

Revitalizing the Schools:
A Systems Thinking Approach
by
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When companies like Motorola must invest millions annually to educate its workers in basic math and reading skills, it reveals a deeper problem—an ineffective educational system. Revitalizing our schools is fundamental to our ability to remain competitive in the rapidly changing global marketplace. This special report provides a glimpse of the slow-building revolution—fueled by a systems thinking approach—that is taking place in education. —C.L.K.

Fortune magazine recently labeled the US school system "our most endangered institution," highlighting a growing national concern about the quality of education in America. Steadily rising rates of illiteracy and dropouts underline a harsh reality—schools simply are not preparing students to be productive members of society.

Many corporations, who have watched their skilled labor pool shrink over the past decade, are responding with a slew of innovative approaches to education. In 1989, Fannie Mae began a ten-year mentor program in a Washington, DC high school. Sears and United Airlines, along with 14 other Chicago-area corporations, have donated \$2 million to start a model school that practices school-based management. Citicorp, Exxon and RJR have donated money toward the Coalition of Essential Schools, a network of over 50 schools dedicated to curriculum reform which focuses on active, small group learning.

The Role of Systems Thinking

Out of these innovative educational programs, a vision of a radically different school system is emerging—one that is managed more like an organization, where teachers are accountable for their students' results and principals have the power to give raises and fire teachers; a school where the curriculum stresses critical thinking skills over dry facts and learner-directed learning replaces the typical lecture format. Systems thinking holds the promise of making such a school a reality.

Primarily, systems thinking is being applied to schools in one of two ways: as a problem-solving framework that enhances students' understanding of a subject; and as a restructuring tool for creating a more effective educational system (see "Systems Thinking in the Classroom: Two Accounts" for an example of how systems thinking is being used in the classroom). The two perspectives are not mutually exclusive. Says Jim Daniel of the Kentucky Educational Foundation (KEF), "As systems thinking creates a new culture within the school system, that change should eventually translate into systems thinking being taught in the classroom, as a problem-solving approach."

A "Hybrid"

Frank Draper, a biology teacher at the Orange Grove Junior High School in Tucson, Arizona was first introduced to systems thinking in 1988. Dr. Gordon Brown met with Draper and another science teacher to explain to them the power of systems thinking in the classroom. "He talked briefly about system dynamics and showed us a videotape of students using computers. Then he brought out STELLA, a system dynamics application for the Macintosh," recalls Draper. "Our first words were 'We can use this!'"

Draper took a copy of STELLA home, tinkered with a few models in the manual and created a few of his own, "all with the awareness my teaching would never be the same." Three years later, the same might be said of education in Orange Grove. Systems Thinking is now being used in almost all of the science curriculum at the junior high

school, and it is in the process of being expanded to all six schools in the district, including a new high school that is under construction.

Orange Grove Junior High is a hybrid of traditional educational techniques and innovative new methods. Teachers still give grades and have one-hour classes devoted to a particular subject. But courses no longer have specific titles, such as biology or history—report cards sport such broad-ranging topics as human studies and marine studies, which emphasize the systems orientation of the subjects. Classes are scheduled in blocks (for example, science and social studies are back-to-back), so that they can be shortened, lengthened, or combined to allow students to pursue more in-depth projects in one subject or both.

Because of the flexible scheduling, teachers are able to pursue more interdisciplinary projects with their students. For example, one class recently conducted a mock trial to learn first-hand how the legal system works. However, the subject of the legal dispute was scientific, allowing them to expand their knowledge in that area as well.

In a traditional school system, with its rigidly defined class schedules, such a project might provoke anger by teachers whose classes were preempted for the mock trial. But at Orange Grove, the use of systems thinking in the classroom has led to structural changes in the entire school to support such learning. Teachers for each grade now share the same planning period, which helps them plan inter-disciplinary projects together. And to encourage communication and collaboration across all levels within the school, teachers, administrators, and staff are organized into teams and task forces that meet to discuss wide-ranging issues.

Systems Thinking has sparked a dramatic change in the roles of teachers and students at Orange Grove. "In our classroom, students shift from being passive receptacles to being active learners. They are not taught about science per se, but learn how to acquire and use knowledge, scientific and otherwise," says biology teacher Frank Draper. "Our jobs have shifted from dispensers of information to producers of environments which allow students to learn as much as possible."

From Vermont to San Francisco

The Systems Thinking and Curriculum Innovation Network Project (STACI) began at the Brattleboro Union High School in Vermont in 1985. Four committed teachers wanted to use systems thinking to improve their teaching, but they had no computer skills or understanding of systems theory. Undaunted, they applied for and received a grant from the US Department of Education, and enlisted the support of High Performance Systems, creators of STELLA, to give them technical assistance and training.

Their work attracted the attention of researcher Ellen Mandinach of the Educational Testing Service (ETS), who was interested in studying the impact of technology on learning. ETS, through its affiliation with the Educational Technical Center at Harvard, established STACI to examine the introduction of systems thinking in the Brattleboro High School.

Mandinach, the director of STACI, describes the Brattleboro experience as an "eye-opener." Although the process was slow-going, Mandinach reports that in this last year there has been a substantial amount of systems thinking being used in the Brattleboro school. Most importantly, ETS researchers learned first-hand how systems thinking takes hold in the classroom, and what it takes to get it going—two lessons that would serve them well in California.

At the prompting of an Apple Computer representative, ETS decided to try a similar experiment on the West coast. "We learned from our early experience in Vermont that teachers need lots of resources, training and support," explains Mandinach, "so rather than pick one site in California, we decided to use a consortium of schools." In order to create a continuity of systems Teaming for the students, they selected two San Francisco middle schools and the four high schools that they feed into.

The kick-off event for the STACI project in San Francisco was a two-week training course put on by High Performance Systems in July of 1988. Since then, they have continued ongoing training with the teachers—one week in June and one refresher weekend in February. Teachers are linked by electronic mail throughout the year to exchange ideas and offer support as they work to integrate systems thinking into their curriculum.

The extent to which systems thinking is used varies among the participating teachers—one physics teacher's goal is to integrate his entire curriculum into a systems theory, while other teachers are using it initially in just one subject area. In the Hill View Middle School in Menlo Park, CA, the science, math, and literature teachers are working together on a multi-disciplinary approach to their subjects by collectively teaching nine-week units organized around a common topic.

Mandinach describes STACI as an "implementation project" whose focus is on developing materials, training teachers, and providing resources for those teachers to develop systems-based curricula for the classroom. But she adds, "Ultimately, it is a study of the impact of systems thinking on students, classrooms, and schools.

"What happens to teachers, their instruction, and the classroom environment when a systems approach is used? You cannot introduce systems thinking into a school without changing the structure of the school. Do teachers start to cross disciplines, or communicate differently with each other and with their students? And, ultimately, do kids learn more effectively or efficiently using systems thinking? These are the types of long-term questions we are trying to answer."

Pre-College Education Project

Professor Emeritus Jay Forrester, the founder of system dynamics, has been the driving force behind the pre-college education project at MIT. Funded by John Bemis of Concord, MA, the project is staffed by MIT undergraduates who are exploring ways to introduce systems thinking into local schools. The project is only a year old and still at a "beginning point," says staff advisor Nan Lux, but in the past year the students have put together several tutorials for 11 teachers at the Cambridge Rindge and Latin School. The interactive tutorials, explains Lux, are intended to "grab teachers attention and show them another way to teach their subjects."

One of the most exciting things to come out of the project is the idea for creating a central clearinghouse to track the work being done on systems thinking in education. Although the plans are still in the works, Forrester sees the center as a "focal point to maintain communication between the network of schools, expand the presently available training seminars for teachers, and assist teachers in preparing their new materials for wider dissemination."

Kentucky—Starting Over

In 1989, prompted by a lawsuit in which 23 Kentucky school districts charged that funds were not being distributed equally, the Supreme Court declared the entire Kentucky state educational system unconstitutional. This watershed event sparked a complete restructuring of the state educational system. The result: the Kentucky Educational Reform Initiative (KERA), described as an "integrated, comprehensive, systemic effort to change public schools."

KERA will have wide-ranging effects on the way schools are structured and classes are taught. The end result, according to Jim Daniel, will be to "change the educational system to an outcome-based system." By 1996, schools will be graded on how well students solve problems, work in teams, and make the transition to higher education, the workplace, or the military.

KERA also established baseline performance goals for the schools: those schools that perform above the base range will receive more money and resources, while those who

fall below the range will be penalized. In order to foster choice in the school system, school districts will be required by law to publish their rating. If a school is declared in "crisis," parents can take their children out of the school at the state's expense. Successfully implementing KERA may prove even more challenging than drafting the legislation. To help facilitate that process, KEF has created the Institute for the 21st Century, a two-year leadership education and training program for educators. The goal of the Institute, says KEF's Daniel, "is to use a systems thinking approach to produce leadership teams of change within ten selected school districts." Each of the ten district teams participating in the project was nominated by a business partner and was selected on the basis of its commitment to change. The teams have eight members, composed of superintendents, principals, teachers and counselors who are key change agents in the district.

Together, they will embark on a two-year educational program that includes week-long resident sessions, ongoing learning modules on specific aspects of KERA (such as implementing school-based management and ungraded preschool programs), and monthly regional meetings for sharing ideas and experiences. The idea behind the wide range of activities is to give a comprehensive educational experience around all aspects of implementing a systems approach to school reform," explains Daniel.

The ultimate goal for the Institute is to foster innovation in education. In the type of school they hope to create, says Daniel, "teachers won't go to school to lecture students. Instead, they will act as resources and a facilitators for those students."

The Nordic Experience

In the Nordic countries, systems thinking was introduced as a result of their efforts to bring computers into the schools as interactive educational tools. Says Professor Pål Davidsen of the University of Bergen, "System dynamics filled that vacuum between the available technology and the educational goals of the schools."

The highly centralized educational system in the Nordic countries required a different approach. Rather than bringing systems thinking directly to the schools, it has been introduced in the graduate teachers schools. The idea, according to Davidsen, is to "train the trainers"—to teach educators how to use systems thinking, and let them develop tools and curriculum that will integrate systems thinking into the classroom.

Initially, computer simulations were used only to support the current curriculum by illustrating key concepts. Now educators are exploring more inter-disciplinary activities. For example, in a systems thinking study of the marine pollution, students can trace declining fish population to an overgrowth of algae caused by chemical fertilizers. This leads to a study of crop fanning and fish farming and their interaction—economic, cultural, and sociological. Understanding the many interrelationships requires further study of government regulations concerning both industries, the biological systems of aquaculture and agriculture, and the methods by which pollutants are transferred to and within the sea.

Computer models, explains Davidsen, remove the constraints of traditional educational material. "Computer models have a high degree of interaction, unlike textbooks. In effect, students can create their own course material, giving them a degree of creativity that is missing when working with textbooks."

Results

Early results of the use of systems thinking in the classroom have been anecdotal, rather than empirical, but they are encouraging. Frank Draper, for example, has witnessed a remarkable change in his classes: "Not only are we covering more material, but we're covering it faster and the students are learning more useful material than ever before."

Preliminary results from the ETS study at Brattleboro reveal interesting differences in skills acquired by students taught with traditional teaching methods versus those who were taught with a systems approach. In a General Physical Science class, so-called "traditional" students were able to identify and define patterns of speed and motion on simple graphs, but had difficulty with more complex problems. Systems students, on the

other hand, were more adept at synthesizing parts of problems to understand the entirety.

Another set of students in a physics class was given a story problem to solve, first using the traditional quadratic equation approach, then by designing a model and testing various hypotheses. After the exercise, students commented that when working with quadratic equations, the numbers did not have concrete, real-world meaning. But with the model, they were able to demonstrate theoretically and practically what the problem and solution meant.

Although the results of the Brattleboro study are preliminary, ETS's Mandinach notes that students "seemingly achieved a more conceptual understanding of the content and solution processes by using the systems approach." A more thorough implementation and systematic examination of the curriculum is in progress and will continue over several years to determine the impact of systems thinking on general problem solving skills. While many communities are making significant progress in introducing systems thinking into the schools, they are a long way from achieving the visionary school described at the beginning of this article. The main roadblocks are a lack of resources to fund innovative projects and the knowledge and experience to restructure the existing school system—two areas where businesses can play an important role.

Getting involved in the school system can no longer be viewed as a charitable activity—it is vital to businesses' survival because the labor pool on which they draw is the product of that school system. As Vivian Ruth Sawyer of Humana, a partner in the Kentucky reform initiative, points out, "We owe that responsibility to our stockholders for the long-term prosperity of our business."

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