Ten years ago, in “Skewered on the Unicorn’s Horn: The Illusion of a Tragic Trade-Off between Content and Critical Thinking in the Teaching of Science,” I addressed the nature of critical thinking, how to teach it, and the benefits and costs of doing so (Nelson 1989). I argued that, although many faculty feared that they would have to teach less content if they were to teach critical thinking, the trade-off was actually illusory—as imaginary as the unicorn’s horn. Here, I have been asked to revisit this analysis and to explicitly extend it to a wider array of disciplines.

The unicorn still thrives in much of academia. When I introduce faculty to various approaches to fostering critical thinking in their classes, many still initially fear that teaching critical thinking will mean that they have to teach less content. There is, of course, a sense in which these faculty are right. If one measures teaching by what the teacher presents or “covers,” then time spent on anything except lecturing on content is, by definition, a reduction in coverage. However, if one asks how to maximize student learning, then covering as much as possible clearly is a seriously flawed approach.

The effects of replacing a substantial portion of traditional coverage with required, guided student-student interaction have been well documented. For example, McKeechic (1994), in the classic introduction to college pedagogy (now in its ninth edition), summarizes the relevant studies as showing that discussion usually is better than lecture for retention of information after the end of a course, transfer of knowledge to new situations, problem solving, thinking, attitude change, and motivation for further study.

Three examples here will suffice to illustrate the magnitude of the effects often achieved with guided student-student interaction. Adding required peer checking outside of class and structured small group work in class reduced the D and F rate for African Americans taking calculus at the University of California, Berkeley from 60 percent to 4 percent with no reduction in the expectations (Fullilove and Treisman 1990; Treisman 1992). An experienced math professor taught calculus with no F’s for the first time in his career after switching some of the homework to reflection in English and using structured small groups during class (Angelo and Cross 1993). Most spectacularly,
in a meta-analysis of studies of several alternative approaches to teaching some key concepts in introductory physics, Hake (1998) found that such approaches always were superior to traditional physics teaching. These approaches usually doubled or even tripled the increase in student understanding produced by traditional physics teaching.

One of the lower levels of critical thinking is right answer, quantitative problem solving in which the entire class is expected to arrive at the same answer, usually by fairly straightforward application of algorithms presented in the class. The preceding examples illustrate that, even at this level, massive improvement in learning to think critically can be achieved dependably by partly or wholly replacing traditional, coverage-focused lecturing with carefully structured, active approaches. Pedagogy matters, and much is already known about how to make it more effective.

However, I feel a deep affinity with those faculty who still are worried about unicorns. Like most faculty, I came from a background where pedagogy was almost a dirty word and where suggestions that college teaching could be taught were ridiculed by full professors of international renown. Any formal knowledge of pedagogy was thus “taboo” (Nelson 1997).

Serendipity intervened. A colleague cited Perry’s (1970) Forms of Intellectual and Ethical Development in the College Years as essential reading for anyone interested in teaching undergraduates. The central lesson in Perry’s scheme is that learning to think critically requires an incremental series of major reorganizations in our students’ views of knowledge and knowing. This insight stimulated developments in my teaching that greatly enhanced the students’ enthusiasm and fostered more powerful critical thinking and a deeper understanding both of the content and of the nature and limits of science.

Perry’s scheme still is central in my considerations of teaching and learning as well as of what critical thinking is and of how to facilitate it. Success at many of the central tasks of liberal, disciplinary, and professional education can only be achieved by implicitly or explicitly fostering the students’ progress. In summarizing the scheme and the teaching moves that relate to it, I draw mainly on Perry (1970, 1981), Belenky et al. (1986) and my own earlier expositions of some of these ideas (Nelson 1986, 1989, 1994, 1996, 1997).

A Teacher’s Overview of Perry’s Scheme and of Its Implications for Fostering Critical Thinking

Perry (1970, 1981) found that students typically enter college with a simple view of knowledge that essentially precludes them from understanding complex issues. Some students progress through a series of transitions to more effective modes of thinking, but a substantial majority graduate unable to deal effectively with uncertainty and complexity. Four modes and the three transitions among them are especially important for understanding college teaching. The formal names for the modes are Perry’s. Those in quotes are my attempts at mnemonic tags.

Mode 1: Dualism or “Sergeant Friday”

Truth as Simple and Eternal

In this approach, the intellectual world is seen dualistically as almost exclusively right or wrong, both factually and morally. Students assume that valid questions have certain answers. Right versus wrong spelling and arithmetic ground this perspective. Grades should be equally unambiguous. Like Sergeant Joe Friday,
the television detective, students here want "just the facts, ma'am" and expect to memorize them (just) long enough to pass the exam. Thus, they feel that teachers should serve as gigantic, flourescent yellow highlighters who emphasize the parts of the text that must be memorized. Alternatively, teachers should teach the unambiguous way (the equation) to find the right answer. Students here so resist uncertainty that they might question a teacher's competence if shown two ways in which to work a problem.

Furthermore, teachers are not to add to the text; there is plenty there already. We certainly should not disagree with the text; if we were that smart, then we would have written it. If the text is not "right," then why are we using it? And, worse, how could anyone decide what parts of the text to believe?

We will have dualists in most classes. Some students approach all classes this way, and many approach some classes this way. Much teaching in freshman courses focuses on two tasks that dualists can do well: memorizing information and solving right answer problems. Such teaching works in the narrow sense of letting the students pass the exams. However, dualistic students might be unable to decide what facts are "relevant" and what algorithms are "appropriate." Thus, paradoxically, focusing teaching on facts and right answer problems might make even these aspects harder for many students to learn.

Alternatively, when uncertainty is rampant in course but its sources are not understood, students might assume that the uncertainty is the teacher's fault—that if the teacher were competent, then the truth would be clear.

Even when both the extent and sources of uncertainty are clear, students may try to preserve dualism as the general state. When I have teaching the content of ecology in the way I suggest here, but without any structured student-student discussion, students repeatedly said essentially, "Nelson is a pretty good teacher, but it is a shame that ecology is uncertain. They should let him teach some real science sometime." This was their way of limiting the range of knowledge that was uncertain.

Students appropriately are reluctant to accept the idea that knowledge is uncertain. They understand how conclusions that present seem so convincing might be flawed. How can we help students understand the extent of sources of uncertainty in what we teach?

One very powerful tool is the history of knowledge. It is helpful to include examples from mathematics and physics because students often regard these fields as touchstones for certainty.

Kline's (1980) Mathematics: The Loss of Certainty summarizes the "calamities" that fell the view that logic alone could establish the structure of reality. If logic provided truth about reality (rather than about imaginary universes that ours only approximates), then space would be Euclidian rather than a function of the distribution of matter, and two quarts of alcohol added to two of water would yield exactly one gallon rather than distinctly less (they dissolve in each other).

Data also fail to yield certainty. What did physicists 100 years ago "know" to be absolutely true beyond all possibility of doubt? What do we now know to be wrong? Important answers include the following: space wa

Transition 1: Perceiving Uncertainty as Real

No one thinks critically about things that seem to them to be unquestionably true. An understanding of both the extent of uncertainty and of its sources is essential. When students understand just the sources, they often assume that uncertainty is just a theoretical possibility and that the material actually is eternal truth.
thought to be perfectly Euclidian (rather than bent hither and yon by matter), motion was thought to be Newtonian (rather than relativistic), and matter was thought to be indestructible (rather than interconvertible with energy).

The general point is that whether or not scientists ultimately can find certain truth, they often have wrongly thought that they had it. Put differently, the failure of Euclidian geometry shows that even complete agreement among all relevant authorities on good empirical and theoretical grounds for a millennium or so is not adequate to guarantee truth.

Fundamentally, the complexity of reality often allows multiple interpretations of a data set, including some not yet envisioned. This precludes “proof” by even apparently perfect agreement between prediction and data. Hence, the insistence by statisticians that we reject nulls (as we cannot not prove theories). Worse, the same factors that preclude certain proof also preclude certain “falsification.” Instead of the hypothesis falsified being wrong, an auxiliary assumption made in testing it might be wrong (e.g., Kitcher 1982). Physicists falsified continental drift by showing that no known physical force could move continents. The “flaw” was not anticipating the discovery of sea floor spreading. But no proof or falsification in any field can ever be guaranteed against the discovery of new forces or against the relevance of additional factors. Hence, the tentativeness or uncertainty of all empirically based knowing.

Even though historical examples often are very powerful, it is important to also focus on more recent shifts, bringing these to bear on the course at hand. Otherwise, the students will fail to understand the tentativeness of current views and might even conclude that, although past ideas have fallen consistently short of truth, present views really are certain. In most disciplines, the normal flow of knowledge, and especially the gradual demise of the unquestioned dominance of “modernist” ideas and the emergence of “postmodern” alternatives, provides a plenitude of examples. Anderson (1990) provides a quick, teachable, multidisciplinary introduction to these alternatives.

**Mode 2: Multiplicity or “Baskin Robbins”**

**Personal Truth**

When students first encounter unavoidable uncertainty, they have no way in which to select better options. Instead, they divide reality into two realms. In one, authority still provides correct answers. In the other, absent consensus among authorities, each person’s position is fully valid and no one can say that one position is better or worse than another. Lacking any better standard in this second realm, students pick an opinion because it feels intuitively okay, much as one might pick a flavor for an ice cream cone. Such choices are based on feelings or intuition, not on reasoned analysis. Perry termed this mode “multiplicity.” Students here often actively distrust authority, reason, abstraction, and especially science (Belenky et al. 1986).

Most graduates from four-year programs have multiplicity as the most sophisticated mode they use spontaneously in thinking about real problems (e.g., Belenky et al. 1986; King and Kitchner 1994). In this sense, liberal, disciplinary, and professional education all fail even for most of the students we graduate.

**Transition 2: Perceiving Opinion as Insufficient**

**Comparisons and Criteria**

The transition from dualism to multiplicity required that students recognize the inevitability of important uncertainty on many questions.
The transition from multiplicity to greater sophistication requires the recognition that despite this uncertainty, justified choices can be made. Often, one or more ideas or other human productions (be they poems, economic or scientific analyses, management or nursing plans, or whatever) can be shown tentatively to be superior to most other comparable productions. Alternatively, although there may be a fair range of acceptable productions, many others are demonstrably terrible. Thus, the choices among theories and other human productions must be justified on comparative rather than absolute grounds. And asking “To which theories is this one preferable?” leads naturally to “On what criteria or grounds is it preferable?”

As an example, the big bang theory for the origin of the universe is widely taught, even though it predicts that matter will have been initially spread so evenly that galaxies would never form. But differently, the big bang theory has been known to be wrong for decades (as galaxies clearly do exist). This illustrates uncertainty. The big bang is taught not because it is “right” or “true,” nor is it chosen on feelings or intuition. Rather, it is widely taught because it is “better.” The alternative models assume either an unchanging universe or a “steady state” of endless unchanging equilibrium. These are the comparisons. The big bang is better because it accounts for the cosmic background radiation, the changes in the average composition of stars through time, and certain other features of the universe that are left unexplained by the alternative models. Explanation of these additional data sets is one of the criteria on which the big bang model is better than the alternatives.

The basic task here is to explicitly delineate, and to help the students learn to use, the forms of argumentation and the criteria used by our disciplines in deciding which ideas to accept tentatively. Several difficulties interfere with this goal.

First, unfortunately, we often focus on teaching one (currently) “best” theory for other production, leaving the comparisons implicit. Thus, we hide the very perspective that the students need to think critically about the material.

Second, many of the transitions we use between modes of representation (e.g., words, drawings, illustrations, equations, graphs) have become second nature to faculty but are not evident from the students’ perspective and serve only to make the argument more confusing (Arons 1979).

Third, several aspects of the justification for a choice may have been learned tacitly by faculty (Polanyi 1966) and thus not be easily explained. It took me considerable effort to articulate the forms and criteria for the field: teach. In sum, we often recognize and present good arguments and good examples without articulating well what makes them good.

Finally, although comparison is the core of much of argumentation in many disciplines, criteria and other aspects of argumentation differ appreciably among fields (e.g., Broughton 1984, 1994; Hare-Mustin and Marecek 1988). In much of natural and social science, match the external reality is central. Describing real empirical patterns accurately and providing testable causal explanations that account for the patterns are core criteria in any comparison in some of the humanities, by contrast, match to internal environment is essential, and all of the “facts” can literally be fictional. In other areas, the feasibility and acceptability of the policies or other social actions that emerge from an idea are crucial considerations.

The overall point is not that particular criteria must be used across disciplines. Rather, students cannot learn to think critically until
they can use criteria appropriate to our disciplines to select among alternatives. We aid them when we make the comparisons and criteria explicit.

Comparisons are especially effective in most disciplines when they are clearly unbiased (or, if you prefer, minimally biased). I formalize this for students in the areas where I teach by focusing on comparisons that are demonstrably “fair.” Fair comparisons are based on new discoveries that could have supported each of the alternatives being compared. Radioactive dating provides a fair test, in this sense, of earlier ideas that the earth is either quite young (based on Biblical interpretation) or hundreds of millions of years old (based on analyses of erosional and depositional rates). It is fair because neither of the earlier theories is based on radioactivity and because it could have supported either or neither of the alternatives. A young earth is rejected in science not because it has a religious source but rather because it fails a long series of fair empirical tests.

A nagging question underlies much student anxiety during this transition: “how can knowledge simultaneously be both uncertain and useful?” I like to take this one level further and ask how knowledge can be wrong and still be useful. If wrong ideas can be useful, then uncertain ones surely can as well.

Consider the brilliance of the flat earth model. The earth is in fact very flat—precisely as flat as the surface of a small pond on a still day. Although the pond is wonderfully flat, it domes imperceptibly up in the middle to exactly match the earth’s curvature. Moreover, the flat earth model is by far the most widely used quantitative model of the shape of the earth in practical human applications such as architecture and engineering. (We assume that in a square room, opposite vertical walls will be parallel rather than vertically divergent; this assumes that the earth is flat.) Thus, the flat earth model has precisely the same present scientific validity as do Newton’s laws of motion. Both capture important pieces of reality. Both are of immense, quantitatively precise, practical importance. And both are quite wrong and wrong in exactly the same sense. Each is a quantitatively quite good local first approximation that fails spectacularly on larger scales. Our current explanatory models in most, if not all, fields are useful in about these same senses, and many (perhaps all) either are now known to be wrong or will likely turn out to be wrong in about the same sense.

Mode 3: Contextual Relativism or “Teachers’ Games”

Understanding Decisions Within Disciplines

After they complete this second transition, students can understand that one can use the criteria and forms of argumentation of a field to tell better from worse and make sense of the chaos of uncertainty in a way that is satisfying to the teacher, if not to oneself. However, many students treat such intellectual activity as either teachers’ games or disciplinary games. Often, there is a strong element of sophistry here, albeit not the “any opinion is equally good” of multiplicity. Rather, students now often still think privately that any framework or game is equally good (it is this sense that I emphasize by using the term games) and may cynically consider the justified answers teachers require to be “bullshit.” Indeed, Perry (1970) found that students who were unwilling to give answers that they did not fully believe often had the toughest time in college. Thus, it helps to emphasize for students that, in most cases, we do not want their own raw opinions. Rather, we want the best answers that they can provide within the rules of our fields.
The students' sophistry and cynicism here show that, despite our delight in their understanding of our disciplines, these students still are not capable of mature critical thinking. They cannot effectively compare alternative paradigms, choose appropriate applications in complex situations, or understand the interrelations, say, of science and public policy. If we do not ask them to treat such issues, we might not realize that even many of our best students fall short of what we expect from a liberal, disciplinary, or professional education.

Why Disciplinary Discourse Is Not Enough

Developing Intellectual Empathy

The necessity for further development can be seen if we examine the development of empathy (Belenky et al. 1986). When we treat issues as dualists, we rely on an authority to provide the answers. We see no validity in asking why authority chose those answers. Authority chose them because they are the truth. Because we do not understand why our group believes as it does, we have no base for understanding why other groups believe differently; they are simply wrong. Indeed, we frequently regard other views as not just factually wrong but also morally wrong—as evil (Perry 1970). Thus, we have no base for either intellectual empathy or tolerance.

In areas we treat with multiplicity, we believe that authority cannot provide dependable answers. If we must pick an answer, then we do so unreflectively (again, like choosing ice cream). Thus, we have no articulated understanding of our choice and, hence, still no grounds for intellectual empathy. But we want others to tolerate our choices and thus expect to tolerate theirs. This leads us to try for unlimited tolerance in areas where we see that there are no clear answers.

In the intellectual "games" of contextual relativism, we understand that people living in different contexts often legitimately believe differently. We might even take as one of our central tasks the attempt to understand how intelligent, even brilliant, people (past and present) ever came to believe things that are so different from those we currently believe (Russell 1945). Thus, we are rapidly developing the capacity for intellectual empathy.

But we still have essentially unlimited tolerance for different frameworks. Great tolerance might seem to be a virtue, but students often carry it to extremes. Given an introduction to modern German history, they can see that in many ways Hitler was brilliant and effective. But they are reluctant to say that despite our agreement with parts of Hitler's framework, key parts of what he did were wrong or crazy (Belenky et al. 1986). To make such judgments, one has to assert one's own values as preferable in key ways to some of the alternatives. One has to begin to take stands again, as one once did in dualism, but now based on an articulation of one's own values and analyses and not just as an echo of authority's positions.

I have sketched the rationale underlying this conclusion for the development of intellectual empathy. The same conclusion follows from several alternative considerations. For example, the development of multicriticuality follows a sequence of modes or stages very like those of Perry's scheme. Indeed, Bennett (1986) suggests an almost one-to-one correspondence with Perry's modes. Bennett's analysis makes clear that progress beyond the multicultural equivalent of teachers' games is crucial.

The overall point is that contextual relativism fails to provide frameworks for choosing among approaches in nonarbitrary ways and for deciding when and how to combine disciplines (or cultures) in solving real-world problems.
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Such frameworks are made necessary by the
complexity of these problems; their causes and
potential solutions transcend individual disci-
plines. The teacher's third basic task is to de-
lineate the values inherent in the practice and
application of our fields, the limits of our fields,
and the consequences that follow from apply-
ing them.

Transition 3: Joining
Values and Analysis

How can we best foster this third transi-
tion, the one that allows deep professional com-
petence and sophisticated ethical judgment?
The teacher's basic task is to delineate the
values inherent in the practice and application
of our fields, the limits of our fields, and the
consequences that follow from applying them.
Many disciplines strive hard for objectivity. We
often misleadingly downplay, especially in sci-
ence, the role of values in the decisions made
both within the field and in its applications
(e.g., Graham 1981; Harding 1986, 1993).
Morrill (1980) discusses several general ap-
proaches for relating values to other content,
especially in the social sciences. I have found
several approaches to be helpful here.

Hypothesis testing. The role of values at the
core of much of natural and social science is
well illustrated by our procedures for deciding
when evidence is adequate to accept or apply a
hypothesis. We use our evaluations of conse-
quences to justify our initial stance toward a
hypothesis (accept until shown to be probably
false or reject until adequately supported). Why
do we usually take an initially skeptical view of
hypotheses proposing new effects? When
should we take a different stance? Would your
stance differ for new food additives versus eth-
nic spices? For AIDS drugs if you were a patient
or the one in charge of regulation? Similar
evaluations let us then decide how much con-
trary evidence should lead us to reject our initial
stance. Consider the 5 percent level for reject-
ing null hypotheses. Try asking, "Why 5 percent
rather than 10 percent or 1 percent?" and
"When should another level be used?" Note
that 5 percent rarely is appropriate for applying
science or for reaching conclusions that have
real-world implications. "How sure should we
be that a new drug is safe?" provides an exam-
ple. Such value judgments are central to hy-
pothesis evaluation and application across
much of the natural and social sciences (e.g., see
Nelson 1986 for the creation or evolution and
nuclear power controversies; see Hare-Mustin
and Marecek 1988 for gender differences; or
see any statistics book).

Paradigm choice and paradigm mixing. The cen-
tral role of values also is evident in decisions as
to which paradigm or field we should apply to
particular questions. This can be illustrated by
considering cases in which different approaches
are now used. For example, what are the advan-
tages and disadvantages of addressing schizo-
phrenia as a genetic defect, as a biochemical
disequilibrium, or as a response to social stress?
The limits of each of our disciplines usually
can be shown by even a brief consideration of
how a major real-world problem should be
addressed. Biology can demonstrate some con-
sequences of pollution but provides only little
suggests that we teach students to expect that
each field provides a biased view and that solu-
tions typically require a dialectical interplay of
the strengths and weaknesses of various fields.
Basseches (1984) emphasizes the importance of
the dialectical approaches in achieving ad-
vanced levels of critical thinking.

Comparing one's own values to those of one's
major. Alverno College (1987; see also Earley,
Mentowski, and Schafer 1980) has developed materials for teaching values at each Perry level in a wide range of disciplines. These materials suggest that each major should teach values analysis in a series of steps graded across several courses. These culminate, in part, in asking seniors to delineate the value commitments inherent in their majors, to compare and contrast those commitments with their own, and to discuss how they see the differences playing out in their careers. With slight rewording, this becomes a very helpful exercise for helping individual faculty reflect on their own commitments and values.

The teacher as the lesson. In verbal presentations of his findings, Perry often emphasized that students at this level have just one question of you as a faculty member: “Are you alright?” The student can see that this new approach to knowing requires both that the student leave behind many of his or her earlier views of why things should be and that the student accept considerable responsibility for himself or herself and his or her world. The student wants to know whether you are happy enough and moral enough. Who the teacher is becomes an essential part of the learning experience in a new and deeper way.

Put differently, students need to see us as faculty modeling the taking of stands securely grounded in our values in the face of uncertainty and complexity. The place where this is most effective is that which affects the students most directly. One way in which to do this is to articulate for ourselves and for the students the answers to questions such as “How are my personal values reflected in the choices I make as to what content to teach and what not to teach?” and “How are they reflected in the choices I make as to what pedagogical approaches to use and what not to use?”

A Bit of Reflection

By now, we have bluntly crossed several layers of the taboos that surround teaching. We must not just explore the pedagogical literatures both generally and in our own disciplines, but also must ask whether the ways in which teaching can be done better are the ways in which our graduate programs are taught, are the most effective ways for our particular students, thus challenging our disciplinary culture. And, in most fields, there is a further taboo against seeing that teaching always is at least implicitly teaching about values both in the content choices and in the choices of pedagogies. But teaching necessarily becomes explicitly about values when we choose to openly model and require “adult” thinking.

Mode 4: Commitment

I have struggled to find a mnemonic for the approach Perry termed “Commitment,” emphasizing with a capital C the qualitative distinction from decisions or “commitments” made at the less sophisticated stages. I sometimes just use “adult” thinking here, but not in a descriptive sense, as many adults do not use this approach. Rather, I use it in a hopeful and normative or prescriptive way, asserting that this is the way in which adults usually should think. Belenky et al. (1986) call it simply “constructed knowing.”

To operate as sophisticated adults, we must combine “games” and adjudicate among various combinations thereof in different contexts. Thinking becomes more complex and more responsible in several senses (Belenky et al. 1986). We come to see knowledge as constructed rather than discovered. We see decisions as contextual, as based inevitably on ap
proximations, as involving trade-offs among conflicting values, and as requiring that we take stands and actively seek to make the world a better place. We understand that to do significant good, one must risk doing harm, and that to do great good, one must do significant harm (Levinson et al. 1978).

A doctor who is unwilling to risk harming us is useless. Powerful drugs have significant, occasionally lethal side effects. Doctors must accept that some of their patients will be harmed or die from the side effects of drugs and other treatments appropriately administered and from the consequences of appropriately withholding drugs and other treatments. And that is without any mistakes. A parallel argument can be made for teaching: if we do not teach for sophistication, then we harm all of the students, and if we do, then we might occasionally cause more stress than we intended. More generally, trade-offs and risks are the rule, not the exception, in important real-world decisions.

The small minority of students who do use this mode know that problems can be approached from diverse frameworks. They can indeed delineate the advantages and disadvantages of various frameworks, address contexts and trade-offs, and articulate why they advocate or use a particular approach. Most gratifyingly, they take responsibility for the validity of their beliefs and for personally making a difference in the world (Belenky et al. 1986). Education has worked.

When we, as faculty, fail to get students to this level of critical thinking, we leave them poorly prepared to deal with personal and professional decisions. Moreover, this type of thinking is required for any useful approach to the major issues of our times including diversity, social problems, environmental issues, technological change (e.g., in the applications of medicine and genetic engineering), and changing economic and geopolitical systems. These issues all require minds that can grapple successfully with uncertainty, complexity, and conflicting perspectives and still take stands that are based on evidence, analysis, and compassion and are deeply centered in values. This ability must be a major goal of liberal, disciplinary, and professional education. Fostering the sequential transitions is a major route to the goal.

Mosaicism

I have sketched only Perry’s main line of development. Students may retreat to earlier modes if the challenges of sophistication become overwhelming. More important, students in intermediate stages (where most are) usually take a mosaic approach. Some areas encompass truth, others include naked opinion, and (for sufficiently sophisticated students) yet others include issues resolvable by disciplinary criteria or trade-offs among disciplines.

Estimates of a student’s dominant mode are less helpful for teachers than is insight on how the student is approaching the current topic. Furthermore, Perry emphasizes the importance of learning to apply in new areas the modes one has mastered in others. Explicit comparisons of different topics with those from areas in which the students are more sophisticated sometimes facilitate rapid changes in thinking (Perry 1970). Such comparisons complement the teaching moves that facilitate particular transitions.

The Other Half: Matching Challenge with Support

The most fundamental lesson for teachers from Perry’s study is that critical thinking is acquired incrementally. The second key point is that
learning critical thinking is existentially as well as intellectually challenging. In asking students to learn to think more critically, we ask them to set aside modes that have served them well and still tie them to family, friends, and prior teachers. (Similarly, when we ask faculty to teach in new ways, we ask them to set aside or modify pedagogical modes that have served them well and still tie them to colleagues and mentors. They, too, need support to help them alter their pedagogy.) Perry’s (1970) fine treatment of the existential factors that students face is deeply enriched by that in Belenky et al. (1986). The interplay of intellectual and existential factors dictates a balance of challenge and support in facilitating critical thinking (Knefelkamp 1980). Support has several elements.

Explicitness. The central intellectual challenge is mastering critical thinking and applying it to course topics. Both support and intensified challenge are provided by making uncertainty, criteria, and values explicit and central. I treat these aspects extensively early in the course and then use them to frame subsequent lectures and discussions. Almost daily, I emphasize alternative theories and criteria for evaluation. This requires about 10 minutes per 75-minute “lecture” period. We also usually devote a discussion period and an exam question to the question, “What view of the nature of science is presented in this course?”

Larger perspectives. Critical thinking is facilitated by frameworks that encourage students to ask, “How am I thinking about this?” (McKeachie 1994). Explicitly teaching critical thinking requires students to ask, “What criteria are appropriate here?” and “What values is the author applying here?” I also have students read and discuss Perry (1970). They can then ask, “Am I approaching this as a question of truth, of opinion, of disciplinary criteria, or what?” A third framework is provided by noting the interplay between positivism (or objectivism) and constructivism that dominates much current intellectual dialogue. Lave (1987) and Anderson (1990) both discuss the interplay across broad swaths of the intellectual landscape and draw out its central role in understanding differing views on the nature of knowledge and knowing in a variety of intellectual disciplines. Novick’s (1988) analysis, although focused on history, is quite valuable in considering other areas as well.

Accessibility. Lectures and readings that require thinking near the limits of the students’ current frameworks may tax their abilities to summarize and anticipate exam questions. If so, then they can study extensively without accomplishing much. Making the material more accessible helps. I distribute lecture outlines that state difficult points and list questions on both lectures and readings. Questions central to main themes are starred. Exams are drawn from these lists and include a disproportionate number of starred questions. Because students might not recognize inadequate answers to the new type of questions, I assign selected questions as homework. The students then discuss them in small groups. Allowing retakes of at least the early exams further encourages mastery of critical thinking (Nelson 1996).

Structured small group discussions. As I noted in the introduction, extensive discussion as an integral part of each course greatly facilitates the mastery of critical thinking processes. Critical thinking must be practiced. It is not a spectator sport. Discussions provide a guided opportunity. Moreover, new ways of thinking might seem less alien when mutually explored. Small group discussions also increase content learning, application skills, and enthusiasm (McKeachie 1986); build rapport; and facilitate out-of-class group work.

As a major influence, I have adapted the students to my own preferred reading. They quickly evaluate, evaluate, and filter information, and often decide whether groups (five in my classes) are structured in a way that builds, maintains, and plans participation. We adopt participatory approaches primarily. Preparation is much improved. On the one hand, I also see the approaches inciting a “lecture” period.

Rehearsals. By emphasizing the importance of critical thinking in hearing and writing, pedagogically I encourage a variety of opportunities. Opportunities for writing and reading are built into the course. Answering students’ questions, I sometimes find that faculty-led model questions are the best option of all.

Fostering voice encouragement (as mentioned, 19). Questions and answers are often uncertain, and questions as well as answers may seem difficult. Later, I may encourage students to discuss the model. I often pressed that...
out-of-class group study and the deeper understanding it produces.

As a major part of much of my teaching, I have adapted Hill's (1969) approach. The students prepare a worksheet over an assigned reading. They summarize the author's argument, evaluate its support, determine an appropriate burden and level of proof, and then decide whether the argument is adequate. Small groups (five to seven) use the worksheets to structure their discussions. Grades cover preparation and participation (emphasizing roles that foster participation and understanding). This approach produces nearly 100 percent careful preparation for participation discussion and much improved understanding of the ideas at hand. I also use several other discussion approaches including some in nearly every "lecture" period (Nelson 1994).

Rehearsals. Knefelkamp (1980) emphasizes the importance of multiple rehearsals in teaching critical thinking. Multiple opportunities for rehearsing important ideas are provided in the pedagogical approaches I normally use. These opportunities include lecture comprehension, writing and participating in mini-discussions built into the lecture period, individually answering study questions, group review of study questions, discussion preparation, discussion, faculty-led review sessions, the exams, and the option of restudying and doing an exam retake.

Fostering voice. Fostering the students' own voice encourages intellectual change (Belenky et al. 1986). In fostering the recognition of uncertainty, we sometimes must accept opinions as valuable without evaluation. I initially found this troubling because unjustified opinion seemed contradictory to critical thinking. Later, I realized that students had implicitly taught me its importance. They invariably expressed their feelings prior to seriously discussing a reading and asked for an unevaluated "parting thoughts" section on the worksheets. My interpretation is that most of my students use multiplicity as the base where they like to start and end.

I now look for other opportunities to ask for opinions, reactions, or experiences. For example, early in a course, I often ask, "What have you heard to be the problems with evolution?" Questions asking for public perceptions of a field or topic can be used in nearly any course. Similarly, to foster analysis and the integration of values with analyses, we can provide opportunities for students to start their analyses in the modes they normally use. Discussion and study groups provide such opportunities and facilitate out-of-class conversations.

Connected teaching. This concept from Belenky et al. (1986) has two main aspects. First, it is important to show that you care about the students' learning. I do not let covering material take precedence over asking whether my explanations or the students' discussions need to be clarified or elaborated. This requires pacing the lectures so that the students can listen actively instead of acting as dictation machines (lecture outlines help) and stopping occasionally so that the students can decide whether they have questions. Caring also is manifest in knowing the students' names. This is difficult for me. I take the students' pictures and find that I can learn the students' names for classes up to a bit over 100.

The second key aspect of connected teaching is revealing the teacher as an individual striving, like the students, to interpret a complex and uncertain world. Although lectures require much prior thinking, it might seem to the students as if professors spontaneously think the way in which we lecture and, consequently, as if "real" thinking is beyond the students' reach (Belenky et al. 1986). This im-

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impact can be softened by exploring new ideas as they emerge during class and by noting how our own personal understanding has changed. Share the changes, the mistakes, and new information (and other factors) that led to changes, the alternatives you have individually explored and rejected, and the changes you are now considering. Sharing the triumphs and the false starts involved in creating new ideas is central. I recently have come to see as central here the explicit explanations of why I am teaching certain content and of whom I expect to benefit by using my pedagogical array.

**Student Reactions and the Unicorn Dehorned**

How is all of this received by the students? How does it affect the apparently tragic trade-off between teaching critical thinking and teaching content?

*Students are more enthusiastic.* Students have become more enthusiastic as my goals became clearer and my teaching moves became more effective. Several distinguished teaching awards, two of them student initiated, document their enthusiasm.

*Students work harder.* The experience of teaching also has changed remarkably. Most of my students seem to hunger and thirst after stronger thinking skills, and many spontaneously see that questions such as “How am I thinking about this?” and “What criteria will help?” apply quite widely.

I formerly took the mastery of the most sophisticated students as evidence that I taught well and that the other students just needed to apply themselves. Perry’s study and the many follow-up studies (Moore 1997) show that mediocre performance often reflects not lack of hard work but rather lack of complex understanding. Many students need to study differently rather than more. Perry’s scheme helps me define “differently” for them and for ourselves. It now seems that few of my students fail to work hard enough. The increased support allows many more of them to be successful.

However, some students do find learning to study differently and doing the more advanced critical thinking tasks almost impossible, difficult. In freshman courses, the proportion seems similar to the 15 percent that Aron (1985) found in teaching critical thinking in physics. Recognizing that some students are not yet ready for the tasks I set intensifies the usual dilemmas of grading. I usually design the assessments so that diligent students using each modes can get C’s (illustrating yet again the extent to which value judgments must be made in teaching).

*Students learn more regular content.* The steps that facilitate critical thinking also facilitate content acquisition. These steps affect the way in which lectures are framed more than the details of the material presented. The opportunities for rehearsing critical thinking also serve for rehearsing other content. Students’ enthusiasm for discussion and for critical thinking carries over to other content. A higher proportion of the class now masters difficult content. Furthermore, much of the content will be retained as examples of critical thinking processes. The trade-offs between the teaching of processes and the teaching of content that once seemed so evident are, as I noted in the introduction, as imaginary in practice as unicorn horns.

Teaching critical thinking now seems a necessary part of effective college teaching, partly because critical thinking is necessary for effectively understanding and using content and partly because the teaching moves that facilitate
critical thinking and the enthusiasm they generate also facilitate the learning of normal content.

**Will these approaches work in your classes?** I have used them successfully in introductory biology courses, in both science and great books-focused freshman honors courses, in intensive freshman seminars (dealing in part with modernism and postmodernism across the curriculum), and in an upper division course for nonmajors as well as in the upper level majors course I usually teach. These approaches work for the entire array of courses I teach.

More pertinent, perhaps, I have introduced this approach to thousands of faculty in workshops ranging from three hours to three days and more. The responses are almost uniformly enthusiastic. Faculty from many disciplines have spontaneously reported later that it led to major improvements in their classes.

**Robustness**

Perry’s (1970, 1981) framework was of immense help to me in developing this approach. Do the teaching goals and moves depend on Perry’s scheme for their validity? No. Many of them parallel goals and moves suggested from diverse bases such as direct analyses of critical thinking tasks in science (e.g., Arons 1985; Hake 1998) and more generally (Paul 1990), from reviews of critical thinking (Kurfiss 1989), educational psychology (McKeachie 1986, 1994), student development generally (Knefelkamp, Widick, and Parker 1978; Cornfeld and Knefelkamp 1978; Kegan 1994), and feminist pedagogy (even in science) (Barton 1998; Barton and Osborne 1998; Harding 1986, 1993; Rosser 1986, 1998; Whatley 1986). The diverse theoretical approaches that Hare-Mustin and Marecek (1988) and Anderson (1990) link as “postmodern” have implications for teaching that both parallel and enrich those I find in Perry. Parallels and enrichment both also are evident in Belenky et al.’s (1987) synthesis of Perry with feminism and in the many other joinings of Perry’s scheme to complementary frameworks (Moore 1997). Perry’s scheme remains fundamental among this diversity, however, because it focuses most directly on the development of critical thinking, an objective that is universally acknowledged as a central goal of higher education.

College faculty are in a strange position intellectually. We are very eager to show the rest of the society the advantages of studying what is known about how to do their jobs more effectively. However, most of us have had almost no training in the literature on the theory and practice of college pedagogy, and most of us have made at best only token efforts to remedy this deficit. Indeed, many of us treat pedagogical knowledge as a taboo (Nelson 1997). Not only do we not know the literature, we even assert that there is nothing to be known. Fortunately, this taboo approach is beginning to lose it dominance, as reflected in the very existence of this volume.

Indeed, I believe that the burden of proof is shifting. Those who continue to use only straight lecture to cover the content, with or without traditional labs and large group discussions, may soon be professionally or morally obliged to show that they are at least as effective as they would be if they adopted the approaches that typically are distinctly more effective.

**References**


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