The Use of Biological Metaphors in Thinking about Learning: Some Initial Thoughts about "Emergent Learning"

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In the past decade or so, the Piagetian idea of constructivism has moved to center stage in the educational-research community. It is difficult to go to a session at the annual meeting of the American Educational Research Association (AERA) without hearing paeans to constructivism. At the last few annual meetings of the Association of Science-Technology Centers (ASTC), sessions about constructivism attracted the largest audiences and generated the most in-the-hallways discussion.

In many ways, this "discovery" of constructivism is very positive (if overdue). Constructivism is typically presented in opposition to "transmission" models of learning. Viewing learning as the active construction of knowledge by the learner, rather than the transmission of information from teacher (or parent or museum exhibit) to the learner, is certainly a step in a good direction.

But there is a problem -- and an irony -- with this new embrace of constructivism. In the way it is discussed among many researchers and educators today, constructivism has a distinctly "engineering" feel to it. When people discuss the "construction" of new knowledge, they sometimes talk as if learning involves the placing of one "knowledge block" on top of another (or replacing one knowledge block with another). In today's discourse, the metaphors and imagery surrounding constructivism are rarely fluid and organic, but rather rigid and mechanical.

This view of constructivism is both misguided and ironic. Piaget began his career as a biologist, and his subsequent work was deeply influenced by biological ideas and biological ways of thinking. The Piagetian dynamic between assimilation and accommodation was clearly inspired by his observations of biological phenomena. Piaget viewed learning not as a mechanical construction but as a complex, dynamic interplay in which the mind refashions certain ideas to fit into its existing models and structures -- and sometimes refashions its models and structures to better accommodate new ideas.

It would be useful, we believe, to re-inject some of these biology-inspired

models and metaphors into current-day discussions of thinking, learning, and education. The idea is to return to Piaget's roots -- but with an added twist, drawing on recent thinking from the so-called "sciences of complexity."

In recent years, there has been surge of interest in the study of how complex phenomena can emerge from simple interactions among simple components. In some ways, this research can be viewed as an attempt to apply systems-oriented biological thinking to a wide range of other phenomena. That is: How can new systems-oriented models of biological phenomena (such as the foraging patterns of an ant colony, or the collective response of an immune system) help us understand other patterns and phenomena in the world (such as the formation of traffic jams on a highway, or regularities in a market economy)?

We believe that these biologically-inspired concepts and metaphors could be particularly useful in the study of learning and education. In particular, the idea of "emergence" can provide a valuable new framework for thinking about the nature of human learning, the design of learning environments, and even the process of reform in the educational system.

When educators think about learners acquiring new concepts, they too often think of a new concept "replacing" an existing "faulty" concept. The metaphor of emergence provides a different set of images. Emergent systems (such as ant colonies) are often characterized by critical thresholds and phase transitions: one small change can lead to radical restructurings and fundamentally new behaviors. The idea of emergence provides a new framework for thinking about conceptual change. The addition or revision of one idea can lead to major reorganizations of conceptual structures -- and the emergence of new concepts in the learner's mind.

The idea of emergence can also be useful in thinking about the design of learning environments. When we set up The Computer Clubhouse, an after-school learning center for inner-city youth, we wanted to encourage collaborative activities. But we did not want to assign youth to teams, as is often done in classroom-based collaborative activities. Rather, we wanted collaborative groups to emerge as a natural part of ongoing activities. Projects at the Clubhouse are not a fixed entity; they grow and evolve over time. An adult mentor might start with one idea, a few youth will join for a while, then a few others will start working on a related project. Design teams form informally, coalescing around common interests. Communities are dynamic and flexible, evolving to meet the needs of the project and the interests of the participants. A large green table in the middle of the

Clubhouse acts as a type of village common, where people come together to share ideas, visions, and information (not to mention food). Often, communities will coalesce suddenly, in a type of phase transition, when the ideas and participants cross some type of critical threshold.

As in natural-world systems, diversity is important to this process. At the Clubhouse, we try to attract a diverse community of adult mentors. One reason for this is obvious: we want the mix of mentors to reflect the diverse backgrounds and interests of the Clubhouse youth, so that mentors can more easily relate to (and serve as role models for) the youth. But that is only one reason. We also want diversity for systems-oriented reasons. Just as ecosystems flourish when there is a diversity of participants, so too with the Clubhouse. Diversity leads to a greater robustness in the system. There is also an evolutionary argument in favor of diversity. In an environment like the Clubhouse, the "selection" of new project ideas works best when there is a rich "variation" in the ideas (and mentors) involved.

Designing an "emergent learning environment" requires a shift in traditional ways of thinking about "control." Learning experiences can not be directly controlled or planned in a top-down way. Indeed, the experiences at the Clubhouse have been quite different from we (as developers) expected. Educational designers can not (and should not) control exactly what (or when or how) students learn. On the other hand, it is wrong to try to eliminate all structure and control. The absence of all structure is just as bad as an overly-controlling, top-down structure. Instead, we need to develop new notions of structure and control, based on the ideas of self-organization and emergence. The goal is to create fertile environments in which interesting activities and ideas are likely to emerge and grow and evolve.

Many of these same issues apply to the spread of new ideas through the educational system. Just as learning experiences can not be imposed on students, educational reform can not be imposed on classrooms and schools. Indeed, educational change can be viewed as a type of "learning" by the educational system. Many well-intentioned educational technologies and reform efforts have failed because designers and reformers tried to exert too much centralized control -- or none at all. Again, new notions of control are needed. New ideas must evolve in the educational system in a more emergent way. The challenge is to find ways of introducing ideas so that they replicate and spread on their own.