Finding Understanding:
Theoretical Modeling, Threshold Concepts, and Educational Reform

Robert Coven

Philosophers of Education:
Major Thinkers from the Enlightenment to the Post-Modern Era

NEH Seminar, Summer, 2014
Boston University

Peter Gibbon
Peter Wright

July 31, 2014
The debate over educational reform has become mired in a kind of intractable, internecine warfare, pitting proponents of what seem to be antipodal ideologies that are politically and culturally freighted. At the risk of oversimplifying, the progressives (romanticists) ask us to “follow the child” and focus on providing engaging and gentle guidance in order to bring out the innate, inquisitive qualities of our young charges. Traditionalists (essentialists) suggest that discipline and content should be our major concerns. The pursuit of either extreme has led to the faddish implementation of ineffective policies. A sensible course would be to take the good from each—to seek a middle course of well-regulated liberty (Rousseau, 1773) where discipline and freedom peacefully coexist and where students can benefit from the pursuit of both content and critical-thinking skills. Good education relies on a number of interdependencies, e.g. teacher and student, community and individual, math and science, English and history. The theoretical modeling pedagogy, focusing on threshold concepts, that will be the subject of this essay, represents an attempt to reconcile the discordant positions that have developed—taking the best of traditionalism and progressivism—and giving students knowledge and skills that are deep, permanent, transferable, and useful.

In 1840, Horace Mann complained about the inadequacies of the hidebound methods used for instruction:

The leading, prevailing defect in the intellectual department of our schools, is a want of thoroughness,—a proneness to be satisfied with a verbal memory of rules, instead of a comprehension of principles,—with a knowledge of the names of things, instead of a knowledge of the things themselves…. [K]nowledge is hardly worthy of the name, which stops with things, as individuals, without understanding the relations existing between them (p. 45).
Much of history instruction is still lecture and textbook based, with an emphasis on the memorization of minutiae (e.g. names and dates). Such rote work only provides the most tenuous grasp of the material; students are not able to translate or deploy what they “know” in different situations. As Rousseau (1773) noted, children do not retain what they do not understand. They may memorize some superficial aspects, but they are unable to translate what they have memorized to a new context.

Students often fail to see the forest for the trees, memorizing rules, dates, and names, without the flexibility to apply core concepts and patterns to different contexts. As Bain (2000) explains, “the complicated picture of the discipline does not fit a transmission model of learning” (p. 334). Students need to be able to visualize a correct internal image of, for example, how historical forces operate, as their teachers and experts in the field tend to do automatically.

Furthermore, traditional teaching tends to present history as a fixed and immutable doctrine, revealed through the words of established authorities: the textbook and the teacher (VanSledright, 2011). As a result, “students tend to have a static, formulaic vision of history. The past is filled with facts, historians retrieve those facts, students memorize the facts, and all this somehow improves the present” (Bain, 2000, p. 337). Locke (1996) suggests a different goal, positing that true education should be seen as “an increase of the powers and activity of the mind, not as an enlargement of its possessions...[That is,] reading furnishes the mind only with materials of knowledge; it is thinking that makes what we read ours” (p. 193).

Progressive educators have suggested changes that would put history instruction more in line with modern cognitive science and the theories posited by those studying
motivation. More authentic and relevant modes of instruction, it is said, will lead to students being more engaged and motivated—and better-informed in areas that matter. These students will also better develop conceptual understandings and critical thinking skills that will be helpful to them in all their future endeavors.

A path to better learning can be found in the best of what Barth and Shermis (1970) presented as social science through reflective inquiry.\(^1\) Through this method of learning, students are guided in identifying relevant and significant problems, developing probing questions, making the kinds of connections Locke (1996) outlined—in his, *Of the Conduct of the Understanding*—and examining evidence through the lens of interdisciplinary criteria.\(^2\) According to Milson (2002), “The research base has indicated that students learn history most effectively when they are engaged in asking historical questions, collecting and analyzing historical sources, and determining historical significance” (p. 348). Students develop historical thinking skills as they examine original, historical evidence (Jefferson, 1786; Dewey, 1915) and develop their own interpretations about the past (Sexias, 1998; VanSledright, 2002; Wineburg, 2001).

When students have opportunities to construct knowledge rather than only reproduce what they have been given, to understand topics deeply instead of only superficially, to express themselves by explaining their ideas, and to study topics that have some significance beyond the classroom, they are more likely to care about learning

---

1 There has been research into the effectiveness of the theoretical construct known as: Technological Pedagogical Content Knowledge (TPACK). “TPACK refers to the complex interrelationship between a teacher’s technology use, instructional methods, and understanding of the subject matter.” (Cox, 2008, p. 17)

2 In a later article, Newmann and Wehlage (1993) delineated five criteria for what they termed “authentic instruction”: higher-order thinking, depth of knowledge, connectedness to the world outside the classroom, substantive conversation, and social support for student achievement
and be willing to devote the serious effort that learning requires (King, Newmann, & Carmichael, 2009, p. 49). As Rousseau (1773) remarked,

> We acquire, without doubt, notions more clear and certain, of things we thus learn of ourselves, than of those we are taught by others. Another advantage also resulting from this method is, that we do not accustom ourselves to a servile submission to the authority of others; but, by exercising our reason, grow every day more ingenious in the discovery of the relations of things (p. 410).

The rewards of authentic intellectual work (King, Newmann, & Carmichael, 2009) make it worth the effort. Authentic learning, according to King, Newmann, and Carmichael (2009), takes place when students are able to apply the skills of practicing historians to analyze evidence, and parlay their prior knowledge into developing a clearly articulated and deep understanding of the past (King, Newmann, & Carmichael, 2009).

Mann (1840) provides support for this, saying that,

> [A] systematic acquisition of a subject knits all parts of it together, so that they will be longer retained and more easily recalled. To acquire a few of the facts, gives us fragments only;—and even to master all the facts, but to obtain them promiscuously, leaves what is acquired so unconnected and loose, that any part of it may be jostled out of its place and lost, or remain only to mislead (p. 47).

Theoretical modeling is a pedagogy that responds to the need for authentic intellectual work. Modeling is a constructivist technique borrowed from Physics education. 3 Modeling Instruction began when a college Physics teacher, Malcolm Wells, discovered that even when using inquiry-based teaching methods, students generally did not exceed a 40% retention rate (Hestenes, Wells, & Swackhamer, 1992). He realized that no matter how much the teacher asserted the rules of physics, the students

3 The closest analogy to the modeling method in history is modeling in physics—a recent development and from which modeling in the humanities was derived. Despite its newness, there is a growing body of literature on modeling in physics and the brain science on which it is based.
systematically misunderstood them and continued to apply their own, pre-Newtonian, concepts to the experiments and homework problems (McDermott, 1993). Physics teachers who used Modeling techniques had retention rates of 60-80% (Hestenes, Wells, & Swackhamer, 1992). This is because students in modeling classes develop their own visual representations of theories, processes, and forces, which enhance their understanding of the material presented.

In a Physics course that uses Modeling, students conduct the usual lab experiments, but set out on their path of learning without formulas or textbook problems to solve. Instead, they diagram what is physically happening, and explain their theories to each other. They extract their theory from the data, and then try it out on new problems, predicting what their results will be. In this fashion, their understanding of the physicality of the problems evolves before they encounter the associated formulae. Modeling causes students to confront these incorrect preconceived notions and correct them through dialogue with their peers. As they reach consensus on a diagram that represents what really happens, their internal model of the physical world changes to represent reality. Now, because most Physics courses rest on a small handful of core models, instead of studying formulae to prepare for exams, students can simply study how their diagrams work and the kinds of problems to which they apply. Formulae are also easier to recall and employ because they can be re-derived from diagrams and graphs that make physical sense.

There are, of course, disciplinary differences between physics and history. In the typical physics classroom students tend toward an already established model to describe the natural world; students in the history classroom must wrestle with the ambiguity of
historical interpretation. For instance, they must make informed decisions about the relative significance of historical evidence, wade through a large volume of resources, look for patterns, and make a judgment (not necessarily true or false) about the past. The epistemological differences between the sciences and humanities raise the concern Hirsch (1996) mentions when he suggests that critical thinking skills are domain-specific and not transferable.

A second of Hirsch’s (1996) concerns is that an inquiry-based curriculum will not provide sufficient content. Good modeling, however, provides content and concepts. Modeling cannot occur, nor skills and concepts imparted, without the provision of appropriate material to analyze. Models are built and tested with data—the better the material, the stronger the model. Students need a basic background context and content. Therefore, in order to facilitate and guide student work, modeling teachers must be well versed in their fields (Locke, 1996)—in order to select resources that are accessible, pertinent, and relatively free of distracting minutiae.4

The focus of a model is on broad concepts, e.g. theoretical frameworks, forces, and themes—the why, more so than the who, what, where, or when. The latter are still used by the student, but in modeling this information serves as source material (like lab data) from which to extract underlying processes, forces, or theories. These self-constructed theoretical frameworks provide young scholars with the means of tackling information encountered in subsequent studies. A student who understands, for example, the way the transcontinental railroad in the United States acted as a force of change, of technology overcoming nature, and of transportation as a spur to migration or as a means

4 NB: Admittedly, this is only a partial response to Hirsch’s (1996) stated concerns regarding the disappearance of a common core of knowledge from our schools and society. It is a problem that should be wrestled with, but it is outside the scope of this essay.
of exclusion, can see how that the same pattern of consequences occurs with other new technologies, such as the telephone, television, superhighways, and the Internet. Students, through modeling, consider the disciplinary elements that are important to historians: defining and refining their terms, examining the relevance and credibility of sources, and making use of methods and metaphors from outside the purview of a typical Humanities course. Because students must derive their own theories rather than obediently record them from teachers, class discussions become seminars of peers, in which all are engaged.

History is a verbal discipline, one that traditionally uses text as both input and output. But humans are, by nature, visual. Our remarkable brains developed in a pre-literate context, in which we navigated and understood our environment through our senses—mainly that of sight. Our brain is hardwired to see patterns and connections and to recognize similarities and anomalies with incredible speed—thanks to the effectiveness and acuity of visual cognition. The rapidity with which we make these associations—these mental pictures—is a hallmark of human intelligence and creativity (Ayers, 1999). The epistemology of visualization and perception lies at the heart of modeling. And that is what makes it so transformative and effective in producing actual learning. The student actually changes his worldview, sees the world differently, in a more sophisticated, nuanced way. In effect, the insights that history teachers hope will come with time and experience in studying history, and which have become an almost unconscious yet powerful force in their own historical thinking, will come about because they have been foregrounded to the focus and goal of the class.
Although modeling is designed to provide a simplified, visual representation of a theory, process, or system, this does not mean the method is, therefore, not necessarily reductionist. In order to help avoid over-simplification, student groups are often given a different sub-topic on which to focus their research and model development. This results in another layer of complexity—giving the class the opportunity of a deeper and broader view of the historical concept being investigated.

The modeling pedagogy applied to the study of history, including the integration of primary sources and group deliberation, culminates in the student presentation of a “model,” or an “external representation, to describe the historical phenomenon under study. Whereas writing is a common external representation used to move students toward deeper historical understanding (Voss & Wiley, 1997), here students create visual diagrams, in the most simple, general terms possible, to describe their understandings about the past. As Jefferson (1816) would have it, “The more a subject is understood, the more briefly it may be explained” (p. 95).

This development and presentation steps challenge students to begin to see patterns in their world through their study of historical data—economic cycles, for example. In the process of creating a model—often expressed in the form of a metaphor—students come to recognize patterns that help them make sense of past and present (and provide plausible guidance for the future). Students come to understand that history is an integrated and interconnected system— influenced by common forces—and not a random set of events.

Modeling’s main method of creating this understanding—the construction of explanatory metaphors—is one quite familiar to any English or history teacher. Wormeli

---

5 There is a kind of simple play inherent to this work, conforming to suggestions made by Locke (1996).
Coven (2009) extols the many virtues of learning through metaphors. Through visual metaphors, often drawn from their knowledge from other disciplines (Jefferson, 1786), students display their understanding of telltale patterns and connections. These simplified sketches and analogies allow students to test with new and unfamiliar cases and provide them with a self-constructed framework with which to analyze data and understand their world—particularly other places and other times. Students can see the ways in which forces interact, how cause leads to effect, where events overlap, the speed at which epidemics spread, the hierarchy of a class system, and the complexity of trade networks. For example, in developing a model on cultural diffusion through trade, a group might draw an image of the semi-permeable barrier of a living cell to represent the combination of free flow and restriction in a particular trade system. The process of discussing and creating these very metaphors and connections, along with the simplified diagramming, makes abstract concepts meaningful and memorable. The metaphor or diagram serves as an organizing mechanism that makes it easy for students to remember the elements that contribute to the system. Having established a coherent logic, students retain their understandings and can apply them to similar situations.

The modeling pedagogy, supported by some accompanying heuristics that I provide, has three major goals, that students: 1. develop a historian’s habits of mind—coherent, inductive reasoning based on evidence that has been vetted for accuracy, bias, and completeness—which leads them to a deeper understanding of events; 2. are able to see the complex interplay of forces in action in history and honor that complexity by viewing events through a broad set of lenses; and, 3. are able to apply their knowledge and skills to new data and in different disciplinary contexts.
Theoretical modeling is an expression of constructivism (Manfra & Coven, 2011; Coven & Hamilton, 2010). Modeling departs from the didactic approach in which students are provided with “objective truths” to memorize and feed back. Instead, the pedagogy provides a way of getting students to construct their own meaning. Workings in groups--using data of many types, e.g. artifacts and texts--students discern the patterns that appear in historical events. They look for, and diagram, the forces of history and the ways in which events reflect the complex causes and effects that can be seen in economics, politics, intellectual life, culture, and social organization (Manfra & Coven, 2011; Bain, 2000).

Modeling relies on students to develop their own theories through induction and deduction, construction and deconstruction (James, 1922). In searching for the patterns revealed in historical events--in discovering the forces of history--students are engaged in authentic disciplinary work. As the process (model development) and product (theory) are generated by them, they are owned by the students. Students are thus engaged in the creative construction of historical knowledge. The meanings they discern are, of course, inflected by their own experiences. This subjectivity helps them to understand that while history, itself, does not change, its interpretation is always in flux and is a social construction. Students become informed interpreters and contributors to the socially-constructed worldview. Through modeling, students learn to form their own frameworks—i.e. they engage in historical theory making (VanSledright, 2011).

In theoretical modeling, as it is implemented in history, groups of three to four students are asked to collaborate on discovering underlying patterns revealed through their analysis of historical case studies. A typical modeling unit begins with the kinds of
research tasks familiar to any historian. This process of examining primary and
secondary materials—analogous to a physics experiment—provides students with
historical context and data. In the second stage, students go through a sifting process,
eliminating topics that are tangential or too broad, and deciding what, ultimately, to
include. The central activity of modeling, the construction and visual representation of a
concept/theory, is done using two-foot by three-foot whiteboards to prepare a diagram of
a concept. As each group develops their models, students are pushed to engage with their
peers, to discuss and explain the rationales behind their ideas and arguments—sometimes
to the level of meta-cognition—and to listen.

As students draw, they are compelled to explain their reasoning behind their
work. Inconsistencies are revealed, requiring revisions to the diagram, but also to the
student’s initial idea. At this point, students often revise their diagram to reflect their
growing theoretical framework, the “forest” that they have extracted from the “trees” of
the materials read and presented by the teacher. The drawing represents the “shape” of
their idea. In examining historical case studies, students might diagram the forces acting
on a character or historical figure, or depict a pattern seen in events and their
consequences. The best diagrams are clean, with simple, clear shapes representing
perceived forces, relationships, and patterns. The models are simplified and abstract
representations that students can manipulate, mentally or actually, to depict different
situations or to be applied to different situations. The goal is not to create a work of art or
representational cartoon but to offer a visual tool for discussion.

---

6 In Physics, this entails drawing graphs and lines representing the forces they observed in their
experiments and patterns they find in data collected and tabulated.
The intellectual exchange that occurs is an important component of critical thinking. In the presentation phase, students explain how their diagram represents the theory that their group has developed. Some groups will have well developed theories and diagrams, while others will be less encompassing and may even contain errors of analysis and judgment. The group discussion exposes these inconsistencies, not to find fault, but to account for differences and missing or incongruent elements. More importantly, students once more revise their internal model to something that will be useful to them. As students gain confidence, they learn to separate themselves from their work, allowing for greater insights.

In modeling, there is no correct answer, nor a right way to arrive at a solution. This puts process above product—favoring mastery over performance. The models, and the discussions that follow, push students to seek insight from within and from their peers. For learning—a deep understanding of concepts combined with transferable skills—to take place, students must believe that the tasks set before them have value—to themselves and others. They must also believe that both the process and product have importance and utility. As Locke (1996) states, we should “make the child comprehend (as much as may be) the usefulness of what he teaches him and let him see by what he has learned that he can do something which he could not do before” (p. 125). Developing theory through modeling is challenging, but the challenge makes the success sweeter (James, 1922). Theoretical modeling engages students in a way that the material takes on relevance and immediacy it simply cannot attain in a textbook and lecture environment.

When students feel competent at completing a valued task, they tend to do a better job of availing themselves of productive metacognitive strategies (Schunk, et al., 2008).
These improved strategies have been shown to correlate with better academic performance overall by helping students attribute their success with the modeling method to stable and intrinsic factors (Schunk, et al., 2008). As prior success is a component of a positive self-concept, success leads to positive expectancies for similar tasks in the future, and may also lead to greater enjoyment of particular tasks and disciplines (task-value). Thus, success breeds success—a positive, self-fulfilling, self-perpetuating recursive cycle leading to even greater achievement (Hirsch, 1996).\footnote{There is anecdotal evidence showing that students take advantage of the “Matthew effect” (Hirsch, 1996) and carry the epistemological elements of modeling into their other studies. But the sample, so far, is too small to allow for a generalizable statement.}

The modeling pedagogy, in addition to emphasizing authentic, hands-on experiences for students, encourages students to interact, collaborate, and develop consensus-based representations of their understandings. Students build on one another’s ideas—a cross-pollination that is at the crux of collaboration. In historical education this means that students are working in groups to engage in historical thinking. Often this may lead to controversy and debate, but ultimately helps students develop not only deeper understandings (longer term memory), but also skills we associate with civic engagement (Dewey, 1915).

In modeling, done properly, students engage as equals, teaching and being taught by each other. As Locke (1996) suggests: “When anyone has learned anything himself, there is no such way to fix it in his memory and to encourage him to go on as to set him to teach it others” (p. 137). High school students may not be as capable as adults at viewing history through multiple lenses, or have all the content knowledge necessary for in-depth analysis, but they can be moved toward a more complex view of history (Dulberg, 2005). The historical thinking (VanSledright, 2011) that is fostered by the
construction of theory, pushes students to confront the deep, historiographic issues that form the core of the discipline.

As in all other fields, history has a set of these threshold concepts, central ideas that integrate multiple layers of understanding and that are pivotal to authentic work and understanding. Students who have not gotten through the intellectual barrier—had their epiphany—can only see the most superficial elements put before them. With clarity, however, comes “a new and previously inaccessible way of thinking about something . . . a transformed way of understanding, or interpreting, or viewing something without which the learner cannot progress” (Meyer & Land, 2003, loc. 4161). Threshold concepts are not blocks of information or a discrete set of skills; though, the provision of key content and essential skills is necessary to enabling students to pierce their intellectual barriers. When a student truly understands a threshold concept, she has gone well beyond the gathering of information and even knowledge, to the attainment of a “qualitatively different view of subject matter”: Wisdom (Meyer & Land, 2003).

Threshold concepts are, by definition, those most difficult to understand. The teacher has to develop a sense as to how, how much, and when these challenges are to be posed (Locke, 1996). If the teacher aims too high and a threshold concept is introduced before the student has the wherewithal to deal with it, the barrier will remain impervious. As Locke (1996) explains: “[I]n the mind once jaded by an attempt above its power; it either is disabled for the future, or else checks at any vigorous undertaking ever after, at least is very hardly brought to exert its force again on any subject that requires throughout and meditation” (p. 204). The same holds true if expectations are too low. As with any great challenge, students (and teachers) will avoid effort and seek an easier
path. If, in the face of initial failure, the teacher oversimplifies the concept or resorts to the mere transfer of information the student will likewise resort to rote memorization and formulaic processing. The student will remain benighted and bereft of authentic learning. This is what Russell (1963) is warning of when he states: “The acquisition of concrete knowledge is pleasant to most children. . . . But abstract knowledge is loved by very few, and yet it is abstract knowledge that makes a civilized community possible” (p. 221).

The student should not be abandoned post-epiphany. Instead, the teacher should guide their pupil through the process of internalizing the threshold concept and learning to deploy it in other contexts (Meyer & Land, 2003). It should also be understood that the removal of one barrier, and its associated misconceptions, is not the endpoint. Rather, it is a new starting point from where other threshold concepts can be pursued and the journey to deep, permanent, transferable, and useful wisdom can continue.

The objective of modeling is to engage students in the development of disciplinary skills, the construction of knowledge, and most important, to help them through the “troublesome barriers” that prevent them from making breakthroughs with threshold concepts. In so doing, modeling is a means of imbuing students with habits of mind that will serve them in all their pursuits as thinking individuals. As Wineburg (2001) states,

high school students can know a lot of history but still have little idea of how historical knowledge is constructed. It is doubtful that teaching these students more facts . . . would help them [understand history] better . . . when they remain ignorant of the basic heuristics used to create historical interpretations. (p. 84)

Burenheide (2007) points to research that suggests, when students are given the opportunity to ask important questions (Damrosch, 2007) and to construct their own
conceptual framework (through modeling), they become engaged participants, internalizing “the historical facts that are often the goal of other [pedagogical] methods” (p. 57), and able to perceive patterns and transfer their knowledge to novel situations. (McDermott, 1993). Self-derived, visual, and powerful models provide students with a conceptual framework that allows them to understand complex situations. It is, perhaps, ironic that simplification (modeling) can lead to a more sophisticated and nuanced view.

Modeling instruction holds tremendous promise for Humanities classes, just as it does for Physics and other science courses. It offers a way for teachers to become more efficient at getting students to retain and truly understand material and to be adept and confident in applying it to new scenarios. By shifting the focus away from piling on more and more information to understanding and deploying core concepts, modelers become historians—thus mastering the discipline.
References


Cycles of History
EPICS

I. Economic
   a. Environment/Geography/Land/Nature
   b. Labor
   c. Capital and Money
   d. Infrastructure
   e. Agriculture
   f. Industry
   g. Banking/Markets/Mercantile

II. Political
   a. State (Government and Institutions)
   b. Law and Justice
   c. Rights, Restriction, and Duties
   d. Relations with Others (Diplomatic/Military)

III. Intellectual
   a. Philosophy
   b. Education
   c. Ideology
   d. Theology
   e. Science
   f. Technology

IV. Cultural
   a. Mores
   b. Rituals
   c. Art—High/Popular—Crafts
   d. Literature
   e. Architecture
   f. Sports/Entertainment
   g. Food

V. Social
   a. Demography
   b. Migration
   c. Community
   d. Family
   e. Individual
   f. Class
   g. Race/Ethnicity/Religion
   h. Gender
   i. Health
Forces in History

✦ Stasis vs. Change (Order vs. Chaos)
  ✦ Settlement vs. Migration (Motion)
    • Colonization
    • Expansion
    • Urbanization
    • Emigration/Immigration
    • Forced migration / settlement (slavery)
  ✦ Nature vs. Technology
    • Environment (Challenges and Opportunities)
    • Resources (Conservation, Preservation, and Exploitation)
    • Ideology
    • Cultural & Intellectual View
    • Limits and Prospects

✦ Control vs. Resistance (Power)
  • Control by authority / majority
  • Resistance to authority / minority
  ✦ Inclusion vs. Exclusion (Us vs. Them; Defining Identity)
    • National
    • Group
    • Individual
  ✦ Cooperation vs. Competition
  ✦ Hierarchy vs. Equality
  ✦ Group vs. Individual