Running Head: Chaining: Scaffolding Holistic Meaning Across Lessons

Microworld Chaining: Scaffolding Holistic Meaning Across Lessons in High School Biology

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Abstract

Constructivism is a learning process that has been used for as long as humans have been learning. It has fallen into disfavor as a result of societal changes, but is being rediscovered as new technologies make it feasible to use constructivist methods to teach children while still isolating them until they are adults. The concept of microworld chaining is one such method, and can be used to scaffold or replace existing pedagogical methods.

Microworld Chaining: Scaffolding Holistic Meaning Across Chapters for High School Biology

All humans learn. It is part of what it means to be human. For as long as humanity has been a distinct species, we have learned from one another both how to function as parts of a social unit and how to utilize what the environment has to offer in order to survive. There are certainly many different ways to learn, but historically, and across culture, most learning has taken place in the context where it would also be practiced. Only recently has learning been centered in specially designated places that are removed from virtually every function of society that this learning is meant to support. Although there are arguments for economy of scale and that the complexity of the accumulated knowledge of humanity dictates that it must be formally transmitted to each generation of humans, constructivism holds that "the experience in which an idea is embedded is critical to the individual's understanding of and ability to use that idea" (Duffy, 1992, p.4). The implication of this is that students learning in a classroom about the world external to the classroom are not preparing for the external world, only for additional experiences in the classroom. This is certainly not what educators intend, but seems to be the reality. The problem of transfer, not only made apparent by the paradigm, but actuality generated by the paradigm, is often ignored because it is such a difficult problem for educators to solve. Without a sea change in education and practice, in the integration of educational institutions back into the greater society where they once were, the problem remains. This is to say that unless society is re-engineered to place young learners into the situations where learning and practice co-exist, some other solution must be brought forth.

Thomas Duffy states that **"**constructivism, like objectivism, holds that there is a real world that we experience. However, the argument is that meaning is imposed on the world by

us, rather than existing in the world independently of us" (Duffy, 1992, p. 3). Duffy is arguing that while there is a real world that people react to, a shared world that everyone experiences, it is our minds that attach meaning to phenomena, rather than the phenomena placing meaning into our minds. This is anti-intuitive for many people. We feel, deeply, that the meaning comes from the outside into us because in order to act in the world with confidence, people need to feel they are navigating with facts. It is our interactions with what seems real that gives us this confidence. We are experiential creatures.

Although constructivist principles are not new, their application has been problematic in the classroom because "the technology of paper and pencil is limited to textual explanations and static drawings" (Reiber, 2000 p. 583). It has been difficult to bring constructivist principles into classrooms when students have generally been more interested in generating their own reality in the classroom than pondering some vague reality located, at best, inside a text book or in the chalk dust and wild gesticulations of some harried teacher.

So, the task in designing a constructivist environment lies in generating experiences that feel genuine to the learner. If we can simulate the phenomena of real world, we can create an environment where students impose meaning on simulated phenomena that closely resembles the meanings produced in a genuine context. This is possible because "the technology of computers affords a wider array of representations and experiences", (Rieber, 2004, p. 583). Each student can recapitulate the discoveries made before them. They can interpret operationally consistent systems. Because there is an order to the systems, and learner manipulations provide dynamic, yet ultimately predictable feedback, students should generally apply similar meanings to the simulation as they would the actual phenomena. In this way, the theories and laws of science can be learned in a way that feels genuine to the learner.

Microworlds

The high school science classroom is where students are expected to perform interactive laboratory exercises in order to reinforce the facts they have been exposed to during lecture and in the textbook. The labs can sometimes reinforce learning, but they can also become highly scripted exercises where following directions is what is learned, and not the concepts that are supposed to be imparted. After all, if meaning is imposed by the learner, than a teacher cannot control whether the student focuses on the phenomenon the experiment attempts to model, or the steps to the modeling.

This project includes three microworlds:

- Chemistry: how electrons are responsible for all chemical bonds; microworld looks at a subset, covering the six common elements in organic molecules
- Biology: how nucleotides in DNA use chemical bonds to create codes
- Ecology: how a simple strand of nucleotides can effect survival

They are meant to be played in sequence and the learner should have enough time available to master one microworld before moving to the next. The idea of chaining microworlds together is my own, although it draws on the idea of chunking (Dabbagh, 2005 p. 187). It occurred to me while editing lessons for an online biology course. I wondered what connections students are making between disparate lessons on genetics, evolution, and chemistry. My concern is that they are not putting the 'chunks' together to form a comprehensive understanding of how all of the facts support the operation of a holistic system. Assessment is primarily done by the student themselves, as their mastery the limited domain of the microworld will be mediated by the continuous interaction with the microworld. As a secondary, but important, means of assessment, the student will journal their thoughts on the microworld: by writing a design

document for the microworld itself, with a programmer making a new microworld as the audience. For the second microworld, a simple diagram of the base pairing relationships they uncovered, will track their understanding. In the third entry, they will use their own outside knowledge to speculate on what other traits grasshoppers might influence an individual hopper's ability to evade hungry birds.

Lloyd Rieber argues that microworlds reduce "the distance [between] learning science, doing science, and thinking like a scientist. Learning based on scientific inquiry is championed throughout the literature" (Rieber, 2004, p. 584). Microworlds simulate a slice of what scientists have observed and inferred about a particular domain, providing a way for learners to reach conclusions based on their own direct inquiries rather then vicarious attempts to learn from the discoveries of others. Since the domain of the microworld is systematic and ultimately predictable, repeated iterations of use will allow learners to generate their own internal predictive models based on their interactions. While the hope of teachers is that students will eventually arrive at the same conclusions that scientists did, the critical difference between a pedagogy based on microworlds and one based on traditional learning environment is that the meaning is generated by the student. There is much less ambiguity as to whether it is an academic system that is being learned, or the ability to comprehend the complexities of the real world.

In describing symbolic simulations, Margaret Gredler refers to two levels of structure: surface and deep (Gredler, 2004, p. 572). He defines the former as the components of the simulation that are observable to the learner and the latter as the iterations of interactions between the learner and components of the simulation. My interpretation of this is that the deep structure also must contain the rules governing the interactions. These rules have been determined by the designer; in this case, they come from the sciences of chemistry, biology, and ecology. By interacting with

the visible surface structure, the leaner will naturally develop hypotheses regarding the rules of the deep structure. In doing this, the learner will begin to construct the knowledge the teachers are attempting to pass on.

Rieber's Qualities of Microworlds (2004, p, 588)	My Microworlds
Domain specific	Three microworlds: 1) electron transfer; 2) nucleotide bonding makes a protein; 3) fitness of a specific trait
Provides a doorway to the domain for the user by offering a simple example of the domain that is immediately understandable	Only one interaction controlled by the student, but many iterations
Leads to activity that can be intrinsically motivating	Manipulation of objects and observation of to determine rules underlying the observed reactions to input
Leads to immersive activity best characterized by words such as play, inquiry, and invention	As above, with no preset order to manipulations; guided by student in an inventive and inquisitive nature
Situated in a constructivist philosophy of learning	Learning is exploratory and assessments include constant self-assessment using microworld feedback; a journal to be read by teacher

Expansion

Chaining microworlds to scaffold holistic understanding of complex systems could be expanded to other student populations. From a language perspective this would be fairly simple as there is little use of language. By simply editing the buttons, this could be made widely accessible.

In terms of expansion to more advanced levels, the addition of more elements to the first microworld could expand its utility. The second microworld could be expanded to have students attempt to code for particular proteins, although this would require hundreds of nucleotides, might be overly tedious for the majority of students, and might not encourage a desire to play and investigate. The third microworld is perhaps the most expandable, both to higher and lower levels of ability. With now changes, but as a standalone microworld, it could be used for much younger students. For more advanced levels, additional traits for grasshoppers could be added, or traits of additional organisms, i.e. bird and plant traits, could be made into variables.

A thread of concepts that moves across domains simply needs to be identified, and then a microworld is constructed for each domain the thread crosses. This could possibly be used to translate a series of case studies, as in a cognitive flexibility hypertext, where each case is turned into a microworld. The problem in adaptation would be identifying what aspects of a static case should be made dynamic in the microworld. One possibility is that the decisions made by the case actors might affect what the learner can do in each microworld, and the contrast provided by the variation in range of possible action may make for lessons well learned.

Regardless of how microworlds are implemented as part of a learning system, well-constructed microworlds provide experiences that are transferable from the learning environment to a genuine environment. Increasingly, as more and more of humanity's work is performed at a

distance as dictated by the information age, microworlds can provide genuinely genuine experiences. In a reversal of the trend of extricating learning from practice and placing it into an artificially enclosed environment, or making simulation of practice as the mandatory predicate to practice, we see practice itself becoming increasingly indistinguishable from simulation: remote arthroscopic surgeries, remote piloting of war drones, shopping online, or Simlife. Even in this reversal, what distinguishes microworlds and constructivism is the expectation and necessity of activity in the learner versus passivity.

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