FUNDAMENTAL CHANGES IN HOW WE TEACH: A NARRATIVE ABOUT TEACHING SYSTEM DYNAMICS AND THE ART OF LEARNING

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When you think about it, it makes no sense. But in the United States, we've been doing it this way for well over a century—everybody in a single cohort is taught the same thing at the same time. Students quickly learn they may speak if they have a *good* question or the right answer. Teachers take courses in how to conduct courses such as these, learn the addresses of publishers and organizations that will sell them ready-made curricular materials, determine the clerical skills to compute grades, to track attendance, to keep classroom order. One might walk into any humanities room in any school in America and find roughly the same thing: rows of students, about 28, texts open, notebook ready, and a teacher lecturing. In the sciences, little changes except for the labs, but in many cases these, too, suffer from sameness. The prepared lessons, we all heard in graduate school, were made "teacher-proof"—so finely tuned, not even a novice teacher could mess it up. And students learned. As did the teachers. Students learned things but not ideas; teachers learned to manage but not to teach.

The accouterments of instruction have grown abundantly so that most schools hire someone to fix the broken equipment: overhead projectors, video machines, tape players, audio accessories. Nonetheless, teachers conduct themselves in much the same way as ever. Indeed, the old joke goes this way: if 18th Century American genius Benjamin Franklin were to return to the United States in the 20th Century, what would he recognize? Schools, of course, because they have changed the least. Longevity, however, breeds bureaucracy, and education has acquired a stirring strength to perpetuate itself just as it is. Significant forces in American education still call for "return to basics," a longer school day and year, increased discipline, and a national curriculum. In the face of such a monolith, change is daunting.

Nevertheless, as we in the CC-STADUS Project (Portland, Oregon, USA) have taught our classes based on system dynamics, we have witnessed change in profound terms, both personally and professionally. Some changes were welcome—a chance to teach what we loved and believed; some changes were necessary—what worked before would no longer do; some changes were painful—the students needed to take more control.

A striking similarity among successful teachers in the CC-STADUS project is interest in ideas *outside* one's field. This may be what drew teachers to the project in the first place—teachers were predisposed to see things differently, to defy the norm and take students beyond the delineations and dissections of Cartesian methods. We can not overstate this crucial piece of our success: <u>teachers must see the world systemically before they teach it so</u>. However trite this sounds, it is critical. Merely carrying a single system dynamics activities into a biology classroom, but having no insight into the connections to other disciplines or the manifest feedback in an organic system, will only lead to student and teacher confusion. This is why some portion of training time at CC-STADUS is given to this idea; ultimately, though, the teacher will have to go the intellectual distance to reframe the world in her mind. This takes time. And some courage.

Though system dynamics and the use of STELLA lend themselves felicitously toward the sciences, the Humanities remain difficult to penetrate not so much for lack of models but for lack of willing teachers. Of all disciplines, none is so entrenched as the Humanities. One need only look back a century to the rise of science to recall the enmity the arts harbors for natural sciences—Matthew Arnold and Thomas Huxley argued poetically and pointedly over this issue—and the split remains deep, not just in world view but also in how each discipline prepares its cadre of instructors. Science teachers are predisposed for labs and computers and individual instruction. Using a computer in a Humanities course, however, borders on a deadly sin. Since the computer is the primary tool of system dynamics, computer literacy has been a major obstacle and represents a deep chasm Humanities teachers must cross. Even when willing, there is much to learn.

In a recent class, Sophomores gathered in a computer lab to work through *The Rulers*, a STELLA model on population control that puts teenagers in charge of a desperate country for a century and they must fix it. In ten minutes, disaster struck. The instructor, not prepared for the permutations eager students might exercise in a computer model, found himself barraged by questions, freezing screens, illogical graphs, and utter student chaos. Moving to another classroom to use unfamiliar equipment was no trivial matter, as this instructor found. In time, though, a more natural flow of one-to-one questioning and responding emerged as well as a clearer sense of when to focus the whole class on one idea; even such minute details as where to stand and what to point at when presenting with a computer and a projection panel can place an experienced Humanities instructor on novice ground.

Without a room full of computers, one teacher with one computer and a projection panel can still lead a deep discussion as the whole class creates through the interaction. A very useful discussion in a basic Biology class, especially as an introduction to systems, takes a broad shape and then a deep clarity as stocks and flows are identified and then connected in front of the entire class. This critical moment helps students delineate that most crucial distinction: what is a stock and what is a flow. Even so, the teacher must eventually get students before their own machines and building their own models; it is in this arena that quantum leaps occur.

The nature of system dynamics demands some measure of independence for its devotees. If we wish students to fully study, then we must grant them some intellectual independence and allow their curiosity to lead them. In Physics and Biology labs using STELLA, opportunities abound. In this new setting, the teachers grant the questioners primacy. A teacher might introduce some conceptual material on acceleration, and then allow students to work through a series of increasingly difficult models that test some of the conceptual material as well as some equations and precise data. More advanced students are free to experiment and test their own well-educated notions, each time receiving immediate feedback that redirects their personal search. Even so, the instructor, no longer bound to a text all must do at once, is free to pose ever more complex and thoughtful problems, each suited to a particular student need or capacity to raise questions about an expanding idea. Likewise, the struggling student can receive such thoughtful, prolonged attention from the teacher who knows the other students are well engaged. No longer one question for the many, but a myriad of questions, each appropriate, for the multitude.

As the modeling reaches deeper realms, the teacher and student explore together—a student's curiosity and imagination teamed with a teacher's wisdom and experience. This intellectual intimacy, brief on a daily basis, but profound over time, conjures the master-apprentice models of earlier times. For the students of average ability, this relationship bears much fruit. Many of these students have languished through course work, doing what's required but retaining little over time, just enough to pass or a bit better; many of these students are lost in the vast crowds of American education. But the visual aspect of system dynamics engages students both *conceptually* and *pragmatically* so that many more students are drawn into this question-rich learning. This dialectic mode of instruction is far more endearing to these students for whom teachers were oft viewed as authoritarians rather than mentors. Because the computer model makes explicit what heretofore was unknown in a student's mind, the teacher and student now have very clear venues for questions and suggestions. The best teaching and the best learning still take place at this primary level—the intellectual intimacy of teachers and students breeds trust, curiosity, imagination. It is not that this didn't happen before; it was just rare. System dynamics creates more possibilities for this as it enjoins minds in deep ways: students solve complex problems and teachers instruct directed minds.

Among the pleasing surprises of this enterprise have been teachers reaching outside their disciplines. This occurs primarily when the model is simple and teachers as well as students readily identify its application to other areas. We all realize that a key concept in system dynamics is archetypal structures, a recurring pattern of behavior that is consistent or, at least, recognizable within *and* across disciplines. Gregory Bateson called it "the pattern which connects." In these archetypes, teachers find some common ground. The oscillation that occurs in a watershed through winter rains also occurs in the Israelites relationship with Yahweh in *Judges*, albeit for different reasons. Students with a propensity for mathematics find their way into a model through equations, while those of a more aesthetic sensibility find openings on the diagram level. At one school social science, English and science instructors will team teach one course; at another school Biology teachers often send their students with model in hand to ask an English teacher for help.

Classroom and faculty-lunchroom conversations flourish as this cross-pollination widens. People read outside their standard academic discipline. All of these people are confronting information from a radical perspective; whereas they once thought they saw disparate things, they are actually viewing the same, large phenomena, but now through the same lens. One can imagine that the traditional idea of "academic department" will likely evolve, but ought <u>not</u> include a *system dynamics department.*

An English teacher reads science books and wonders about the ratio of food per person over a twenty-year time period. A Physics teacher creates social science models or teaches a Literature class on *Lord of The Flies*. A Mathematics teacher assists students with bear populations or increasing disorder in Van Gogh's paintings. In such experimentation, students have been gracious and willing subjects. They have found themselves advising school boards, local voters, governmental councils; they receive job offers and scholarships to major universities; and they help us teach a bit more brightly, a bit more effectively, and a bit more courageously. Ultimately, the whole project comes down to what the students are doing. Within the CC-STADUS project schools in Portland, Oregon, USA, students and their fortunate teachers find themselves charting new intellectual territory.