ANDY HURFORD

The University of Texas at Austin

Complex Systems, Learning, and Teacher Education

My Vexation:

From metaphors to highly mathematized models, complexity theories are informing research and understandings in many and diverse fields (e.g., economics, sociology, forestry, and low temperature physics). Recently, application of complexity and systems thinking to educational research has begun to blossom. The problem is that very little of the work being done at research levels is affecting teacher preparation. Worse, the absence of systems perspectives in the curriculum of pre-service math and science teachers will likely insure that another generation of public school students will also not be introduced to the powerful ideas that systems theories provide. In order to teach complexity to tomorrow's citizens, it will be necessary to provide teachers with opportunities to build their own conceptions, understandings, and pedagogies of complex systems.

Complexity understandings and metaphors (such as "ecologies," "adaptation," and "self-organization") can help learners and teachers see and make sense of the dynamic nature of science and learning respectively. Infusing a systems perspective into education can help to contextualize learners' world knowledge and help them to think about important interrelationships rather than looking for "silver bullet" solutions to complex questions. Complex systems perspectives provide powerful counter-arguments for myopic decision-making and oversimplification of natural and man-made challenges and opportunities.

One challenge is the problem of a lack of prior knowledge on the parts of students *and* teachers—in general neither group has had much experience thinking about complex systems. What is called for are injections of complex systems thinking at all levels of education because building familiarity and knowledge of complex systems is a necessary prerequisite to capitalizing on the utility of systems perspectives. Before students in public schools can be effectively introduced to complex systems their teachers must have the beliefs and pedagogical content knowledge necessary for infusing systems into classroom learning.

Most importantly from my point of view is that learning itself is by no means a linear process. The notions of learning as the steady accumulation of small bits of information, or of the learning in classrooms as a simple collection of individual learners, are fundamentally flawed. We know that what students learn depends on what they bring with them to the learning situation. Socio-cultural contexts can powerfully affect learning. Students in classrooms interact in ways that vary from mutual education to resisting learning. Teachers need to see the "big picture" of the connectedness in learning and in classrooms and to be prepared to use learning theories in combination in order to optimize learning gains.

Beyond learning *about* complex systems, learning *is* a complex system. Teachers need the opportunities of seeing learning in their classrooms in terms of ecologies where sensitivity to initial conditions, self-organization, and inherent diversity can help them take advantage of the system and enhance the learning of the group. Teachers also need to understand learning theories as connected and complimentary instead of as disjoint sets. To get to where we need to be, I argue that complex systems perspectives deserve a larger share of time, resources, and application at all levels of teaching and learning and am vexed by the fact that this isn't happening.

My Venture:

I believe that it is both possible and necessary to help learners begin to think in complex systems terms. The world is just too interrelated to be understood as the simple additive combination of participants and activities, informed citizens must be prepared to think globally. I have data to support the claim that pre-service teachers can effectively learn about complexity and use that knowledge to their advantage in teaching and learning. Preliminary findings from my dissertation research are showing the same thing. If teachers gain facility with complex systems ideas and activities, the odds that their students will be exposed to such activities and that they will take away useful knowledge increase dramatically. It is important to note that systems education is very much not just for advanced students. There is also research published that indicates that younger, underrepresented, and disadvantaged students can do an excellent job of learning ideas that are considerably beyond the basics (c.f., Stroup, 2002).

ANDY HURFORD

The University of Texas at Austin

Complex Systems, Learning, and Teacher Education

We have powerful new technologies (e.g., HubNet [Wilensky & Stroup, 1999], NetLogo [Wilensky, 1999], TI Navigator[1], SimCalc[2]) that invite learners to participate in complexity simulations in individual and group contexts and to build and adapt their own working models of complex systems. These technologies can support and inspire learning situations that are as yet unimagined. In addition, some researchers argue (Lesh, Hamilton, & Kaput, 2006) that we should temper efforts to satisfy the NCLB legislation with attention to what "heavy consumers" of science and math graduates (e.g. engineering, computer science, etc.) say they need to compete in today's marketplaces. Students participating and making communal sense of complex systems simulations are precisely the types of learning experiences that Dick Lesh and his associates are advocating.

Finally, I would argue from cognitivist, socio-cultural, and constructionist (Harel & Papert, 1991) points of view that learning *about* learning *as* a complex system has the potential to make theories of learning more plausible and practicable for teachers. Learning theories education in teacher preparation courses tends to be taught piece-meal—behaviorism, constructivism, information processing models, and strategies instruction are taught as relatively disjoint sets. Perhaps it is the disconnected and decontextualized nature of learning theories instruction that reduces teachers' likelihood to spend the time, energy, and imagination to give these theoretical perspectives their due. Although space/time here doesn't permit an adequate discussion, at the conference I will argue that complexity models can be used to *parsimoniously* unite theories of learning into a cohesive whole that connects the theories and makes their applications much easier to see and implement.

Proposal

I think that steps like the following may help to encourage the teaching and learning about complex systems in schools and may specifically motivate teachers' conceptualizations of learning *as* a complex system.

A) We should encourage efforts to teach people about complex systems at all ages.
B) We should become more facile at using technological tools for teaching about complex systems and invest in the development of more, and more sophisticated, tools.
C) We should incorporate complex systems, and learning as a complex system in teacher preparation programs.
D) We should invest in basic research into learning as a complex system.

Invited Questions

A) Are there other arguments against teaching about complex systems to the various student-audiences?
B) How do you feel about basic research into learning as a complex system?
C) What needs to happen to make such research more viable, useful, etc.?
D) What do you see as the potential benefits of teaching about complexity, and about learning as a complex system?
E) What am I missing?

[1] http://education.ti.com/educationportal/sites/US/productDetail/us_ti_navigator.html
[2] http://www.simcalc.umassd.edu/