Systems Thinking
A Skill to Improve Student Achievement

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Educators who understand that schools are complex interdependent social systems can move their organizations forward. Unfortunately, many education leaders today fail to grasp the interconnectedness of these components, resulting in little or no progress. As such, many planned changes address only symptoms, not the underlying root causes, of the problems. Subsequently, meaningful improvements do not occur. On the other hand, a number of outstanding education leaders are slowly moving toward approaches that consider schools as "organic organizations" capable of learning and continuous improvement. "The idea of a school that can learn has become increasingly prominent during the last few years" (Senge et al. 2000, 5). Central to this idea is Peter Senge's fifth discipline, systems thinking (1990).

Often leadership decisions cause many complex and unforeseen reactions. "Systems thinking is the ability to understand (and sometimes to predict) interactions and relationships in complex, dynamic systems: the kinds of systems we [educators] are surrounded by and embedded in" (Senge et al. 2000, 239). Systems thinking encourages leaders to use such concepts as continuous incremental improvement, organizational learning, and feedback loops. Systems thinking requires leaders to see the whole school as a complex organization with many interdependent components.

A systems perspective enables educators to make decisions related to improvement of student achievement and understand the impact of each decision on the organization. However, the No Child Left Behind Act (NCLB) has interrupted the status quo of schools and has forced education leaders to reconsider various methods of organizational change. The act has required all public schools to develop clear definitions of achievement, which provide the basis to evaluate progress. Senge (1990) identifies five disciplines that learning organizations consistently exhibit—personal mastery, mental models, a shared vision, team learning, and systems thinking. The fifth discipline, systems thinking, is especially appropriate for schools that are attempting to improve student achievement. In *The Fifth Discipline* (1990), Senge presents his model of systems thinking and the allegories that define the laws of systems thinking. These allegories illustrate common pitfalls that prevent systems thinking within organizations:

- Today's problems come from yesterday's solutions.
- The harder you push, the harder the system pushes back.
- Behavior grows better before it grows worse.
- The easy way out usually leads back in.
- The cure can be worse than the disease.
- Faster is slower.
- Cause and effect are not closely related in time and space.
- Small changes can produce big results; but the areas of highest leverage are often the least obvious.
- You can have your cake and eat it too—but not all at once.
- Dividing an elephant in half does not produce two small elephants.
- There is no blame.

In this article, we examine how schools can avoid these barriers to systems thinking in relation to improving student achievement. We then illustrate common errors associated with non-systems thinking and recommend solutions. These allegories can help educators

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avoid the underlying errors commonly made by non-systems thinkers. Because humans are hard wired for narrative, we believe that leaders can best understand, recall, and apply principles of systems thinking if the common errors are associated with stories and examples. The ultimate message is that systems thinking is a useful tool to initiate organizational change and continuous improvement.

Today's Problems Come from Yesterday's Solutions

Veteran educators have extensive histories with failed programs that had been designed to improve student achievement. The education profession continuously revises old programs and practices; the usual practice is to renew, rename, and then re-implement them as new programs. John Pulliam provides a graphic account of the profession's failure to learn from solutions to yesterday's problems:

> Much of what is regarded as new or innovative in education has a long historical record. For example individual instruction, team teaching, open classrooms, schools without walls, alternative schools for secondary students, work-study programs, nongraded schools, and competency based programs were all tried in one form or another by the progressive educators of the 1930's. (1991, 7)

The failure to recognize that supposedly new and improved programs are recycled former failures is an example of non-systems thinking.

Careful research would reveal the artful disguise of yesterday's failed solutions, so it is incumbent upon education leaders to evaluate the past success of parallel or close to parallel programs before they are implemented in schools. Nevertheless, education leaders can find many examples of data-based best practices that relate to student achievement (Darling-Hammond 2000; Marzano 1998; Marzano, Gaddy, and Dean 2000). However, for these programs and practices to succeed, motivated and capable people are needed to implement them. Marzano, Gaddy, and Dean (2000) conducted a meta-analysis to identify instructional strategies that have high probability of "enhancing student achievement for all students in all subject areas at all grade levels" (4). They identify nine categories of strategies that strongly relate to student achievement, discuss instructional approaches, and provide examples. Their research indicates that both effective teachers and effective principals relate positively to student achievement. Thus, the hiring and retention of quality teachers and principals is fundamental to systematic improvement.

The Harder You Push, the Harder the System Pushes Back

The field of education has many examples of systems "pushing back" because of ill-planned improvements. The No Child Left Behind Act was passed with the intent of improving student achievement—all students and schools will demonstrate proficiency on rigorous state tests. Many educators do not believe that this one-size-fits-all approach is realistic. As a result, the system is pushing back or resisting—standards are being reduced, educators are seeking employment in the private sector, funds are being redirected, and legislators are discussing revisions of the law (Bracey 2002; Mathis 2003).

Hard work alone is not sufficient to correct basic systems problems. Holistic analyses of problems are required. Instead of pushing harder on the various components of the system, leaders need to foster organizational learning, identify root causes of low achievement, and then systematically make adjustments. A systematic approach could require that each school establish a plan to ensure continuous incremental progress—feedback loops, documentation of individual students' progress, evaluation of systems, and planned, data-based improvements to the systems.

Data-based decision making is a high-leverage leadership approach that can facilitate systematic change and can promote improved student achievement (Berhnardt 1998; Holcomb 1999; Schmoker 1996). A data-based culture can empower teachers by providing timely feedback, improving access to meaningful information, and involving them in meaningful decisions. Knowledge enables districts to develop transformational changes, to learn, and to improve. Educators need to identify leverage points where small efforts can make large differences.

For example, disaggregation of data is a high-leverage activity. When the lowest achieving students can be identified by content area, the school can specifically address the needs of those students. Schmoker (1996) provides examples in which data establish the need to improve and then identify strengths and weaknesses. He states: "Data promote certainty and precision, which increases teachers' confidence in their abilities" (38).

Behavior Grows Better Before It Grows Worse

Many school improvement plans address symptoms but fail to correct the underlying system problems. These changes are low-leverage modifications. "Low-leverage interventions would be much less alluring if it were not for the fact that many actually work, in the short term" (Senge 1990, 60). The accountability required by NCLB includes an extensive increase in the amount of testing, and the penalties for failing schools are severe. As a result, many educators are undertaking two short-term solutions—teaching to the test and teaching students test taking skills. These familiar solutions improve short-term achievement scores, but the rate of growth will not be sustained over time.

Systems thinking is required at all levels of educational enterprise. Constructivism provides a good

example of systems thinking at the classroom level. This approach stresses that learning is an active process and that new learning is constructed from previous experience, ideas, and the environment. Jonassen illustrated the holistic nature of constructivist learning environments:

> "Constructivist environments facilitate learning through collaboration, context, and construction of knowledge. Through assimilation and accommodation, individuals use many elements of the learning context and relate those elements to their own experiences, thus creating new knowledge" (1994, 36).

The curriculum should be conceptual, help students apply knowledge, and enable students to experience constructive learning. Narrowing the curriculum to meet the demands of testing results in an overemphasis on rote memorization of facts, a neglect of higher order thinking skills, and the suppression of intellectual curiosity—this is non-systems thinking. Constructivist approaches emphasize essential principles and concepts and will result in higher test scores as well as a memorable education for students because they teach students how to apply that knowledge to new situations (Brooks and Brooks 1999).

In addition, a constructivist approach has significant systematic implications for staff development. Teachers often teach as they were taught. Therefore, teachers need to experience constructivist approaches as learners. For example, a three-year project funded by the National Science Foundation trained teachers to build and use systems thinking and computer modeling in science, mathematics, and social science classrooms (Zaraza 1995). The project used STELLA, a computer software program specifically designed to model systems. Zaraza provides numerous examples of teachers using systems thinking in the classroom, resulting in changes in teaching styles, increased in-depth learning, and improved critical thinking skills. In addition, the construction of the models enhanced student understanding, facilitated higher order thinking skills, and improved creativity and critical thinking skills. Students in the study exhibited increased self-motivation and became self-directed learners.

The Easy Way Out Usually Leads Back In

School bureaucracies define appropriate solutions to standard problems and educators routinely apply these familiar solutions as problems develop. Repeated applications of familiar solutions, even though fundamental problems persist or worsen, are a reliable indicator of non-systemic thinking (Senge 1990).

A common belief is that student achievement can be improved if better qualified teachers are in the classrooms. In most districts, salary advancements are not connected to teaching assignments or district needs. Teachers advance on a salary schedule regardless of their achievements. Little relationship between teachers' scores on standardized tests and student achievement exists, and the data fail to support the generalization that teachers with advanced degrees equal higher student achievement. This idea is unsupported by the available evidence (Darling-Hammond 2000; Goldhaber and Brewer 2000).

Darling-Hammond (2000) establishes that student achievement improves when teachers' knowledge and skills correspond to both the topic being taught and the characteristics of the students being taught. Ingersoll (2001) discusses the issues related to out-of-endorsement teaching assignments. New approaches are needed; teachers should be rewarded for skills that relate to improved student achievement. For example, higher salaries should reflect increased skills and improved pedagogy in teaching assignments. In other words, pay the good teachers who produce results more than the teachers who fail to do so. Clearly, these suggestions disturb existing bureaucratic structures, but current approaches have yet to produce the desired results.

The Cure Can Be Worse Than the Disease

Non-systematic solutions often aggravate, rather than improve, education problems by creating short-term solutions that are ineffective against long-term problems. "The long-term, most insidious consequence of applying non-systematic solutions is increased need for more and more of the solution. . . . [I]ll-conceived government interventions are not just ineffective; they are addictive in the sense of fostering increased dependency" (Senge 1990, 61). For example, if student math scores are low, then these underperforming students must attend summer school before advancing to the next grade level. These types of approaches address symptoms, but few leaders believe the root causes have been addressed. Consequently, more failures will result next year during testing.

Low achievement scores are a symptom of a broader system weakness. To avoid this pitfall, leaders must go upstream from the problem and ask the following types of questions: What data define the problem? Do we have a clear understanding of why scores are low? When the data are disaggregated by content, by age, and by teacher, what are the results? Are all students weak in the same areas? What system changes will most likely improve the scores? How can the impact of changes be evaluated? These critical questions can guide thinking toward identifying root causes rather than symptoms and help convert problems into opportunities to improve the system.

Faster Is Slower

Education systems have established traditional rates for student achievement and outlined the processes

schools need to follow to meet these standards. They also have created a calcified bureaucracy to enforce these rigid steps. However, in general, systems slow to an optimal rate of improvement whenever the growth rate becomes excessive. Often, the optimal rate is much slower than the fastest possible growth (Senge 1990). Rapid implementation of new programs causes confusion, fear of failure, and covert rejection. If teachers do not implement the planned programs, energy and resources are wasted.

A carefully planned implementation process is more effective and efficient; small pilot programs put into operation by teams of willing, well-trained teachers can implement the program as designed. Additional teams and teachers can be added when training and examples of success are available. Well designed implementations provide training, feedback, designed adjustments, and individualized support for teachers. Slowing the implementation process can actually result in faster system improvements.

As an illustration, Zarapa (1995) reports positive results for a carefully designed and implemented staff development program that taught systems thinking and systems modeling. More than 70 percent of the teachers regularly used the systems modeling software in their classroom and many teachers developed unique systems models. Systems thinking can be taught to teachers and subsequently used to improve student achievement.

Cause and Effect Are Not Closely Related in Time and Space

Senge (1990) recommends that leaders develop an understanding that, in complex systems, causes and effects are often not closely linked. Unfortunately, many education leaders and the general public lack a fundamental understanding of this reality: effective system changes take time. Very often, people expect improvements too soon after changes are implemented.

Systems thinking acknowledges that effective system improvements have minimal short-term effects and significant long-term effects. In education, new programs continuously follow new programs without effective evaluations or sufficient time for changes to impact student achievement. When educators plan programs and related evaluations, appropriate questions help focus thinking and expectations. Before implementing a program, educators should consider the following: What should the program accomplish? Does the school have the necessary resources, money, time, and skills? When will short-term outcomes occur? And, most importantly, when is the soonest that long-term outcomes can be expected? However, educators need to keep in mind that system changes have long-term effects.

The Areas of Highest Leverage Often Are the Least Obvious

Many traditional managers address symptom after symptom and thus resolve low-leverage problems. "It is not enough to see a particular structure underlying a particular problem. . . . This can lead to solving a problem, but it will not change the thinking that produced the problem in the first place" (Senge 1990, 95). For many years, education leaders have treated symptoms, such as low achievement scores, as root causes. Unfortunately, the low achievement will continue to occur because the root causes are ignored.

The identification of root causes and appropriate application of high-leverage solutions are very complex tasks. A variety of approaches may be necessary to obtain a thorough understanding of how a complex system works. Schools need to develop effective leaders who have diverse perspectives and are capable of implementing change. Thornton and Perreault further explain: "Effective leaders anticipate resistance to change, identify root causes, and take steps to eliminate the barriers to success" (2002, 87).

Waters, Marzano, and McNulty (2003) identified twenty-one characteristics of effective education leaders. These characteristics are proven to be statistically related to student achievement and teacher performance. The researchers used meta-analysis to establish significant effect sizes. The variables include the extent to which the principal

- fosters a sense of community and shared beliefs;
- establishes a set of standard operating procedures and routines;
- protects the teachers from issues that would detract from their teaching time;
- understands curriculum, instruction, and assessment; and
- establishes strong lines of communication.

The researchers also identify a set of variables that defines a "balanced leadership" framework. Their findings suggest that districts can positively impact both student achievement and teacher practices through the establishment of selection procedures and staff development practices to promote such a leadership framework. Thus, this type of systems thinking seeks to ensure that principals are competent leaders who possess the necessary skills to develop effective programs to improve student achievement and teaching practices.

You Can Have Your Cake and Eat It Too—But Not All at Once

Often, traditional managers deal with decisions from an either-or perspective: either quality products or low costs, either local control or central control (Senge 1990). "In the box thinking" (i.e., we have

always done it this way or the budget is too restrictive) exacerbates this dilemma.

However, if high-leverage approaches are utilized, this dilemma can be resolved. Betts (1992) recommends that schools develop increased capacity for self-direction, self-organization, and self-renewal. These learnable skills require additional staff development and willingness to delay gratification. Indeed, education leaders need to be farsighted, making current investments for future improved student achievement.

Understanding this fundamental concept, the Waters Foundation has supported the development and implementation of systems thinking and systems dynamics at the K–12 level for a number of years. Scheetz (1997; 1998) reports positive progress for twelve schools at various stages of implementation of systems thinking and systems applications. The schools successfully applied systems thinking and dynamic modeling both in classrooms and organizational planning and decision making (Scheetz 1997; 1998). The reports identify positive outcomes associated with improved higher order thinking skills, applications of systems thinking in problem solving, and changes in teaching approaches. Necessary conditions for success include staff time, staff development, and supportive leadership.

Dividing an Elephant in Half Does Not Produce Two Small Elephants

Senge notes that everyone realizes that any attempt to divide an elephant would result in a king-size mess. However, the symbolic meaning of this allegory can be illustrated by traditional linear problem solving. The basic approach divides a problem into small components and then develops a solution for each component. As a result, linear approaches address symptoms and resolve low-leverage problems, but root causes remain unsolved. By design, schools function within boundaries—school buildings, departments, and education disciplines. In education, many institutional barriers are highly reinforced by the "natural" bureaucratic order. Simple solutions do not solve complex problems; holistic approaches are required.

For many years, Deming (1986) encouraged managers to break down barriers between departments. For example, the lack of articulation and coordination failure between elementary schools, middle schools, and high school are common barriers that make transitioning students more difficult. These boundaries restrict thinking and encourage blaming failure on components outside the department. Planning and problem solving within the discrete schools or departments will only reinforce established boundaries and prevent systematic solutions. Education leaders must break down the barriers between schools, departments, and groups; they must promote flexibility and new approaches to cooperation.

The Santa Cruz, California, County Office of Education, for example, developed a continuous improvement model to promote systems thinking within regional schools (Siri and Miller 2001). Well-defined criteria were used to promote an alignment of vision, mission, curriculum, instruction, and assessment throughout the school system. They were able to build the capacity of the staff and boost student achievement.

There Is No Blame

When a crisis occurs, the typical response is to quickly find someone to blame or to punish rather than identify the causes and solve the problem. "Blame accomplishes very little, yet receives significant managerial attention. The problem is people spend a lot of time defending themselves. When that defense extends to selecting innocent scapegoats, it can destroy any semblance of teamwork" (Poirier and Tokarz 1996, 157). In short, blame erodes the ability of the system to seek objective solutions.

Deming (1986) illustrates a weakness of traditional management with his 85/15 rule: 85 percent of what goes wrong is because of system problems, and only 15 percent is because of workers' ineffectiveness or lack of skill. Systems thinking assumes: systems cause most of their problems; solutions lie within the systems; and systems cannot blame outside circumstances for problems (Deming 1986; Senge 1990). High-leverage improvements occur when systems are corrected.

Educators commonly blame socioeconomic status, family structure, and social conditions for low student achievement. Because these circumstances occur outside schools, they become unquestioned excuses for failure and justifications for status quo. The end result is that educational systems are not examined. In contrast, systems thinking assumes that schools can improve student achievement regardless of external circumstances. Siri and Miller (2001) report that, together, systems thinking and emphasis on continuous improvement shift the focus away from the blame for failure to the development of the support structures necessary for success.

NCLB stresses accountability, student achievement, and the importance of organizational improvement. The act requires that schools and districts collect extensive data on student achievement. Systems thinking schools will use the data to plan systematic improvements. These schools will evaluate relationships among components within the system, identify root causes, and plan appropriate solutions. They also will avoid blaming outside sources for any lack of improvement in student achievement.

Benefits of Systems Thinking

The use of systems thinking to improve organizational productivity is a relatively old idea. More than

twenty years ago, theorists presented models of systems thinking and discussed effective ways to improve organizations (Checkland 1981; Miller 1978). These past experiences can help today's education organizations progress toward their goals. Prusak explains: "Organizations develop shared frames of reference, recall of past events, the creation of stories and myths, vicarious learning, unlearning and memories" (1997, 53).

Systems thinking should be a vital component in efforts to improve education. To succeed, educators need to focus on making changes to the system, identifying high-leverage improvement, and aligning feedback with learning goals. When systems thinking becomes an integral part of the instructional process, the benefits of systems thinking as a method for improving student achievement will be enormous.

Key words: leadership, problem solving, systems thinking, student acheivement

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