Technology in the 1940’s. Brown went on to be head of the Electrical Engineering Department and Dean of Engineering at MIT. During retirement, he devoted energy and skillful leadership to bringing system dynamics into the Catalina Foothills School District in Tucson, Arizona.

Dr. Jay W. Forrester, Germeshausen Professor, Emeritus, at the Massachusetts Institute of Technology, directed the system dynamics program at the MIT Sloan School of Management until 1989. He is the founder of the field of system dynamics. He also holds the patent for magnetic core memory, which for many years was the standard memory device for digital computers. Since his retirement in 1989, Dr. Forrester has worked to bring system dynamics into classrooms through the Pre-College Education Project at MIT.
Setting

The Acton/Acton-Boxborough School Districts are comprised of one high school, one junior high, and three elementary schools. The district serves a total of 4200 students.

School/District Goals/Philosophy

- We are an educational community learning to participate in a global society.
- We believe that the first responsibility of the schools is to teach skills and knowledge. (School is about academics.)
- We believe that all members of the school community are life-long learners.
- We believe that it takes the entire community to educate a child. Everyone learns most effectively from people who themselves are learning. Students also learn better when they participate in all phases of the learning process. (Everyone is constantly learning.)
- We believe that everyone must have the opportunity to learn in a way that allows for differences, fosters self-esteem, instills a respect for diversity and teaches that service to the community is an important contribution. (Each individual is valuable.)
- We believe that the school climate/atmosphere should reflect a pleasant, attractive, safe and productive environment in which to work and learn. (The environment promotes learning.)
- We believe that the future of our local and global community depends on educating our students to be responsible citizens who are capable, knowledgeable, flexible, healthy and reflective. (Future citizens must be prepared.)

Project Goals/Philosophy

A core group of Acton-Boxborough teachers, administrators and community members is committed to the exploration and implementation of the use of systems thinking and dynamic modeling into the K-12 curriculum and organizational practices. A crucial element of that work includes participating in a consortium with area school districts for the purpose of ongoing learning and mutual support.

History Of Project

This project began during the 1992-93 school year with the efforts of an interested community and school board member who encouraged the use of systems thinking
and system dynamics and worked to provide area teachers with related training. A sabbatical for a high school chemistry teacher from a neighboring school district provided a local mentor for the Acton-Boxborough school district as well as the chemistry teacher’s own school district. One of the opportunities made available to the Acton-Boxborough teachers was a workshop utilizing the “Fish Banks” computer simulation.

During the 1993-94 school year, an afternoon seminar for educators from Acton-Boxborough and nearby Concord was held for the purpose of learning about applications of systems thinking/system dynamics and other disciplines of “The Learning Organization”. A curriculum workshop focused on the use of dynamic modeling in schools was facilitated by professors from Trinity College during the following summer.

Continuing efforts during the ‘93-’94 school year included another dynamic modeling workshop for the Acton-Boxborough math department. Subsequent use of STELLA and systems thinking began in eighth grade math. The Systems Thinking and Dynamic Modeling conference which had previously been held in Tucson, AZ was held in Concord during the summer of ‘94. A total of ten teachers and administrators from Acton-Boxborough attended. Interest in further study of the possible applications of systems thinking and system dynamics resulted in a series of meetings with representatives from GKA, a Boston consulting firm. The meetings utilized the tools and concepts of systems thinking for the purpose of addressing school district issues. A steering committee was formed to coordinate follow-up activities and planning. The steering committee met on a regular basis during the ‘94-’95 school year along with a newly formed consortium of educators from local districts. Meeting agendas included analysis of school district issues, discussion of related resource materials, and continued work with GKA to create a model of change within a school system. The use of STELLA was expanded to include honors classes in physics. A grant committee was formed to explore the idea of applying for NSF funding. The grant application was made but was rejected. Curriculum workshops facilitated by the consortium of school districts during the summer of ‘95 included Acton teachers.

Following the summer workshop, teachers who had participated in the training explored applications of systems thinking and dynamic modeling in the high school curriculum. Three additional workshops were made available to Acton-Boxborough teachers. The focus of the workshops was systems thinking and dynamic modeling tools and their relevance to education, both administratively and in the curriculum. The sessions concentrated on practice with systems thinking tools and their usefulness. Examples of how systems thinking is being used across the country to achieve synergy and create learner-centered education were provided. Systems tools and uses of STELLA were implemented in junior and senior high school English, in high school math, and in high school physics. During the school year, a seventh grade team became involved with the successful application for a state CESAME grant focused on the use of systems thinking and dynamic modeling for the purpose of
improving math instruction and learning. The Acton-Boxborough team was joined by teachers from local public school districts and charter schools in the planning of the grant and will work together on the implementation of the plans.

Efforts are in place to continue providing opportunities for Acton-Boxborough teachers to learn about and to implement systems thinking and dynamic modeling in their classrooms. A core of teachers is now in place with successful experience in utilizing these tools and interest in expanding that core is growing. The Systems Thinking and Dynamic Modeling conference sponsored by the Creative Learning Exchange is once again being held in Massachusetts and will provide an additional source of information and motivation for area educators.

**Quotations from Project Participants**

- “Systems thinking works.”

- “Behavior over time graphs are a concrete representation of student thinking that leads into a student-run discussion. (The kids LOVE it when I issue each group an overhead transparency for their graph and explanations.)”

- “Behavior over time graphs provide a means for students to own not only the story, but the presentation of it.”

- “The decision of where to place each particular point on the graph generates rich discussion in the group, and then explaining and defending, sometimes changing in light of peers’ arguments, brings students to a deeper understanding of a work than other strategies tend to.”

- “STELLA is a tool that give students a concrete means to explore their thinking and to test its validity. As they create models, students think through the relationships inherent in a piece of literature.”
Setting
The K-8 Carlisle school district is located in a suburban community outside of Boston, MA. The three main buildings on campus house 230 students in grades K-2, 250 students in grades 3-5 and 210 students in grades 6-8. Beyond the eighth grade, students attend Concord-Carlisle High School.

District Mission Statement
The mission of the Carlisle Public Schools is to structure our school in order to promote student success by engaging them in meaningful tasks. When tasks are meaningful, students will invest their talents and energy and thereby gain the skills and knowledge which are valued by the larger society and which will enable them to thrive and compete in the 21st century.

Broad Objectives:
• Commitment to the belief that all children can learn and that it is our responsibility to ensure that every child reaches his/her maximum potential.
• Develop a core curriculum and engage in instructional activities characterized by high expectations and quality student performance.
• Promote a learning environment that is respectful of diverse student needs, abilities, aptitudes, and learning styles.
• Create a system of continuous assessment and improvement of education for the student, teacher, and the community with the goal of developing a society of life-long learners.
• Facilitate professional growth and development of all members of the school community.
• Develop operational, planning, and management strategies that enhance instructional excellence.

Vision Statement:
The mission of the Carlisle Public Schools is to develop a society of life-long learners who possess the behaviors, skills, and knowledge essential for contributing members of a democratic society and a global economy.

Project Goals/Philosophy
Initial ideas included moving students from data collection to plotting information to making predictions to system dynamics. The sequence was one of experience, model,
predict. Models were used as a tool to get kids thinking systematically. Current goals are to expand the use of systems thinking and system dynamics in both the classrooms and the organization of the Carlisle School District. The expansion process will include the identification and implementation of elementary applications of systems thinking and system dynamics as well as additional middle school applications. Throughout the process, efforts will be made to clarify curricular and instructional goals, as well as overall school goals and to match the tools and concepts of systems thinking with those goals.

**History Of Project**

Interest in systems thinking/system dynamics for one Carlisle teacher began in the early 80’s through a course taught by Nancy Roberts. Additional information about applications of systems thinking and system dynamics in schools came with the Systems Thinking and Dynamic Modeling Conference that was offered in Concord during the summer of 1994. Conversations following that conference included ideas from *The Fifth Discipline* and the potential of connecting systems thinking/system dynamics to the development of a learning organization. The concepts seemed appropriate for an approach to a vision for the school district. District teachers also attended summer workshops for more intensive training in computer modeling.

During the 1994-95 school year, applications of systems thinking/system dynamics were started in middle school math and science with the development of models for use in the classroom. Two interested parents with system dynamics background became mentors for the project. A study group of interested teachers and administrators began to meet on a regular basis with the community mentors for workshops, dialogue, and practice of applications. The project was set up on a basis of learner-centered learning, letting educators learn to model when they were ready and needed to use it. The availability of the mentor as a resource and the time for teachers to really understand modeling were considered very important. Additional community involvement has been invited through the implementation of a yearly forum, the first of which included Peter Senge speaking on the topic of needed changes in schools in order to educate students for their future. Break out groups during that forum brought community members and teachers together for dialogue. The intent of the forum was to create a feeling among all participants that significant change could be created together. Teachers continued classroom applications and attended another summer workshop in computer modeling.

A new teacher in social studies helped to extend the applications during the 1995-96 school year. The study group described above has continued to meet and is beginning to acquire and develop examples of instructional materials and strategies for more and more subjects. Students are asking to use the models and other tools and concepts in a variety of units of study. Ideas for organizational applications are also being studied. The shared experience of the teachers, administrators and two
interested community members in their efforts to learn about and create models has been very important. It has been a translation of verbal support into active support. In some instances, the group has analyzed existing models borrowed from other schools as a vehicle for discussion and learning.

In addition to in-district efforts, a consortium of local school districts has served to encourage applications of systems thinking and system dynamics and to provide and share ideas about a variety of applications. An off-shoot of the consortium is a state grant for the 1996-97 school year to further develop applications of systems thinking/system dynamics for middle school mathematics.

Plans for the 1996-97 school year also include expansion of the project to the elementary classrooms. Administrators and several teachers from both the middle school and the elementary school will attend the Systems Thinking and Dynamic Modeling Conference during the summer and will meet in August and throughout the school to continue development and analysis of systems thinking and system dynamics and to plan for applications that seem to best fit the Carlisle School District.

Quotations from Project Participants

Notable Results:

• “It has begun to permeate the way in which we think even though we haven’t figured out all the ways to get it into the classroom.”

• ” By using the models, it’s possible to see the problem more clearly, have deeper understanding. It’s an extension on lab experiences.”

• “Showing kids the model gets them thinking about all the factors that affect one another. It requires really understanding instead of memorizing.”

• “Using models can lead to recognition of patterns of behavior.”

• The district atmosphere is important - it’s one of encouraging teachers to try things. “

• “Flexibility of mind is one of our values.”

• “People here are generous of spirit and time, willing to collaborate.”

• “We used to make up things for interdisciplinary units, this is real. We are looking for universal patterns that transcend disciplines.”

• “Using organizational applications helps us to model behaviors we want from students including being lifelong learners.”
• “This used to be a collection of classrooms - it’s now a school community. There’s greater consistency, more shared ownership.”

• “We’re trying to question teachers to get at what they want to teach, what they want students to learn.”

• “We’re also asking ourselves, what makes classes work or not work? What are the variables? How could we use systems thinking?”

Individual Learnings:

• “Understanding underlying structures gives students a sense of control.”

• “K-12 articulation is essential, we need to learn about what’s important at the early grade levels.”

• “We would like to create a model for each archetype.”

• “It’s like learning to read, it gives you another lens, another way of looking at things.”

• “It makes math and science a part of everything else.”

• “It’s a useful way for getting people to check out assumptions.”

• “It’s a vehicle for working with other disciplines. It opens up conversations.”

• “It’s a forum for talking objectively about complex and/or controversial subjects?”

• “It helps you to get underneath the language. What are you really thinking?”

• “We value ways to make learning connected.”

• “An incomplete model can be an effective learning tool.”

• “There’s value in some of us being good at modeling, it keeps us from being fuzzy.”

• “It’s like music, few people are virtuosos, but lots of people enjoy playing an instrument at their own level.”

Challenges:

• “Learning it is not easy, it takes time. It’s not a workshop, you pick up some of the concepts and use parts of it as you continue learning, trying, adjusting.”

• “In reality, systems thinking is the difficult part, it’s changing behavior. System
dynamics is the discipline to get there.”

• “... working with adults and students who are new to systems thinking/system dynamics and remembering how it was to not think that way and trying to bridge the gap.”

• “We have gone from 40 early release days to 9 or 10. We are trying to synthesize professionalism and budgeting realities. It’s a shared responsibility to find the time to continue learning together without release time.”
Setting

The Catalina Foothills School district is a suburban school district set in the foothills of the Catalina Mountains in Tucson, Arizona. The district includes one high school, two middle schools, four elementary schools and a pre-school with a total district enrollment of approximately 4600 students.

District Mission Statement

Our mission is to provide students with educational experiences that develop character, imagination, knowledge, and skills for lifelong learning. We believe CFSD is a learning organization focused on children, is in a partnership with parents and the community to achieve educational excellence for the good of students and society (Partnership calls for informed participation, mutual respect, and the collaborative pursuit of a shared vision.), and is accountable for the continuous improvement of student achievement, staff capability, curriculum, and decision-making. We believe students have a right to learn, to be listened to, and to be taken seriously and that they have unique talents, individual needs, and the capacity to achieve personal excellence. We believe teachers and support staff are professionals who nurture the growth and development of students and serve as role models and can enhance their capacity to meet student needs through collaborative planning, ongoing personal and professional development, and open communication with students and families. We believe learning is best when the curriculum is meaningful and engaging, students are actively involved, and school organization allows for individual attention and that learning is enhanced by a safe and supportive environment at home and at school.

Project Goals/Philosophy

Use of systems thinking and dynamic modeling is an option for all staff members in the school district. ST/SD is used as an instructional method to deliver dynamic components of the curriculum and dynamic work elements for staff, rather than ST/SD being a curriculum or an end result. The general goal of the project is to develop the skills of people in the classroom and in the organization to think and act systemically, which includes the ability to do the following:

- identify a system, versus a “heap”
- analyze and understand the interdependencies among parts of a system, particularly feedback relationships (how something that was initially an effect ultimately becomes a cause)
• analyze and understand the conditions that create/affect the interdependencies
• analyze and understand the cumulative effects over space and time that are caused by the interdependencies
• determine and understand the potential trade-offs that are necessary in every system
• identify short and long-term effects of trade-offs within a system
• make decisions and take action based on an understanding of the trade-offs and accumulations over time within a system

History Of Project

Throughout the eight year history of the Catalina Foothills Project, a clarity of purpose has evolved. Through continued innovative uses of dynamic modeling and related tools and concepts, numerous strategies for applying systems thinking and system dynamics have been developed for both classroom instruction and organizational issues/situations throughout the K-12 system.

The project began during the 1988-89 school year at Orange Grove Middle School. Initial efforts involved the development of computer models for environmental science by a teacher who was introduced to STELLA through a workshop at Stanford University. Participation in this workshop occurred because of the encouragement of a retired Tucson citizen whose career at the Massachusetts Institute of Technology had led him to a strong desire to see systems thinking and system dynamics become a part of the curriculum and instruction in K-12 education. The ongoing support and mentoring of this “citizen advocate” was a major factor in the initial and continued integration of systems thinking and system dynamics into the Catalina Foothills School District.

During the 1989-90 school year, a grant from a private foundation was obtained to provide support for partial release time to the science teacher who had “pioneered” the use of STELLA in his classes. This release time allowed expansion of the project to include working with another science teacher to develop and implement models into 7th and 8th grade science, adding a student modeling class to the schedule as an elective offering, and preliminary dialogue and planning re: continued expansion of the project to include other subjects and possible applications to school-based decision making.

During the 1990-91 school year, a grant was acquired to fund a full-time mentor position. The science teacher who initiated the use of STELLA at Orange Grove assumed the mentoring position and continued the developing of STELLA models for middle school science, provided workshops to interest teachers in the use of STELLA models and other system dynamics tools in other subjects, collaborated with administration and other staff, and served as a resource to interested educators from...
across the country who were interested in developing similar projects.

Although computer models were being used only in science, many Orange Grove staff members had been involved in three-day STELLA workshops facilitated by staff from High Performance Systems. As a result of the training, staff members began to see implications for using systems thinking/system dynamics concepts in the transition that was underway from the school’s junior high program to a middle school program and the related organizational changes, as well as throughout the curriculum. As a result, systems thinking became somewhat intertwined with the concepts of middle school. There were advantages and disadvantages to this parallel learning process. The advantages included the degree to which systems thinking became an integral part of Orange Grove Middle School and that there was a high level of motivation to learn more. The disadvantages involved a certain degree of confusion about which strategies and results were related to systems thinking/system dynamics and which were related to the process of developing a middle school. Continued practice and learning clarified the definitions of all of the concepts that were involved. Many types of applications were supported in order to learn more about the most effective strategies and to implement aspects of a “task analysis” process to determine which systems thinking/system dynamics tools and concepts most effectively served various instructional and organizational situations.

At the middle school level, more models were developed for science, teachers of English worked on developing dynamic models for literature, and a money management model was developed for math. The staff at Orange Grove Middle School continued to apply their understanding of systems thinking to organizational situations. The staff across the district, as well, began to develop an understanding of potential organizational applications such as using the ST/SD tools to help organize their approach to problem solving and to make their thinking more explicit, just as staff might help students do in classrooms. By the end of the 1990-91 school year, plans had been made to add a high school to the Catalina Foothills K-8 school district. These plans included the integration of system dynamics/systems thinking into the design and development of the high school program. Both classroom and organizational applications were explored at the high school. Although an additional mentor was added for the high school during the 1992-93 school year, the opening of the high school required a tremendous amount of time and energy on the part of both mentors as well as many other district staff. The focus of the K-8 project was on maintenance rather than expansion during this time of many district changes and the related challenges of opening a high school.

Beginning in the 1993-94 school year, the project design changed dramatically. In an effort to differentiate the tools and concepts of systems thinking and system dynamics from other strategies that might be utilized to produce organizational learning, the grant project was divided into two branches: Systems Thinking/System Dynamics and Organizational Thinking. A project manager position was added as well as additional mentors for the purpose of helping K-12 staff use systems thinking/system dynamics in
classroom instruction. A middle school principal served as the manager of the Organizational Thinking Project. That structure served the project for the next two years and great progress was made in the design and implementation of instructional units involving the ST/SD tools and concepts.

Despite progress with the classroom applications of systems thinking and system dynamics, identifying the best strategies for use in organizational situations continued to be a challenge. During the 1995-96 school year, a half-time mentor was added for the Organizational Thinking aspect of the grant. A transition to an organizational approach that was more like the classroom approach was beginning. By the end of the 1995-96 school year, the two branches of the grant were, once again, combined.

Much has been learned from the years of work that had been devoted to identifying and implementing the elements of classroom instruction that would help students think and act systemically. Those elements of classroom instruction also apply to organizational situations and can be used to analyze problems, to examine mental models, to test assumptions, and to identify leverage actions. Re-combining the separate strands of the ST/SD in the classroom and organizational thinking under the umbrella of ST/SD in the classroom and the organization implicitly encourages all staff to treat organizational situations as units of instruction or a discipline in which ST/SD tools and concepts can help bring about increased understanding and improved decision-making. Integration of ST/SD tools and concepts into organizational situations also requires an understanding and a commitment to the process of team learning - increasing the potential of the staff to work together.

The work of the project currently includes the use of tools and concepts that are relevant to and/or contribute to an understanding of systems thinking or system dynamics and that contribute to students and staff developing the ability to think and act systemically (See definition in goals/philosophy). Behavior-over-time graphs, causal loops, including the systems archetypes, stock and flow diagrams, computer models and various types of systems simulations are used in elementary, middle school, and high school classrooms and are applied to virtually every subject area in one or more unit of instruction. These same tools and corresponding concepts are also utilized in the discussion of and decision-making about organizational issues.

At this point, approximately 90% of the district staff members have participated in at least one ST/SD workshop and units of instruction involving ST/SD tools and/or concepts are being implemented at every grade level. (Range of number of ST/SD units per grade level is 1-10) By the end of the 12th grade a student is likely to have experienced ST/SD enhanced instruction in 20-25 different classroom situations, the bulk of those experiences being concentrated at the middle school level. A dynamic model is utilized in approximately 50% of the ST/SD units. In organizational settings (decision making, problem solving, developing visions and other plans for the future, etc.) staff have used behavior over time graphs, causal loops, including the systems archetypes, as well as stock/flow diagrams, and in a few situations, computer modeling
in their work.

**Quotations from Project Participants**

**Notable Results:**

- “Students are implementing systems thinking and using system dynamics tools ‘on their own,’ that is, without a teacher/staff member suggesting or directly influencing them to do so.”
- “People are operationalizing some of the tenets of systems thinking: there is no blame, so people haven’t looked to blame but rather have worked together to create/bring about a desired result; structures generate behaviors, so people have worked to examine what structures would most likely generate desired behaviors, and when undesirable behaviors have occurred, people have eventually looked to see what structures may have generated the behaviors and have worked to change those structures.”
- “There is a growing awareness of and belief in the principles of systems thinking in more and more people in the schools (staff and students).”
- “An increasing number of staff and students are utilizing systems tools, especially at the elementary level and an increasing number of applications are being created and utilized by staff members K-12.”
- “As a result of some of the systems activities, teachers report that their students have a clearer understanding of how various concepts covered in the curricula interrelate.”
- “Systems thinking implemented in the classroom is teacher/curriculum driven.”
- “I have seen special education students really grasp the concepts imbedded in the simulation . . . because there is no “right answer,” perhaps these students feel more comfortable asking questions . . . they are on a more level playing field with the rest of the students . . .”
- “Students demonstrate comfort with the visual aspects of SD tools; some students appreciate how using the SD tools can help organize their thinking and make their thinking more explicit. This seems to be a way to tap into another of an individual’s intelligences, as in Gardner’s seven intelligences.”
- “There is a more comprehensive understanding on the part of the learner.”
- “There is a feeling of ownership of decisions.”
- “There is a greater understanding of the way things work (big picture).”

**Individual Learnings:**

- “. . .seeing systems everywhere in school, politics, history, science, literature, etc.!”
- “. . .realizing how important it is to look for feedback in all systems and how it affects those systems, and where the leverage points might be.”
- “How using simple to increasingly complex tools can lead people to begin to understand how the dynamics of complex systems work.”
- “. . .learning how to apply systems thinking processes to enhance the understanding of concepts taught by high school teachers. . . . how to stimulate teachers to design
their own meaningful systems thinking activities for students.”

• “The system creates the behavior. Focus on the dynamic complexity.”

• “I need to pay attention to what’s accumulating in a system over time, and to what factors are spurring an increase or decrease of that accumulated stock, in order to be able to operate in the system as healthily, and helpfully, as I’d like. And I’ve learned how to use some tools that help me to do that.”

• “Ignorance about what’s happening in a system is NOT bliss, and getting mired in the detail complexity of a system is not the antithesis of ignorance. I’ve yet to learn how to maintain a middle ground between ignorance/avoidance and being mired in detail complexity, that is, being able to stay focused on the dynamics of a system. Over time, I, and others, will just get closer and closer to operating how we want to operate. Which does NOT mean we’ll necessarily get closer to agreeing on every given issue, but we’ll get better at paying attention to the dynamics of situations, and we’ll get better at being able to “show” our thinking to others through the use of SD tools.”

• “Learning how to use the SD tools has been important, but for me it’s been more important to learn why and when to use them, rather than how.

• Importance of mentoring with a systems “body” in your classroom.”

• “It takes a lot of work and time and teacher training is very important as well as consistent practice. Learning together builds trust; is refreshing, all is this together feeling. It fosters a spirit of cooperation.”

• “I’m trying to look at things from more than one angle/view. Sometimes, in fact, a lot of times, I feel like I’m outside the loop. I hope in time I will feel more integrated in the systems line of thinking. I think you can apply it in all areas of your life - work, home, friends, etc.”

• “System dynamics has helped me clarify my thinking about complex issues. It allows me to really pick apart a problem and get to the fundamental aspects of that situation. It also provides me the opportunity to question my own assumptions and beliefs.”

Challenges:

• “. . . persuading teachers to use systems tools to help kids develop long-term thinking without ‘pushing’ those teachers.”

• “Overwhelming workloads teachers must deal with keeping them from learning that systems tools can help them teach kids existing curriculum more efficiently; teachers see working with mentors as extra work.”

• “Keeping opportunities for learning and applying systems ideas front and center in teachers’ minds.”

• “Building community awareness of what is happening with systems in the classroom.”

• “Continued development of systems activities which closely support district outcomes and concepts covered in the curriculum.”

• “Encouragement of school district staff and students to use systems thinking in their lives.”

• “how to go ‘districtwide’ with SD; what structures to put in place to facilitate staff
members across the district learning ‘why, when, how’ of SD/ST.”
• “finding time in which staff members can learn SD and develop applications.”
• “Defining what place ST can serve in K-12 public education .”
• “Teaching in a new way feels awkward and kids aren’t used to the new way of learning and sometimes seem to ‘fall short.’
• “Sometimes I don’t want to do the work or spend the time.”
• “Sometimes I want decisions to come more quickly.”
• “Everyone has to constantly and ‘updatedly’ buy in.”
• “At the elementary level . . .we bump up against the system continually. Time and the amount of curriculum are big concerns for teachers at this time. They feel overwhelmed and don’t want to take on one more thing. (Of course, as mentors, we are saying it’s not one more thing . . .there’s a free lunch involved, but teachers may not perceive it that way . . .yet.)”
• “If we are trying to get the stock of awareness of Systems Thinking Tools and System Dynamics to fill up . . .I think we are accomplishing that. However, if we are trying to get a stock of usage of Systems Thinking Tools to fill up . . .then we are not there yet. I think it’s a delay thing. . .the stock of awareness must be filled for a while before it begins impacting the stock of usage. In that regard the elementaries are a few years behind the middle schools.”
• “Finding ways to bring ST to organizations .”
• “Communicating to parents and new administrators, particularly new superintendent, what ST is and how/why it’s being used in schools.”
• “Assessing results of implementing ST in classrooms.”
• “There is an ongoing concern about whether or not students will be able to transfer their knowledge and skills to new situations. We must continually strive to apply what we have learned so that we can be of better service to our colleagues and to our students.”

1996 Senior Survey - Most Common Comments:

• I did or didn’t enjoy using simulations and other ST/SD tools because . . .
  . . . it was fun so it was easier to learn.
  . . . it’s better than reading or being lectured to.”
  . . . it gave me a better understanding of the real world.
  . . . it was different, it broke the routine.
  . . .it was interactive so I could see the results of my decisions.
  . . .I liked the health clinic.
  . . .it was a waste of time for me; I didn’t learn anything new or useful.

• I did or didn’t learn more by using the simulations and other ST tools because . . .
. . . I understood more by being able to apply the information hands-on.
. . . it's good for visual learners.
. . . I wasn't distracted and paid better attention.
. . . things seem to stick in your mind.
. . . I have used causal loops to explain things in other classes.

Note: A survey (only two of the questions are included above) was distributed to the 1996 seniors, the first class of students to experience ST/SD tools and concepts as a method of presenting the CFSD curriculum. The district project began when these students were in the 7th grade. Approximately one third of the graduating seniors had used a small number of applications during the middle school years and two thirds of the seniors had only used ST/SD during high school. Students graduating next year, who will have had more ST/SD experiences, will be given the same survey. Each succeeding year, seniors being surveyed will have had an increased number and variety of ST/SD instructional experiences. All of the staff in the district, including project staff, will be eager to see if indications of positive impact on students increase as one would expect them to based on the trends in this year’s survey responses and other informal feedback.
Setting

Although the core team of teachers managing this project is from the Portland area, their workshops serve districts located in a variety of settings that range from small, extremely rural to large, suburban and include educators from Oregon as well as other states.

District Mission Statement

Not applicable, see above.

Project Goals/Philosophy

To improve education in mathematics, the sciences, and technology by preparing high school teachers to integrate systems thinking and computer modeling into their classroom instruction.

To promote the use in both high school and middle school classrooms of computer-generated modeling of dynamic phenomena, structures, relationships, and problems as an integral part of the curriculum.

History Of Project

The CC-STADUS (Cross-Curricular Systems Thinking and Dynamics Using STELLA) Project in the Portland Public Schools was awarded funding by the National Science Foundation Teacher Enhance Program in May 1993. STELLA modeling software was chosen as the tool to be used to explore interdisciplinary systems approaches to problem solving. The project involved training led by a core team of high school teachers with expertise in developing and using models, and by business/industry professionals who use dynamic modeling in their respective fields. Participants in the training learned about basic systems thinking concepts and computer modeling techniques, and how to build and use models within their content areas. They also worked in cross-curricular teams to design interdisciplinary models and supporting curriculum materials.
Interest in system dynamics began in 1990 with one Portland high school math teacher. After being introduced to dynamic modeling at a technology conference in Eugene, OR, she sought more information. In the early 1990’s, only a few options for training existed. Most were geared toward the business world but could be adapted to fit education. A workshop offered by High Performance Systems in Seattle, WA provided further introduction to systems thinking and to STELLA.

An opportunity for additional information became available through a project managed by Educational Testing Services which involved the use of computer models in several sites around the country. One project site in California had a teacher training workshop schedule and allowed the Portland teacher to audit the training. Following the training, a group of teachers from Tucson, AZ, who were a part of the ETS project offered further assistance by sharing information about their work. Another Tucson site offered a yearly conference focused on the use of systems thinking and system dynamics in schools.

The teacher was motivated to explore possible applications. A Portland School District administrator was supportive and encouraged the writing of an NSF grant. Working with colleagues to develop a project that utilized STELLA not only in the teaching of math but in interdisciplinary applications was begun. Assistance from the district grant writer was provided for the planning group. Connections with educators from other sites around the country were established and the sharing of ideas that evolved was a major factor in the initial stages of development and has continued to be a crucial source of ongoing support. By the end of the 92-93 school year, a grant for teacher training and support had been awarded to the group by the National Science Foundation.

In the summer of 1993, training in dynamic modeling was provided for 103 high school teachers from Oregon, Washington and surrounding states. Follow-up training was provided for 34 teachers during summer institutes in 1994 and 1995. A variety of models have been developed including cross-curricular models and related curriculum materials, single-purpose/discipline models, and models specifically designed to address the needs of under-achieving and at-risk student populations. The project staff and other trained teachers have provided introductory training in systems thinking and modeling techniques through additional inservice activities.

The project has established a World Wide Web Page on the Internet, along with a Gopher server and an FTP site. Portland Public Schools has dedicated two lines through its Internet node to the project. As of June 1995, the project was attracting in excess of 20 “hits” a day on its Web page.

The project staff is currently seeking a three-year continuation grant from the National Science Foundation Teacher Enhancement Program to refine, evaluate, and disseminate an innovative, in-depth training program designed to improve the ability of math, science, and social science teachers to use computer technology to expose their
students to complex problems and topics within and across traditional curriculum areas that have compelling “real-world” applications.

A long term goal is to establish a Pacific Northwest systems group responsible for ongoing work following the federal grant period. This systems group (formed in collaboration with Portland State University, the Math Learning Center, and business/industry partners) will develop teacher inservice courses and a permanent structure for creating and disseminating high-quality computer models and supporting classroom materials. It will also identify and prepare mentors to provide continued instruction in system dynamics.

**Quotations from Project Participants**

**Notable Results:**

- “It has changed the way I approach my subject.” (mathematics)
- “Using system dynamics has opened the doors to working with other subject areas.”
- “It allows me to approach problems in classrooms that are beyond the normal scope of the course and the normal skills of high school students AND the results include greater student understanding.”
- “Students are able to deal with more sophisticated problems than before and understand them.”
- “Working with systems thinking/system dynamics gives students tools for long term learning, analysis, and problem solving.”
- “This brings an excitement about problem solving. Students normally dislike problem solving lessons.”

**Individual Learning:**

- “Before I was looking for tools to teach this way, now I have a tool.”
- “I now look at math as change over time, it connects the functions and applications seem to be natural.”
- “It’s a general tool for thinking, conceptualizing. I can’t see or run all the interconnections with visualization. I can go beyond my mental models to testing my ideas.”
• “I have learned that a wide range of students find this type of learning valuable.”
• “For at-risk kids, it’s a way of acquiring choice/control.”

**Challenges:**

• “Early applications are difficult. You have to make a shift in thinking - become a behavior thinker rather than an equation thinker.”
• “It takes time to change our ways of looking at things as well as to convince others.”
• “This has released a flood of ideas and it’s difficult to limit oneself to what is doable.”
• “I feel cheated. I would like to go back and learn some things over again in this way.”
• “We need other people to talk to, to share ideas with - that’s getting better all the time.”
• “Balancing the requirement of covering curriculum while using the time to develop applications of systems thinking/system dynamics is difficult.”
• “The structure of schools inhibits use of cross-curricular applications.”
• “Breaking down the barriers is slow but we can begin by training people in cross-disciplinary groups so that they have the experience of seeing what is possible when people work together.”
Setting

The Concord Middle School is made up of two separate buildings one mile apart. Under this organizational format, all middle school students participate in the same courses and activities without regard to their building assignments. Total enrollment at the two middle schools is 576 students. The community is a suburban area outside of Boston, MA.

School Goals/Philosophy

All Concord Middle School staff members are committed to creating an environment and programs that will foster the following student outcomes. These outcomes emanate from our basic values, which permeate everything we do. Students will acquire developmentally appropriate skills and knowledge suitable to the challenges of a changing world. Students will have the confidence to value themselves and others, to recognize their own strengths and weaknesses, to take risks, and to accept constructive criticism. Through successful and varied learning experiences, students will develop lifelong curiosity and enthusiasm for learning. Students will recognize that achievement of true values results from commitment and effort. Students will show concern and caring for themselves and others and will develop a sense of social responsibility upon which they are willing to act. Students will respect and appreciate human differences.

Project Goals/Philosophy

Concord Middle School efforts to integrate systems thinking methodology into the curriculum are related to the middle school goals and philosophy, the district’s commitment to technology, and the Dimensions of Learning model of classroom instruction already in place.

History of Project

“This is an exciting time of innovation, risk taking and change at CMS. Teachers are enthusiastically accepting the challenges before them.”

Concord Middle School has been exploring ways of integrating systems thinking methodology into the curriculum since late 1992. At that time, the CMS principal and
Assistant principal visited Orange Grove Middle School in Tucson, AZ. Listening to students share their projects and problem-solving strategies motivated these individuals to seek additional information about possible middle school applications.

Administrators and teachers attended several conferences during the next two years including the Boston Systems Thinking In Action Conference, The Creative Learning Exchange Systems Thinking Workshop, the Tucson Systems thinking in Education Conference and the Concord Systems Thinking and Dynamic Modeling Conference. CMS teachers and administrators have participated in the Systems Education Consortium that was an outgrowth of the Concord conference, continuously networking to share resources and expertise to help introduce systems thinking and dynamic modeling in the Concord, Carlisle, Concord-Carlisle Regional, Acton, Acton-Boxborough, and Harvard school districts. Concord administrators are active participants in meetings orchestrated by the Creative Learning Exchange in an ongoing effort to create thinking organizations in their system. STELLA modeling and the related concepts of systems thinking have been implemented into the middle school science classes during the past year.

Scheduling experimentation with extended blocks of student learning and teacher planning time is presently occurring at CMS. Block scheduling enables teachers to shorten, lengthen, or combine classes so students can pursue more in-depth projects. A house system provides teachers with common planning time to make connections for students and plan interdisciplinary projects together. The Massachusetts Standards and Frameworks are being utilized to design and implement curricular changes. At the middle level it is essential that content not be learned as disparate parts but an entire system of relationships and dynamics. Experiential learning is most effective at this developmental level.

In collaboration with the Francis W. Parker Charter School, Bromfield School-Harvard, Grey Jr. High-Acton, and Carlisle Middle School-Carlisle, Concord is participating in a state grant (CESAME) project called “Systems Thinking and Mathematical Modeling in Middle School Math and Science”. This is seen as a window of opportunity to incorporate the district’s Frameworks and Dimensions work with that of systems thinking modeling. The emphasis is shifting from a traditional classroom structure to one focusing on researching, thinking, hypothesizing, making decisions and designing real world components. Systems thinking and dynamic modeling will be utilized in this grant project because of the potential to have students involved and active in their learning. Instruction will be planned to maximize individual interaction with content and to encourage administrators and faculty to become creators of environment rather than dispensers of knowledge.

The CESAME Teacher Innovation project is offering an opportunity for CMS math and science teachers to benefit from collaborative work for the purpose of providing an adequate foundation in systems thinking to facilitate learning as CMS students transition to Concord-Carlisle Regional High School where a strong commitment and
STELLA modeling already exists. Release time, curriculum materials, Internet access, and other resources for the grant project are being provided by the Concord School District.

**Quotations from project participants**

**Notable Results:**

- “More 'broad thinking' by students. A simple decision over here causes this problem or effect over there.”

- “Students’ thinking is shifting to a more analytical style. They are better able (and more inspired) to look for deeper meanings and cause and effect relationships.”

- “The tools and techniques of systems thinking have enhanced the existing structure of student-centered learning.”

**Individual Learnings:**

- “I have learned to evaluate and reassess concepts and relationships more fully while processing information.”

- “In preparation for systems thinking activities, I have developed a better understanding of the curricular material and systems in general.”

- “Many of today’s problems are systemic in nature. They are complex and difficult to manage and understand completely. System Dynamics attempts to have individuals ‘see’ all the parts and their impact to one another.”

**Challenges:**

- “These are my estimates on stages of learning - reach a basic understanding, reach a comfort level in modeling with students, work with previously developed STELLA models, understand the mathematical concepts behind STELLA, develop working models for use in the curriculum, develop an expertise. Teach students to model with STELLA. The time to reach the different levels varies greatly. It is difficult to get the time to be where I want to be with systems thinking. The availability of the computer room is also a source of frustration.”

- “Setting specific objectives for a system dynamics course.”

- “Seeing how all students react to the concept.”

- “Finding appropriate models to use with kids.”
Setting

The Concord-Carlisle Regional School District is comprised of one comprehensive high school serving 940 students from the towns of Concord and Carlisle.

School/District Goals/Philosophy

We believe the primary responsibility of the educational system is to develop the integrated intellectual growth of the individual student in an environment that promotes understanding and right treatment of others and oneself.

Intellectual growth depends on the acquisition of certain skills and knowledge and leads to the use of effective processes of higher level thinking, solving problems, and making decisions. Such growth is integrated to the extent that students are encouraged to see the interplay among these processes. Ideally, along with the processes themselves should come a love of learning -- a purposeful, enthusiastic commitment to further growth and application both within and beyond the school.

An individual’s intellectual growth is best fostered when learning experiences are well-matched to the individual’s achievement and potential. The school assists each student to discover his or her own unique potential. Such success should contribute to the desire to achieve further and to a commitment to lifelong learning.

The school system promotes the well-being of the whole person--a healthy mind and a healthy body--through its concern for the social, physical and emotional growth of students. The schools encourage the development of caring, responsible and committed people. All individuals are unique and deserve respect for their basic human dignity. In their treatment of others, individuals must exercise self-discipline and demonstrate respect for human differences.

Project Goals/Philosophy

This project began as a sabbatical for a high school chemistry teacher and was focussed on learning about and developing applications of systems thinking and system dynamics at the high school level. Subsequent efforts also addressed the need for related efforts at the middle school. The belief that motivated the sabbatical project and the continued efforts in this area is that there is a need for systems education and a need for all members of the school community to grow in this area.
Goals include increased use of dynamic modeling in various areas of the curriculum and investigation of potential applications of other systems thinking/system dynamics tools and concepts.

**History Of Project**

This project began with the interest of one high school chemistry teacher who pursued a self-designed study of systems thinking and system dynamics. His study included attending workshops on system dynamics and related computer modeling at Trinity College, M.I.T., and the University of New Hampshire. In addition, he attended conferences facilitated by Orange Grove Middle School and by the Creative Learning Exchange which were focused on systems thinking and dynamic modeling in K-12 education. Related reading and conversations with other interested individuals added to his developing knowledge and understanding.

The concentrated study described above occurred during a year-long sabbatical that was requested following an introduction to systems thinking and system dynamics at the 1992 Systems Thinking In Education Conference in Tucson, AZ. Meeting several “experts” in system dynamics at that conference, including Dr. Jay Forrester, founder of the field of system dynamics, motivated the teacher to seek a year of leave to learn about and develop applications of systems thinking and system dynamics for his and other high school classes.

During the year of study, the teacher also developed five major instructional models and accompanying documents for the use of dynamic models in chemistry. A staff development program for area educators was implemented. High school faculty and administration were assisted and encouraged to understand, study, and apply systems theory and approaches to both organizational and curricular issues.

During the past three school years, work has continued in the development and implementation of systems thinking and dynamic modeling in the chemistry classes at Concord-Carlisle High School. Computer modeling has been implemented as an instructional tool in physics during the past four years and applications for other subject areas are being investigated. Ongoing efforts are in place to continually provide training opportunities for existing and newly hired staff members. Student and parent feedback about and support of increased use of systems thinking and system dynamics is positive and strong.

Area educators have continued collaboration for the purpose of sharing expertise and pooling resources. Representatives from Concord-Carlisle High School meet regularly with the Systems Thinking Consortium (consisting of five school systems) to discuss ideas, to share information, and to collaboratively consider applications of systems thinking and system dynamics to curricular and organizational situations in schools. Articulation between the middle schools and the high school in relationship
to systems thinking and system dynamics is increasing because of the use of these concepts and of computer modeling at the middle schools.

Quotations from Project Participants

Notable Results:

• “Although we could have grasped the concepts of AP chemistry through other methods, using dynamic modeling helped us to understand the concepts forwards and backwards and we went into the AP test with more confidence and more skills”.  
  (Quote from AP chemistry student)

• “I have found that dynamic modeling with STELLA is an extremely useful tool in the teaching of the dynamic aspects of chemistry. In fact, I’d say it’s essential! That is certainly the feedback I am receiving from current and former students.”

• “Visual learners do better and enjoy the program more with STELLA than they would otherwise. Students really develop an awareness of the dynamics associated with chemical interactions. This is an enormous help in problem-solving and in mastering some of the more difficult, abstract concepts. As one student states, the reactions observed in the laboratory really “come alive” for him as a result of the STELLA experiences.”

• “Concepts that formerly took many class periods to develop are now handled in minutes!”

• “Students are examining their own ideas and their peers’ ideas more critically.”

• “The atmosphere of the classroom is enormously improved. Students are eager to learn and they stay on task.”

• “Students are happy and they are confident of their ability to succeed (all this is clearly a super example of the “success to the successful” archetype… and I make it a point of illustrating this fact.) .”

• “Students are clearly more appreciative of each other’s talents.”

• “Students are more sensitive to the needs of their peers.”

• “Students are more in touch with the dynamic, interdependent nature of chemistry.”

• “Students are improving their ability to analyze, criticize, and formulate new ideas.”

• “Students are becoming more precise in the articulation of their ideas”
(Rather than saying evaporation temporarily speeds up when the cover on a container of water is removed and then replaced, they now state that condensation slows down because there is less vapor in the container and evaporation now dominates over condensation until the two opposing rates become equal.)

Individual Learnings:

• “I have found that a very brief overview of the STELLA tools accompanied by a model of a familiar system that can be manipulated and explored works well as a means of introducing students to STELLA. Then I like to have them perform a real lab experiment and then modify a largely-complete model to simulate the lab experience. This is then followed by a few more increasingly difficult modeling exercises. Another major use is that of having students use a pre-constructed model as a means of simulating system behaviors for which they formulate predicted dynamics, view simulated dynamics, reconcile their predictions with the simulations, and formulate new hypotheses. This is proving extremely helpful in the teaching of chemistry.”

• “We are an aging faculty. Science will see five retirements among 11 teachers within the next 2-5 years. Social studies, English, and math will see significant portions of their departments leave within the same period. THERE’S THE LEVERAGE! We need to hire new teachers with systems experience but where can they be found? Certainly, the preservice programs are not providing such training. And that’s something we need to address aggressively.”

• “I am giving serious thought to taking on a student-teacher next year. Perhaps, the resulting growth on the part of the candidate will stimulate at least one pre-service program each year to take a hard look at systems education.”

• “Support for systems thinking/system dynamics should be reflected in overall mission statements and system-wide goals. There should be a coordinated effort to steer the overall system in the direction of systems education practices and experiences. Formal leadership with an assigned responsibility for making it all happen is a key issue.”

• “Getting ST/SD assigned a priority status that is endorsed by the system’s teachers is a must. Proposals of ST/SD workshops, study groups, etc., are certain to receive administrative approval and be funded. I have no doubt the system will pay staff to attend these sessions or provide release time.”

Challenges:

• “I have heard that something like 80-90% of current teaching professionals (nationally) can be expected to retire or change careers within the next 8-10 years. If systems educators fail to capitalize on this turnover, it will be a tragedy.”
• “Overcoming the sense of isolation as a modeler has been a major hurdle. I have been kept going by my students’ successes and administrative/parental recognitions of the positive results and the support of the Creative Learning Exchange.”

• “Persuading an already well-established and successful faculty that they need to tool up on something new is a major challenge. I am first and foremost a chemistry teacher. Not only do I not want to give up my teaching role but I certainly cannot do it alone. Social studies teachers need social studies professionals to entice them. English teachers need English educators to entice them, etc. We need structures for both in-district leadership and training as well as networking between individuals.”

• “Leadership in this area is crucial because teachers are already overwhelmed by too many initiatives each of which seems to consume participants in meeting after meeting after meeting. Sometimes, it seems that working with students is just an afterthought!”

• “It is possible for students to dislike the experience of computer modeling. I suspect that this is due to the approach rather than due to any inherent difficulties associated with STELLA and dynamic modeling, in general. We must avoid asking too much with too little instruction such as the building of sophisticated models from scratch with no prior modeling experience. We must develop ways to introduce students to the modeling concepts and give them experiences which familiarize them with the processes and the thinking that are required.”
Setting

Glynn’s public education system provides instructional programs for nearly 11,500 students (K-12). The school system includes nine elementary schools (K-5), three middle schools (6-8), two high schools (9-12), an adult education center, a night high school, the Risley Learning Center, the Coastal Academy and a partners in Education program. The system is governed by an appointed superintendent and a 10-member Board of Education whose members are elected by the districts they represent. Glynn County has a strong educational heritage which began in colonial days. The Glynn County school district is classified as a small urban area. It has a diverse population, ranging from those who live on resort islands to those who live in federal housing. The northern part of the district also includes a rural segment.

District Mission Statement

In partnership with the home and community, the mission of the Glynn County school system is to provide a high quality teaching/learning environment which assures that every student learns. Guiding principles: We are all students. Every student can learn. Learning is a life-long process. Learning is facilitated in a safe, healthy, caring environment. Education fosters self-worth and self-discipline. Education promotes responsible citizenship and democratic ideals. Education provides opportunities to become productive and contributing members of society. Education instills an obligation to protect our environment. Education develops effective communication and adaptability in our complex world. Our mission will not be compromised.

Project Goals/Philosophy

The original goals of the project reflected in the partnership with Georgia Pacific were to 1) build systems thinking skills among 1st to 12th graders, 2) increase the capability for using these skills to accelerate learning, 3) increase the capability of Georgia Pacific employees to use systems thinking skills in their jobs, and 4) create a capability within the community for applying Systems Thinking to issues affecting the Glynn County populace. Current goals are focused on systems thinking/system dynamics skills and include developing the ability to do the following:

- change the way one see’s the world
- make thought processes visual and explicit (mental models)
- move from self-centered to other-centered (big picture)
• understand other mental models
• trace the history/future of an event - discovering causality, recognizing/predicting effects over time
• deal with dynamic complexity (relationships)
• predict unintended consequences
• see connections between today’s decisions and tomorrow’s consequences - (both short and long term)
• see non-intuitive connections
• generate options and identify leverage

History Of Project

The Systems Thinking Project in Glynn County began in the spring of 1992. The project represented a partnership between the Glynn County Schools and Georgia Pacific, a pulp and paper company. The goals of this unusual partnership were far reaching and evolved from a stated need to improve the math and science skills of the students in the district.

In March of 1992, a group from Georgia Pacific and Glynn County administrators attended a conference in Tucson, AZ to learn about systems thinking in schools. Discussions with a representative from High Performance Systems, a software company, resulted in making arrangements for training and support from High Performance Systems for the development of a project focused on the use of dynamic modeling in the design of curriculum and instruction.

The project began with teams of teachers from the three middle schools during the 1992-93 school year. The primary operational focus of the first phase of the project was to train teacher to deliver systems thinking-based materials and learning environments (units utilizing STELLA models). Three teams of three teachers each (one from each middle school) were provided with ten weeks of release time and classroom substitutes for the purpose of training and learning environment development.

During the 1993-94 school year, the first learning environments were implemented. Students and staff reported positive results. However, the partnership with Georgia Pacific and the related support from High Performance Systems ended during that school year. The trained teachers (the Core Team) worked with their school-based grade level teams to incorporate the systems thinking units into their lesson plans. Two members of the Core Team eventually left the school district and two new teachers were added. Without the support of the partnership and related funding, the Core Team continued to attend summer conferences and to develop related instructional materials that would support the learning environments.

During the 1994-95 school year, funding was acquired from The Waters Foundation to support release time for monthly Core Team meetings and the hiring of a mentor to
begin in the fall of 1995. The Core Team met on a regular basis for discussions and decision making. In addition, they continued to implement the learning environments and to facilitate the planning/training necessary for other members of grade level teams to implement the units. They also developed a summer professional development course to introduce other teachers to systems thinking.

This arrangement continued during the 1995-96 and 1996-97 school years. The addition of a mentor during these years allowed for increased support for teachers using the learning environments and an expansion of their use. The mentor was also able to model the teaching and use of systems thinking concepts and tools for several middle school classes in order to encourage interest and support for their expanded use in the classroom. During that year, the need for additional training for the core team and for a new organizational design became obvious. The Core Team in conjunction with district and building administrators is entering into a new phase of the project in collaboration with a representative from The Waters Foundation to incorporate new structures and practices that will increase the skills of the teachers and administrators involved and will serve to sustain the project over the long term.

Learning Environments currently in use include a predator/prey simulation, a career education and financial planning unit, an alcohol and tobacco unit, a hurricane simulation, a communication unit, math lessons, and an American Revolution simulation. In addition, a lesson plan designed to teach the concept of modeling a system with STELLA icons has been developed and is in use in the gifted program. Plans are in place to involve more teachers in the revision of the existing units as well as in the development of new units directly related to the middle school curriculum. A long term goal is the expansion of the project to the K-12 program.

Quotations from Project Participants

Notable Results:

• “The development of LE’s which support interdisciplinary instruction, student decision making, and the introduction of ST/SD skills and system characteristics in a meaningful way.”
• “Not “pushing” the use of modeling is the way to go - a desire to make ST/SD understandable to all teachers and students in theory as well as application. The ability to simplify the language and introduce ST/SD as an enhancement rather than a replacement to reduce the threat factor.”
• “People (especially other teachers) are asking questions about systems and the project.”
• “Teachers who have been relatively stagnant in the recent past are beginning to try new things.”
• “We have worked to create systems-based curricula.”
• “Students who participate in the LE’s seem to have a different focus after the LE’s.”
• “Some kids feel more empowered to think about their future.”
• “Some students are very excited about learning to model although we haven’t done much with this yet.”
• “This project has helped to break down barriers among the three middle schools.”
• “We’ve created a great deal of systems curriculum.”
• “We seem to have fostered a surge of computer use (directly & indirectly).”
• “There has been a change in our own thinking and associated personal growth.”
• “Students who have come in contact with our ST/SD units seem to grasp the information easier and retain it longer. They also demonstrated the ability to apply what they have learned.”
• “Students can recognize ‘levers’ and possible consequences (or tracks).”
• “There is a hesitation before arriving at a decision (brain engages first).”
• “Students are beginning to confidently approach problem-solving.”

Individual Learnings:

• “By not rushing we have been able to experiment with how to make ST/SD meaningful to students and teachers. We have attempted to demonstrate how ST/SD can enhance what is already going on in classrooms not replace it. By reducing the threat to teachers they are more willing to try things.”
• “A large LE is not necessary in order to change a teacher’s style of teaching, as a matter of fact the use of an LE will not insure permanent change. They are a vital aspect for general distribution but any long term change must come with teachers interested in using small pieces in lessons they are already doing, such as behavior over time graphs, causal loop diagrams, stock/flow diagrams.”
• “Teaching ST/SD as a separate “subject” to students is not as meaningful as introducing the concepts while they are studying something they are familiar with. Better put--teaching it in context rather than separately.”
• “I have come to the realization that interdependence is not just something to talk about in natural systems. It is a necessity in human created systems - projects.”
• “I have become more acutely aware of the levers that I control in both my personal and professional lives.”
• “Contrary to the direction that were led in the beginning, systems thinking is much more than STELLA II.”
• “I am much more aware of the mental modeling that occurs.”
• “I am seeing the interconnectedness of all things, especially in light of how my actions affect those around me, whether they be my family, my students, or my fellow travelers on the interstate.”
• “I have gained an understanding of the ubiquity and power of accumulations.”
• “I can now appreciate the power of supporting negative feedback instead of fighting positive feedback.”
• “I realize now how hard it is to get people to change how they think: you must ‘come back to it’ time after time before they start to internalize it.”
• “The absolute most important thing that I have learned is that I have control over my decision-making and reactions to life.”

41
• “I’ve come to understand that interdependency is a necessity.”
• “I now understand that nothing just happens.”
• “ST/SD goes beyond modeling (become more aware of mental models).”
• “ST/SD has increased my ability to carefully think through problems and to arrive at
  a sensible solution (some of them, sometimes).”
• “For every cause, it is important to look for the effect.”
• “I have an increased sense of needing to recognize my own responsibility for
  actions.”

Challenges

• “There was no “how to” book - we had to take a method designed by non-educators
  or upper-level educators and bring it down to a practical level for us. The project up
  until now has been open experimentation. We recognized the “experts” might not
  know the right way either and that we needed to try different things. We are still
  learning.”
• “Not everyone needs to be able to model - there is so much more. The importance
  of the model is in the making not in the final produce. The discussion that takes place
  to create the model clarifies thinking - a person who has problems modeling solo can be
  talked through building a model and learn just as much. Or building a model
  according to their picture for them and trying to run it might make them realize some
  errors in their thinking. They don’t have to build it themselves.”
• “Teacher training and classroom implementation -- a mentor is vital to support
  teachers -- teaching teachers in classes is only one step -- they then need support to
  actually try things in classrooms.”
• “We have to have enough patience to allow things to develop slowly. If we force
  change upon people it will be temporary and superficial. We must allow people a
  chance to learn at their own pace as we did and use ST/SD in ways that make sense
  to them.”
• “We must continue to explore and experiment with ways to implement and teach
  ST/SD.”
• “Classroom implementation of ST/SD is not enough. We must figure out a way to
  bring the ideas of organizational applications into the structure of our project, schools,
  and school system.”
• “The original structure of the project was idealistic. When it “collapsed” due to loss of
  funding, we did not set up a sound second structure. Our original vision was too broad
  and general and we “assumed” we were all headed in the same direction. Actually,
  we were but each of us was on a different road, so instead of helping each other over
  roadblocks, we caused roadblocks on each other’s road. Going back and making sure
  we are on the same road, etc. is a much more painful process than it would have been
  at the beginning. Of course, at the beginning, we did not know enough to decide on a
  road. A heck of a loop!!”
• “Questioning one’s paradigms is always a challenge. Being aware of these
  paradigms and how they were created precedes shifts.”
• “Modeling!! The only times in my life that I have actually felt stupid are those times
when I attempt modeling with STELLA. We have to help people get past the “STELLAphobia” stage.”
• “Developing a Core Team that can work together is an ever-present challenge.”
• “We are realizing that there is a lot more to ST/SD than STELLA models.”
• “Defining ourselves as a project: what are we trying to do?”
• “Continuing to produce LE’s especially ones that key in on ST/SD skills, not just interesting simulations.”
• “Expansion of the project to the use of ST/SD in all Glynn County Schools will be a major challenge.”
• “Maintaining community among nine busy, strong-willed individuals who have been committed and involved since the first days of the project but who only see each other once a month is difficult.”
• “Putting what we are trying to share in understandable & meaningful terms has been difficult.”
• “We need some type of formal assessment instrument/plan.”
• “We need to win the ongoing support of administration.”
Setting

The Harvard Public Schools are located in the suburban community of Harvard, outside of Boston, Massachusetts. It is a K-12 system consisting of a high school (9-12) and a middle school (7-8) located on the same campus and called The Bromfield School with a student population of 450. The elementary school is located nearby and serves a student population of approximately 600. The working adults in the community of some 5000 residents are employed in a wide range of occupations which include, for the most part, managerial or professional positions. A correspondingly high level of educational attainment and above-average family income have resulted in a community that values education and has high academic aspirations for its children.

District Philosophy/Goals

The Harvard Public Schools are dedicated to giving every student the opportunity and means to acquire essential and applicable knowledge in the content areas, and command of the critical reasoning and higher order thinking skills requisite for problem-solving, research, and continuous learning. Complementary to its focus on students as learners, the schools are committed to helping students develop the interpersonal skills necessary for working effectively and cooperatively with others and to become responsible school, community, and world citizens. In support of the realization of this mission, the schools will embody the community’s standards and expectations.

Project Goals/Philosophy

Our beginning philosophy was simple: to explore ways in which to involve our classrooms in "systems approach" activities and evaluate the benefits and drawbacks of doing this.

It is important to illustrate to students the connections between apparently unrelated aspects of a complex system. It enlivens the potential for interdisciplinary teaching and the development of more critical thinking in the learning process.

1996-97 goals include the expansion of the use of systems thinking and system dynamics in the classrooms and in the organization of the Harvard School District and
to explore ways in which systems dynamics can be used to integrate various disciplines.

**History of Project**

Initially, the classroom teachers involved looked for existing models, talked with people using them, and went to conferences and workshops to learn more about the techniques. As teachers became more proficient, they knew how to better judge the relative benefits and appropriateness of various techniques. They were interested in exposing students to models and systems analysis which paralleled real life experiences, including at least several which dovetailed with experiments they would be likely to complete in the labs of their classes.

June 1996 marks the end of the first eighteen months of the project, “The Introduction of Systems Dynamics into the Classroom” supported in part by the Center for Excellence in Science and Math Education (CESAME). This project involved two high school science teachers, one middle school science teacher and, peripherally, one high school math teacher. Each has introduced several activities into classrooms during the year. In science classes seventh graders observed bacterial colonies on agar plates and built a STELLA model of exponential growth. They also worked with a model of the spread of an epidemic as they studied a unit on AIDS. The ninth grade earth science classes played the Fishbanks game as well as worked on a Fishbanks STELLA model. The environmental biology class worked with a predator prey model. Physics classes worked with models for air drag and modeled a lab experiment on falling coffee filters. They worked with a bungee jumping model, and they related the exponential temperature drop of a coffee cup to a STELLA model of a cooling coffee cup. In Math classes, some students chose to do independent projects using STELLA Models. Their topics were: predicting proper drug doses, the mathematics of exponential growth, modeling infinitely converging series, and predicting optimal bets in monopoly games.

Plans are in place to involve more middle school teachers and to create more interdisciplinary involvement among the teachers. A leap forward is anticipated in terms of more time and resources, deeper involvement and increased numbers of teachers involved due to the acquisition of a grant to fund training and a mentoring position.

Teachers from the middle school are currently participating in a collaborative grant project as a part of the Center for Excellence in Science and Mathematics Education at Northeastern University. The purpose of this grant project is to develop a series of lessons and activities that enable middle school students to think more rigorously about how things change. The team of teachers from Harvard and from four other middle schools in the area will develop hands-on, inquiry-based activities, lessons, and assessments, in conjunction with STELLA simulation software, that would
introduce middle school students to mathematical modeling and a systems approach to complex problem solving.

**Quotations from Project Participants**

**Notable Results:**

- “As students cycle back and forth between hands on data from real events and STELLA models which attempt to simulate those events, they grow in their confidence to build and refine models to better approximate reality. This is an empowering experience for them as they begin to understand concepts to a greater depth."

- “The dialog which results as small, thoughtful groups discuss and refine models, promotes and reinforces critical thinking skills."

- “Students learn that the validity of a model is based on assumptions and that the predictive value of a model is directly linked to the quality of those assumptions.”

**Individual Learnings:**

- “Systems thinking is necessary for successful change.”

- “The learning curve for systems thinking/system dynamics is very steep.”

- “We need time for teachers to meet while at the same time dealing with the controversy over teacher release time.”

- “We’ll know that systems thinking and system dynamics are integrated into schools when the educators who now stand out as innovators in this area melt into the background.”

- “Initial student built models were not sophisticated enough to challenge thinking. We needed to carefully plan instructional activities, including the use of models to stimulate and develop high level thinking.”

- “Although models are accessible through the Creative Learning Exchange, we still need guidance in relationship to “best use.”

- “We need a mentor to make connections between what’s available and what teachers are doing.”

- “Our latest thinking is that we need to minimize the need for teachers to build their own models”. 
• “We need enough models in use in classrooms for the students to see the threads, the progression between the models.”

Challenges:

• “We have made some progress in becoming more familiar with systems thinking terminology, techniques, and modeling but the learning curve is very steep.”

• “Several staff members have identified appropriate ways of introducing ‘systems’ activities.”

• “Although there have been many challenges, we have been successful in struggling through initial model building / model refinement”

• “We are still working to find the time and resources to involve other colleagues in the systems approach to education thereby attaining a greater critical mass and better potential for interdisciplinary activities.”

• “We could benefit greatly from locating a bank of models applicable to various curricular topics which could be refined to meet the needs of teachers just starting in systems thinking and the related pedagogical techniques.”

• “We need help in defining local issues which could be modeled using STELLA and incorporated into classes as relevant topics of interest to students and the local community.”
LaSalle College Preparatory School
Portland, OR

Setting

LaSalle College Preparatory School is a four year Catholic high school located in southeast metropolitan Portland, Oregon, where students are nurtured, loved, and educated by teachers who are inspired by the traditions of Brothers of the Christian Schools. The school serves 540 students in grade 9-12.

School Goals/Philosophy

Fidelity to three essential traditions continue to characterize La Salle in its daily operation:
• Students are challenged to respond positively to their moral and spiritual responsibilities through daily instruction in the Religious Studies curriculum and by the impact of the Campus Ministry Programs of prayer, liturgy, retreats, and service to others.
• Students are challenged to succeed academically according to their intellectual ability. The majority prepare for college through enrollment in courses directed at the challenges of higher education. La Salle’s four-year curricular offerings place a distinctive emphasis on mathematics, science, English, foreign language, social studies and fine arts.
• Students are challenged to grow socially by sharing their personal interests and skills with peers. Such growth is assured by participation in diverse student activities such as leadership opportunities, theatre productions, and the Falcon athletic teams.

In every phase of school operation, the student is respected and revered, approved and affirmed, instructed and loved. Based on the belief in the unqualified value and dignity of each student, this attitude prevails as fundamental in giving life to the three traditions of spiritual formation, academic achievement, and social maturation.

Student interpretations of the six characteristics of a Lasallian school:
• Value the individual. • Push your limits. • Accept everyone. • Respect all persons. • Respond to the poor and overcome injustice. • Prepare for life.

Project Goals/Philosophy

During the next year, the activities of the project will be focussed on increasing instructional applications of systems thinking and system dynamics. Long term goals
would include having every student experience ST/SD tools at least twice at each grade level. In addition, applications to school-wide issues and other organizational situations will be explored.

**History Of Project**

Having participated in systems thinking and STELLA training provided by the Portland CC-STADUS project, one LaSalle teacher began using dynamic modeling in literature classes during the 1994-95 school year. Student responses were very positive and the resulting discussions and writing demonstrated high levels of critical thinking and analysis. Motivated by success, the teacher began to discuss other possible applications with colleagues. Interest was stimulated, especially in the science department.

During the 1995-96 school year, several teachers worked together to implement units of instruction that involved computer models based on system dynamics. Dialogue and collaboration among teachers continued to build an interest in learning more about potential applications of systems thinking and system dynamics and in developing the most appropriate applications for the LaSalle program.

For some time, the staff at LaSalle has worked to equip classrooms with computers and/or other contemporary technology that will help to diversify instructional methodology and thus help the students fulfill their learning potential. In keeping with the school goal of utilizing the state-of-the-art computer facility as an educational tool across the full spectrum of the curricula, computer models have been used in science, English, and Health classes. Use of these models has stimulated interest on the part of students and teachers. Implications for future “whole school” projects that could involve the use of systems thinking tools and concepts include the Senior Project and the junior research paper.

Interest in organizational applications of systems thinking is growing. Possible connections have been suggested during staff planning sessions this spring. During the summer, staff members will participate in workshops that will provide an introduction to and practice with the tools and concepts of systems thinking and system dynamics. Participants in these workshops apply the use of ST/SD tools to a “school-wide” issue and will also plan for instructional applications within and across disciplines.
Quotations from Project Participants

Notable Results:

• “Students want to do more of it. The differences of opinion create discussion.”

• “Students who use models and understand how they work, tend to be more skeptical of other (new) information. They even question the behavior represented by the graphs.”

• “Writing improves at a deep level—that is, not a stylistic advance, but a content/conceptual advance—greater depth and breadth.”

• There is a far deeper understanding of stories that are represented with modeling. Students give much more substantial answer to questions and can answer with more authority. They have to think it through, have to have evidence.”

Individual Learning:

• “Using SD must fit in a curricular context, not just added, but within a planned framework.”

• “Simple models work - give students a starting point to adapt, enlarge model as well as to learn STELLA.”

• “Using computers in the classroom made me feel like a rookie teacher.”

• “Each model is a rhetorical position statement.”

• “I’ve seen it destroy cliches.”

• “Using ST/SD has changed the way I ask questions as a teacher.”

Challenges:

• “Most students now expect it will happen and some of the novelty has worn off (I can hardly believe I am saying this!).”

• “We want to include/introduce STELLA to ALL Freshmen in the next year: we have a small school (540) and so finding one class is possible - we’re hoping for Health.”

• “Faculty members are still reluctant to use it but some are warming up to it. BUT, they are swamped and have little time to learn. I can assist, but I can’t be two places at once. I sense a growing understanding and internalizing of the systems paradigm, however. THAT IS HUGE! We think we can take a major step forward with
awareness. After awareness, comes change.”

• “Developing a common vocabulary through systems thinking is very powerful but takes a considerable amount of time and much dialogue between staff members.”

• “I must Create a System or be enslav’d by another Man’s. I will not reason and Compare; my business is to Create.” (William Blake)
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, 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 concepts 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 included support from The Waters Foundation and workshops for administrators and teachers. While most of the classroom applications are occurring at Lawton School at this point, organizational applications are occurring 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 from 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 administrator, I found it very difficult to garner financial resources to keep this work in progress 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 in the from the beginning in efforts to learn about systems thinking, we went from being part of an 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.”
MAUMEE VALLEY COUNTRY DAY SCHOOL  
Toledo, OH

Setting

Maumee Valley Country Day School is a college preparatory, co-educational, independent school for pre-school through Grade 12 located on 70 acres in south Toledo, Ohio. The total population of 468 students is organized into 3 year-olds, pre-school (4 & 5 year-olds), primary (grade 1 & 2), lower intermediate (grade 3 & 4), upper intermediate (grades 5 & 6), middle school (grade 7 & 8), and upper school (grades 9 through 12). The school attracts motivated, able students who have a range of academic interests and diverse backgrounds, and whose families value education. Its challenging curriculum, student-centered school life and supportive community inspire and equip students for a lifetime of learning.

School Philosophy

The school’s mission is to enable students to become enlightened, compassionate and contributing citizens of our global community, while preparing graduates for their best opportunities in higher education.

Project Philosophy/Goals

Project goals include integrating systems thinking and system dynamics into the Maumee Valley classrooms and organization, and utilizing systems thinking and system dynamics to positively influence the educational goals of the school. Long term goals focus on having all children think in terms of circular causality as well as linear causality and to have systems thinking/system dynamics so ingrained in the school that a mentor will no longer be needed and that the staff will be able to assume a leadership role in providing workshops for others.

History of Project

In June of 1994, the new head of the school came to Maumee Valley with a familiarity of systems thinking and encouraged a math teacher, who was also head of the middle school, to attend the Systems Thinking and Dynamic Modeling Conference in Concord, MA. Excited about the use of computer models, the middle school head introduced the K-12 faculty at Maumee Valley to systems thinking at the beginning of the year faculty meetings in the fall of 1994.
During the 1994-95 school year, a faculty/administrative group reading group met two times each month to discuss readings from *The Fifth Discipline*, "Roadmaps", and other sources. The group included teachers and administrators from the lower school, the middle school and the upper school. Interest in systems thinking, system dynamics, and dynamic modeling continued to grow.

During the summer of 1995, a group of faculty, students, and administrators attended a STELLA modeling workshop at Maumee Valley facilitated by trainers from Trinity College in Burlington, VT. Teachers from the lower school, the middle school, and the upper school were in attendance, as well as students from the middle school. Participants had an opportunity to learn about STELLA and to begin the development of a model or to learn about or adapt existing models that were developed in other K-12 projects.

The group reconvened for a day-long workshop in October to complete work on models. Computer models were used in upper school English and chemistry classes during the first semester of the 1995-96 school year. Students and staff were excited about the results and were motivated to locate, design, and implement additional computer models as well as other strategies for systems thinking. In December of 1995, a team of teachers and administrators from the lower school attended a workshop on systems thinking in elementary education in Ann Arbor, Michigan.

During the second semester of the 1995-96 school year, the systems reading group members continued to meet and added new members. A full semester modeling class was implemented for upper school students. Members of the class have learned about STELLA modeling and have developed models to demonstrated required skills for the modeling class as well as for use in presentations in other classes. Students from the modeling class help other students as well as teachers to design models that are related to the curriculum of various classes.

Members of the Systems Reading Group are working together to plan next steps in terms of group meetings, collaborative mentoring, summer conferences and training, and plans for the 1996-97 school year. Future plans include the use of systems thinking and system dynamics in both the classrooms and the organization at all levels, pre-school through upper school. Plans are in place to acquire a full-time mentor for the staff who would undertake the following tasks: become familar with the school’s curriculum, K-12; do a nationwide search for STELLA computer models that can supplement the MV curriculum; work with teachers to introduce STELLA computer models to their classes; develop with teachers STELLA computer models that teachers want; support teachers in their efforts to create and/or maintain learner-centered learning environments; run workshops for teachers and administrators on modeling and the application of systems thinking in the school.
Quotations from Project Participants

Notable Results:

• “Students are thinking about and questioning the interrelationships of changes in their environment.”

• “I think there is a greater willingness on the part of my fellow administrators to weigh the impact of their decisions on areas other than those for which they are directly responsible. It has provided the language for dealing with issues that might previously have been seen as really not concerning me. Retention and recruitment of students, in particular, have been more readily seen to be affected by other seemingly unrelated decisions throughout the school.”

• “When using system dynamics models, there is an immediate student interest and facility in learning. There is a willingness on the part of students to recognize and talk about complexity and interdependency of issues.”

• “Systems thinking has helped us to discover a large number of hidden balancing loops within the organization.”

• “Self-interest is a strong motivation to resist change. . . . those who seek change as a means towards growth will emerge to set a positive example. This I hope will move the cautious from behind the fence and into the game.”

• “Prior to incorporating systems thinking, the administrators were clearly focused on their divisions, as opposed to their first focus being the school in its entirety. The introduction of systems thinking has provided division heads a broader framework in which to operate. They are now talking systems, and influencing others to look at the whole, to see that specific decisions have impact beyond the immediate problem or concern.”

Individual Learnings:

• “Though our initial experiments with modeling were successful and the students most enthused, we have hardly touched the surface in utilizing systems in our school. We are going to undertake additional training this summer, but it is clear that we need ongoing year around support.”

• “The introduction of systems must be a slow and a steady process. Monies must be allocated for training during the summer and during the school year to sustain development of projects. A systems mentor at the school is essential to make constant, forward progress.”
• “The important learning from modeling is that you must identify what is significant in a situation or a system.”

• “Numbers aren’t the whole answer. Lots of exploration and questioning is needed and evolves from student interaction.”

• “Learning the beginning stages of modeling using STELLA has been quite interesting. Even though I don’t use modeling at this time, going through the process of writing a model has helped me to visualize how systems work. In addition, by practicing systems within the organization, I have more confidence that we are cooperating more and competing less internally. This has the result of helping me to trust my colleagues more.”

• “I have realized how hard it is to get to a level where I can comfortably use STELLA but I am learning how systems thinking applies to nearly everything.”

• “. . .hard to distinguish those learnings that have occurred because of my efforts to understand systems thinking and those that have occurred simply because I am new. My endeavor to understand systems has led me to view organizations in a more objective manner. This I hope will help me become less reactive to peoples’ resistance to change and to better understand their motivations, which will allow me to mend fences and to build better bridges. Confrontations seem to be inevitable during periods of change and understanding is a means of defusing people’s fear and anger.”

Challenges:

• “There is a list of 7 levels of systems thinking and I’m only at level 2/3. I would like to identify what readings and activities will help us move upward on the levels.”

• “Our approach to systems involved computers so much that those not inclined toward technology were scared off. Our biggest challenge is to help the teachers in non-math/science classes to see the ways that systems can be applied in their disciplines. Mostly, I think we need a team leader in systems who can help teachers find ways to integrate systems into what they are already doing.”

• “There is a need for facilitator or mentor to help us with modeling skills.”

• “We need more equipment and/or convenient use of a computer lab.”

• “There is a need to make STELLA output more “catchy” than just graphs and tables.”

• “We are still new at it. I believe enthusiasm for the idea remains strong. The biggest challenge is writing a proposal to secure local funding for a mentor and training. The next challenge is helping the K-4 group of teachers understand how to apply systems
concepts in their classrooms.”

• “. . .trying to convince people that STELLA is not systems thinking but rather a tool through which we are able to demonstrate, model and perhaps even reveal systems. The fear of technology is overpowering for some so the need to help them keep things in perspective is important. This remains a challenge.”
RIDGEWOOD PUBLIC SCHOOLS
Ridgewood, NJ

Setting

The Ridgewood Public School District is located in Bergen County, NJ, 13 miles from New York City. The Village of Ridgewood is an upper/middle class community. The school system includes six elementary schools (K-5), two middle schools (6-8), and a four year high school. Willard Elementary serves 400 students.

District Goals/Philosophy

The district supports its staff through an on-going staff development program that emphasizes the importance of teachers as curriculum designers. Teachers are expected to maintain knowledge and expertise in current educational practice including problem solving and teaching cognition, higher order thinking skills, cooperative learning, whole language, literature-based curriculum, technology as a tool for learning, learning styles, multiple intelligences, alternative assessment, NCTM standards, and a constructivist approach.

Project Goals/Philosophy

The goals of the project have included providing a variety of workshops for staff and for parents throughout the district for the purpose of introducing the concepts of systems thinking and stimulating the development of classroom and individual practices related to those concepts. The content of the workshops is directly related to the instructional skills and practices being emphasized in the school district. Elementary applications of systems thinking and system dynamics have been an area of special focus and involve introducing and reinforcing the concepts that everything is connected to everything, events can occur in cycles, several causes can lead to one effect, and that you can draw a map of an event or system. An understanding of systems that elementary students already have in terms of family, nature, and patterns is encouraged.

History of Project

Following an introduction to systems thinking through Peter Senge’s book, The Fifth Discipline, two district staff members began collecting resources, attending conferences, establishing a network and developing their knowledge and understanding of systems thinking and system dynamics. During the 1991-92 school
year a series of staff development workshops were developed and made available to district staff members. The original workshops included an introduction to systems thinking and training in STELLA computer modeling. Workshops continued through the 1992-93 school year.

During the 1993-94 school year, one of the staff members became an elementary principal. This change in assignment provided an opportunity to focus on elementary applications of systems thinking and system dynamics. He saw systems thinking as a tool that teachers could use to demonstrate interrelationships in the curriculum, including literature, social studies, science, language, mathematics, the arts, and school citizenship. During that school year, teachers at Willard Elementary School were involved in additional training, discussions and collaborative efforts to develop elementary applications of ST/SD.

Efforts to integrate systems thinking and system dynamics continue at Willard Elementary and through the district staff development courses. A number of elementary “pre-modeling” strategies have been designed and implemented including use of encouraging learner-directed learning in collaborative groups and mapping and modeling events and patterns across disciplines. In addition to STELLA software, “Inspiration” and “SemNet” are used to help students to develop mapping and modeling skills. Use of these tools and concepts has also been productive in work with learning disabled students. Staff members also utilize mapping tools to diagram school issues such as inclusion, use of the computer room, professional development, individual and school goals, etc.

An ongoing goal is the spread of systems thinking and system dynamics throughout the school district. Examples of possible middle school and high school applications are made available to staff members at those schools through the available workshops and individual sharing and collaboration. Individual use of the tools of concepts of ST/SD are beginning and are further motivated by new efforts in the state of New Jersey to set standards for systems thinking in K-12 education and by a proposed resource and training center at the Princeton Plasma Lab.

Quotations from Project Participants

Notable Results:

- “Teachers involved with problem solving and cognition recognized systems thinking as a natural extension of their curriculum work. The use of models as graphic organizers have been implemented in teaching problem solving throughout the district.”

- “We were able to show teachers involved with whole language and literature-based
instruction STELLA models of Romeo and Juliet and worked with them to design new maps and models for current grade level literature.”

• “Teachers are using “Inspiration” models to map out their goals for the year. This tool helps to start meaningful dialogue and helps groups build team vision and team learning.”

• “Because our district has a history of curriculum evolution, we can fit ST/SD into existing strategies. It’s not something totally new.”

• “Multi-age grouping, the systems approach, critical thinking, and problem solving have proven to be well-matched strategies which work together well in the elementary classroom.”

• “The long term prognosis is very positive. More and more people are buying into the use of systems thinking, including teachers at the secondary level and our parent community. It does seem to make sense to everyone.”

• “We have incorporated an International Day which utilizes the concepts of systems thinking, involves a number of community members, and give students an opportunity to study a complex problem and to propose long term solutions in a presentation. A similar application came out of a middle school convocation and has resulted in a district-wide celebration of cultural differences where groups are given the task of designing a holiday that celebrates everyone.”

• “In a study involving the use of ‘Inspiration’ software as a graphic organizer results included improvement of memory, comprehension, and analytical skills when students are given a framework and a process of recording data. These experiences with ‘pre-modeling’ skills have positive implications for the related uses of dynamic modeling tools with older students.”

Individual Learning:

• “Systems thinking should be seen as another tool we can use to teach problem solving and cognition.”

• “This is like teaching someone to drive via What do you think will happen if . . . ? vs. Stop! Don’t! Turn that way!!!”

• “We have made the most progress through infusion - any place we could fit it - we did. We have used the ‘do and learn’ approach - maybe it’s the best way.”

• “Systems thinking starts with trying to understand relationships.”

• “Children’s behaviors often reflect an inherent understanding of how ‘the system’
works. *Children are natural systems thinkers.*

- “Learning styles training is very important because it helps staff members to understand varying approaches to mental models.”

**Challenges:**

- “Teachers don’t need one more totally new thing. ST can be used to simplify, get to what’s core.”

- “You need to have patience because the ‘ah-hahs’ may not be seen until students have more than one year of experience with ST/SD.”

- “Articulation with higher grades is essential but challenging and time consuming. We have to keep emphasizing the importance of reinforcing and building on what was taught earlier.”

- “Although we all have busy schedules, we need to consistently seek out and take advantage of opportunities to be with people who are doing more, doing it better.”

- “Parents are a resource but that’s a tricky balance. People are talented and want their talents used but they’re not professional educators and there are time limits. Teaching parents to be involved without taking too much away from school time is a challenge.”

- “Leadership at the central office is crucial but can be difficult to develop given the multiple and complex responsibilities of managing a school district.”