Chapter 6 Designing Education for Understanding

 DRAFT: DO NOT QUOTE

A Classroom Perspective

Over the last twenty years, a new kind of educational institution has arisen in the United States. This institution is primarily for young adults who wish to secure particular skills which will help them to advance in the world. While called a university, in many ways it runs completely counter to the traditional vision of what a university is--or should be--like.

Perhaps the prototypical example of this new institution is the University of Phoenix. In the late 1990s, this university, a franchised profit-making operation, has spread to forty seven sites in a dozen states, and with 40,000 students, it has become the largest private university in the United States. Students at the university can earn degrees in a variety of fields, including nursing, education, information technology, and business. Unlike most American universities, the University of Phoenix features neither a campus, nor a library, nor a permanent faculty. Rather than consisting of academics, the faculty features individuals who are practiced in one of the above-mentioned fields. It is fair to say that there is no intellectual life at the University, in any meaningful sense of that term; ideas have value only if they can be put to immediate commercial use.

Rather, the university features the opportunity to gain skills that are desired in the most efficient possible ways. Classes take place in the late afternoon or early evening. Students (who must be

aged 23 or over) can drive right near the class buildling, take the course, and drive home again. Much of the work takes place through sitting at one's computer at home. Convenience of delivery is the hallmark. William Gibbs, President of the university, declares "The people who are our students don't really want the education. They want what the education provides for them--better jobs, moving up in their career, the ability to speak up in meetings, that kind of stuff. They want it to do something for them." And like the customers of the most successful fast-food chains, students seem satisfied with what the university delivers.

In the preceding chapter, I described a number of pre-collegiate educational models that I admire and indicated how each emerged from its cultural environment. It would be easy to do the same things with the University of Phoenix-- to show how institutions like this meet the needs of busy young working American adults who want to gain new skills and expertise. And I could even indicate how the university prizes the capacity to make use of what one has learned--in my terms, the capacity to demonstrate one's understanding.

My goal, however, is neither to bury nor praise the experiment occurring in Phoenix and all over the United States, in large corporation and in for-profit educational institutions. Rather, I want simply to stipulate in the clearest possible way a set of educational goals that are opposite to those that I cherish. The Phoenix mission is completely utilitarian; there is not the slightest interest in truth, beauty, goodness-- or for that matter, in falsity, ugliness, or immorality. Nor is there interest in how these virtues might relate to one another or how they might be drawn on to help create a better community. As if to confirm this characterization, the University recently dropped its requirement that students have some background in the liberal arts.

So much for a Contrast Case. Let me now shift attention to the kind of education that I personally favor.

False Starts

A sensible way to think about education is to "plan backwards": to determine the kind of a person one desires at the end of an educational regime--for example, at graduation from secondary school. The challenge then becomes to sculpt an educational approach that is most likely to achieve that vision.

It is easy to see why so many educational systems have foundered. Designers survey knowledge and skills that seem important and decide to cover them all. But time is short and there is way too much to cover. Thus, the fatal weakness of an approach that strives to straddle the ever-expanding knowledge waterfront.

Another flawed approach is to paper over the differences within a community and try to please all interest groups: a little bit of this, a little bit of that. This solution is particularly appealing in cases when various cultures, or warring camps, all clamor for recognition. Since no one wants to come down too hard on anyone else, the evident solution --though it ends up being patchwork at best-- is to make sure that every interest group is represented, either equally or proportionally.

This studied ecumenicism works proves devastating in the curricular area. We must teach

science, and there are so many sciences (biology, physics, chemistry, astronomy, geology, not to mention the social sciences, information sciences, etc) that we must make sure to touch on. We must teach the arts, and since there are so many artistic interest groups, we must be sure to include the visual arts, the dramatic arts, instrumental music, vocal music, classical ballet, modern dance-- and of course be sensitive to different cultural embodiments of these several art forms.

Another solution, one all too often followed in America, is to pay lip service to the formal curriculum and bow to the standardized tests, but thereafter to close the classroom door and to do one's own thing. Sometimes, teachers' "own things" are meritorious--after all, there are many great teachers; but the lack of coordination among classes and the absence of accountability to those "outside the door" is lamentable. It is for this reason that American students study the Pilgrims at Thanksgiving almost every year, with unjustifiable redundancy; or that, in a case I recently observed, the Wampanoag Indians are focused upon non-cumulatively several times in a Massachusetts elementary curriculum, while large parts of world and American history receive no mention at all. These factors result regularly in cases where students move from one school to another and discover almost no overlap between the offerings at two institutions.

Teaching for Understanding: A Formal Introduction

I call for an education that inculcates in students an understanding of major disciplinary ways of thinking. The disciplines that I have singled out are science, mathematics,[1] the arts, and history.

[1]Mathematics should be part of every precollegiate curriculum. I mention it here, as part of my generic discussion of curriculum, but touch on it only tanegentially in my treatment of evolution, the music of

Within those disciplinary families, it is important that students study substanial topics in depth. However, it is not important which particular disciplines or topics are featured. And so, at the science level, I do not consider it essential that students survey the entire range of sciences listed above; in mathematics, it is not essential that they master all of Euclid's proofs or every algebraic or trigonometric formula; they need not study every art form nor cover ever historial event.

Instead, students should probe with sufficient depth a manageable set of examples so that they come to see how one thinks and acts in the manner of a scientist, a geometer, an artist, an historian. This goal can be achieved even if each student investigates only one art, science, or historical era. The purpose of such immersion is not -- I must stress-- so that students will become miniature disciplinarians; but rather, so that they can draw on these "modes of thinking" in coming to understand their world. Later, if they want to scan more widely in these disciplines, or if they want to pursue a career in the disciplines, they will have the time and the tools to do so.

It is not easy to bite the bullet and to cast aside many disciplines, not to mention numerous examples clamoring for attention within a given discipline. And that is why so few educators the world over do so. Cultural literacy --with its promise of five minutes on every topic-- seems more inviting than indepth knowledge of a necessarily idiosyncratic set of topics. ("Well, students, that's enough on the Holocaust. Let's move on to holograms.") However, in the absence of disciplinary ways of thinking, cultural literacy lacks an epistemological home; it amounts to a hodge-podge of concepts and facts (the dates of wars, the atomic weights of elements) waiting to

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Mozart, and the Holocaust.

be used somehow, somewhere, some time. Moreover, absent such disciplinary texture and glue, the facts are likely to be soon forgotten. Anyone who doubts this state-of-affairs is welcome to test students a few years later on the factual material of any "subject matter" they may once have studied and see how well they do; or, should one be especially diabolical, to test those policymakers who insist on the inclusion in the curriculum of vast numbers of isolated facts and concepts...and to publish the scores attained by these officials!

Let me introduce my alternative educational vision-- one firmly centered on understanding. An individual understands a concept, skill, theory, or domain of knowledge to the extent that he or she can apply that understanding appropriately in a new situation. An individual with a keen memory might well understand a topic; however, it is also plausible that he or she only remembers the information and has not a clue about how to use it appropriately in a new situation.

This formulation entails an acid test for understanding: posing to students a topic or theme or demonstration that they have never before encountered, and determining what sense they can make of those phenomena. An individual who possesses relevant understanding will be able to draw on appropriate concepts, while not activating ones irrelevant to the issue at hand. An individual with emerging understanding will at least be able to draw on concepts that bear some relevance to the topic at hand; or will indicate which information or resources are needed in order to elucidate the phenomenon. In contrast, an individual with little or no understanding will be stymied or will invoke information with only a superficial or tangential relationship to the theme under consideration.

Consider, as an example, an individual who understands the rationale underlying the program at Reggio Emilia. (Caution: My discussion in the preceding chapter is at most a primer towards understanding that remarkable institution). He will be able to visit a new "Reggio-inspired" school that enrolls 8-10 years olds and make a determination about whether the students' projects are sustained and coherent, whether they lead to enhanced understanding of the phenomena being investigated, and whether the documentation of those activities is accurate and useful. Should the school involve the students themselves in documentation, perhaps as the final phase of a project, that innovation might count as an appropriate adaptation of the Reggio approach with older children.

In contrast, an individual with partial but flawed understanding will more likely draw up a checklist of desired features and simply tally how many are present at the new site. Children's participation as full-fledged documentarians will probably be considered inappropriate and result in a lower "grade" for the school. An individual devoid of understanding will either throw up his hands or will look to see whether the new site has implemented a rainbow project in precisely the way it was originally out at a Reggio school.

Note that the University of Phoenix may well succeed in inculcating mastery of certain practical disciplines in its students. What is lacking is any concern with, or understanding of, the broader themes of life--indeed, with the questions of why the world is as it is and how life can and should be lived.

Difficulties of Understanding

Would that understanding were easy! In my book The Unschooled Mind, I survey a vast amount of research which documents that, by and large, even the best students in our best schools do not understand very much of the curricular content. The "smoking gun" is found among physics students at excellent universities like MIT or Johns Hopkins. These students perform credibly in classroom exercises and end-of-term tests. But consider what happens, outside class, when they are asked to explain relatively simple phenomena-- like the forces operating on a coin that has been tossed, or the trajectory of a pellet after it has been propelled through a curved tube. Not only do a significant proportion of students (often more than half) fail to give the appropriate explanation; even worse, they tend to give the same kind of answers as peers and younger children who have never studied mechanics. Despite years of schooling, the minds of these college students remain fundamentally unschooled.

Perhaps, one might conclude, the problem occurs just in physics. But, alas, that is not the case. Similar difficulties emerge across the sciences. Students who have studied evolution continue to conceptualize the processs as guided by an unseen hand--though in fact evolution consists of a random process of genetic mutations, a few of which manage to survive long enough to be passed on to succeeding generations. Students who have studied astronomy insist that the earth is warmer in the summer than it is in the winter because it is closer to the sun in the summer--and if that were true, of course, southern hemisphere lands like Australia and Argentina would also be warmer in July.

When one examines other parts of the curriculum, similar limitations arise. In mathematics, the problem encountered by students can be described as "rigidly applied algorithms." Students memorize formulas and can then plug numbers appropriately into those formulas. But in the absence of some "trigger" that a particular formula is wanted, they prove unable to mobilize the formula that is actually appropriate. And if they forget the formula, and have to derive it from scratch, there is little chance that they will be able to so, because the formula was never actually understood. It was just a syntactic string that had been committed to memory.

Finally, in the traditional humanistic parts of the curriculum--history, literature and the arts--students are sustained by scripts or stereotypes. All human beings distill experience in order to arrive at typical regularities; nearly every youngster in our society has constructed scripts about birthday parties, trips to a fast food restaurant, a visit to a shopping mall. Having constructed such scripts, we--of any age-- then interpret and remember new events, with reference to those already familiar patterns. This tack proves adequate, when the new event follows the internalized scripts in important particulars. However, one cannot always count on that familiar state of affairs.

Let me give an example. Most five year olds have developed a "Star Wars" script. Life consists of a struggle between Good and Bad forces, with the Good forces generally triumphant. Many programs in the media, and a few events in real life, can adequately be described in terms of such a script. Most historical events or works of literature, however, prove far more complex; to understand the causes of World War I or the American Civil War; or to grasp the thrust of a novel

by Hawthorne or Austen, one must weigh and integrate multiple factors and nuances. Students learn in class to give more complex explanations for such historical or literary events. Yet, when they are confronted with new and unfamiliar materials-- say, a story from another culture, or a war in an unfamiliar part of the world-- even good students lapse to an elemental way of thinking. The Star Wars script is often invoked in such situations, even when such a "good guy/bad guy" perspective is manifestly inappropriate or simplistic.

Obstacles to Understanding

A chief obstacle to understanding stems from the theories developed by children in early life. As noted, children do not require formal tutelage in order to develop representations or theories about inanimate objects, animate objects, their own minds, or the minds of others. These theories develop quite naturally, seemingly automatically, given the flow of experiences in most settings.

The problem, now well-documented, is that some of these theories are misconceptions that prove to be very robust. They can be thought of as powerful engravings that have been incised upon the mind-brain of the child during the opening years of life. The facts learned in school may seem to obscure this engraving; indeed an observer may be impressed by how much information the child seems to be learning, if one simply counts or weighs the mastery of individual numbers, facts, definitions. However, all along, the initial erroneous engraving remains largely unaffected. And then a lamentable event happens. Formal schooling ends, the facts gradually fade away, and the same misconceptions-- the same flawed engraving-- remains unaltered.

Consider a few examples. In the case of biology, for example, the mistaken belief that evolution is

a teleogical process, leading inevitably to the crowning achievement of homo sapiens sapiens surives despite years of tutelage-- as does the Larmackian belief that important adaptations in one generation will be passed on to the succeeding ones. In history, despite numerical counterexamples, many students continue to believe that the world is divided into "good guys" and "bad guys", with the struggle between these Manichaean forces constituting a staple of ife. And they suffer as well the opposite sins of "presentism"--all times are just like our own-- and "atemporality"-- an inability to differentiate events of a generation ago from those of an earlier millenium. For such reasons students have difficulties appreciating important aspects of the Holocaust; that it actually occurred within the lifetimes of their parents or grandparents; that it involved human beings like themselves, most partially flawed, some unexpectedly compassionae; and that in fact attempts at genocide continue until this day, for example in Bosnia and Rwanda.

Unwittingly, teachers are complicitous in the survival of early, inadequate representations and misconceptions. The villains include a text-test context, where the student is simply examined on the contents of texts or lectures, without being challenged to use the information in new ways; short-answer tests, where the individual is given the choices, rather than having to create and select among the choices himself; an uneasy but prevalent compromise, where teachers tacitly agree not to push students too hard, so long as students return the favor by agreeing not to push the teachers too hard. And, above all, there is 'that old devil' coverage. So long as one is determined to get through the book, no matter what, it is virtually guaranteed that most students will not advance toward genuine understanding of the subject at hand.

This state of affairs constitutes the strongest set of arguments in favor of a curriculum that

examines a limited number of topics in depth. For only through rich, probing, and multi-faceted investigation of significant topics is it likely that the inadequacy of early misconceptions become clear; and only through further exploration of those topics, under the guidance of individuals capable of disciplinary thinking, is there a reasonable likelihood that more sophisticated understandings will emerge. Recouping our analogy: First one must smooth out the initial misleading engraving; and then, preferably with judicious instruction, one must construct a new and more adequate engraving.

Consideration of the obstacles to understanding provides an excellent illustration of why--as I earlier argued-- education must take into account both cognitive and cultural factors. To understand the power of early misconceptions, one must adopt the lens of the psychologist and the biologist-- that is, one must appreciate how such misconceptions arise early in life and why--absent aggressive interventions-- they prove so resistant to change. At the same time, one must see the ways in which certain cultural inventions-- the test, the textbook, the conventionally superficial interactions between teacher and student-- all serve to reinforce misunderstandings.

To move toward enhanced understanding, one must adopt both perspectives. One must identify those internal representations in need of alteration; one must construct cultural practices that confront, rather than overlook, the obstacles to deeper understanding; and one must devise measures to determine whether the "corrective cognitive surgery" has been effective.

Disciplinary Expertise

In contrast to the naive student or the well-stocked but still ignorant adult, an expert is a person who really does think differently about topics. The expert has successfully achieved the desired set of engravings. As with the traditional apprenticeship, expertise generally arises as a result of several years of sustained work within a domain, discipline, or craft. Part of that training involves the elimination of habits and concepts which, however persuasive to the naive person, are actually inimical to skilled practice within a discipline or craft. And the remaining part of that training involves the construction of habits and concepts that reflect the best thinking about-- and practices within-- the domain at a particular historical moment.

Let's consider an example. A crucial understanding in the area of science is that correlation does not mean causation. The fact that two events co-occur does not mean that one causes another, even though it may appear on a common sense basis that this causal chain is correct. We discover, for example, that individuals who smoke over a number of years are more likely to get lung cancer, and we are tempted (perhaps correctly!) to assume that smoking causes cancer.

However, it may also turn out that individuals who are poorly nourished are more likely to get lung cancer; this new correlation suggests that malnutrition causes cancer. But because this link seems intuitively less plausible, one is invited to consider the possibility of various intervening variables. Perhaps individuals who smoke are less educated; undereducated individuals are more likely to be poor; indigent individuals are less likely to be able to afford a balanced diet and good medical treatment. Hence, it makes more sense to see malnutrition as a correlate of poverty rather than a primary cause of cancer.

Another chain of possibilities occur. Perhaps the underlying cause of both smoking and cancer is stress. Individuals who are under stress are more likely to smoke; and individuals who are under stress are more likely to contract cancer. Perhaps, indeed, stress increases the likelihood that one will smoke and decreases the likelihood that one will be able to stop smoking; taken together, these two factors increases the likelihood that one will contract cancer. Now one has idenfied a primary variable that may be the underlying trigger of cancer-- at least in the sense that its elimination might significantly reduce the incidence of the disease.

Finally, it might turn out that individuals whose names begin with letters in the first half of the alphabet are more likely to suffer from cancer than those whose names begin with letters in the last half of the alphabet. Perhaps there is a causal link here, but it seems probable that this is mere coincidence.

My point, here, is not to unravel the causes of lung or other cancers but rather to demonstrate a certain kind of systematic and skeptical thinking that lies at the heart of the scientific enterprise. Superficially, of course, the logic of "smoking causes cancer" and "the spelling of one's last name cause cancer" is identical. Only our common sense leads us to favor the first hypothesis over the second. But someone who has learned to think like a scientist will realize that neither statement, on its own, can be substantiated. One needs to initiate a research program, with proper control groups, to discover whether both of these hypothetical causal chains, one of them, or neither of them stands up in the face of scientific investigation. I propose that individuals are more likely to learn to think this way if they probe deeply into an area (like the causes of cancer or poverty or stress) than if they jet by a hundred different examples drawn from a dozen sciences.

Let us consider, as a contrast, the pitfalls that may undermine historical thinking. For instance, suppose that a document is discovered that purports to provide new information about the Biblical King Solomon. An individual unschooled in historical thinking is likely to assume that the document is authentic, and that it describes a person who is much like ourselves. Another unschooled person might conclude the opposite: that the document must be a fake, since so little writing from the time has survived; and that Solomon, being world famous and from a remote historical era, represents an entirely different species of human being.

Neither set of inferences is justified, of course; and the historically-informed individual would think about these issues in a quite different way. She would first of all attempt to discover the conditions under which this document was located; and would perhaps use methods of carbon-dating to pinpoint the time of the document. Were there evidence to suggest that the document was authentic, she would then turn to the issue of whether the picture of Solomon was consistent with, or contradicted historical and contemporary notions of, the Hebrew leader. This investigation might include revisiting other texts of the era, as well as commentaries from succeeding centuries. Finally, believing that Solomon once lived, but that he represented a civilization that in many ways was quite unlike our own, she would try to characterize the new Solomon in a way that suffered neither from presentism ("All people are just like us") nor from exoticism ("Anyone who lived before my grandparents is as remote as an alien from another planet").

Again, such habits of mind are not arrived at easily, nor are they likely to result from a course of

study that blitzes, in thirty-five breathless weeks, from Plato to Nato, or from Cleopatra to Clinton. But it is the ways of thinking that are crucial here: only armed with some notions of how historians work will the student be able to make sense of the various claims that he or she may read about, say, the causes of the Vietnam War or the character of Martin Luther King Jr. Only equipped with some understanding of how scientists proceed will a student be able to evaluate claims about the causes of AIDS or the advisability of taking a certain hormone to increase fertility or prevent baldness or osteoporosis.

Four Approaches to Understanding

There is, alas, no royal road to understanding; or, to put it positively, many clues suggest how best to enhance understanding. I'll mention four that have seemed particularly promising to me and my colleagues at Harvard Project Zero.

l. Learning from suggestive institutions Some ancient institutions, such as the apprenticeship, harbor instructive clues for understanding. In an apprenticeship, a novice spends a great deal of time in the company of a master. The master tackles new problems as they arise, and then draws the novice into problem-solving (and trouble-shooting) at a level appropriate to his current skills and understandings. The rising journeyman thus receives much healthy exposure to examples of understanding as well as many opportunities to exhibit incipient understanding and receive apt feedback.

Clues may emerge as well from new institutions. My favorite examples here are science

museums--as well as other "hands-on" museums-- in which children are encouraged to explore exhibits at a comfortable pace. Of course, such an opportunity in itself does not constitute understanding. What is compelling about effective museum exhibitions is that they encourage youngsters to try out their own theories and to see for themselves what works and what does not. For example, students can propel balls through various kinds of tubes, and make predictions about how the objects will fall and where they will land after exiting the tube. The balls can be dotted with lights so that their trajectories can be more readily observed. There can also be simulations or virtual realities, in which, again, the course of the ball can be observed, predictions checked, theories (and their underlying engravings) revised in the light of often surprising new "data".

Such hand-on experiences often reveal ways in which the children's current thinking is inadequate. And, if there is spirited conversation, proper guidance and scaffolding, or an ingenious and reflective child, a more appropriate theory can arise. That "freshly minted engraving" can in turn be checked and revised in the light of new observations.

2. Direct confrontations of erroneous conceptions. Going one step further, one can actually confront students with ways in which their current conceptions are inadequate. Consider, for example, the child who believes that one is warm when one puts a sweater on, because the sweater in itself harbors warmth. Once this explanation has been offered, a parent or teacher can suggest that the sweater be left outside each evening. If the sweater itself is a heat generator, then it ought to be warm on the following morning (or at least warmer than neighoring rocks or other items of clothing left out in the cold) . If, however, the temperature of the sweater proves

identical to that of surrounding entities, one has challenged the child's theory that the sweater itself generates heat.

When it comes to the "rigid algorithms" activated by many students of mathematics, it makes sense to create a situation where students must think along the lines of those who have created the formula, and see whether they can themselves progress toward an appropriate formula. Consider, for example, the amount of time that it takes a vehicle to traverse a certain distance. Students can be equipped with a whole range of vehicles, a stop watch, and a room with various race courses and barriers. They can then be asked to predict how quickly various vehicles will cover specific distances, and what might be done to alter the speed or the success of a particular vehicle.

Engaged in such an activity, many students will discover the irrelevant variables-- for example the size, shape, and color of the vehicle, the barriers, the dimensions of room-- as well as the relevant one--the average speed (rate) of the vehicle. Some will move toward a formulation which approximates the classroom staple: distance covered = rate x time. And even those who do not arrive on their own at that formula will at least be more likely to understand the formula once it has been introduced. They have now had considerable experience in manipulating variables that are (or are not) relevant to the problem at hand.

Finally, in the case of scripts and stereotypes, the proper antidote is "regular assumption of multiple perspectives." Scripts and stereotypes reflect a certain perspective at a certain moment in time. If, however, students accumulate lots of experience in thinking about a situation or event

from a number of points of view, they are less likely to embrace a simplistic, one-dimensional explanation. And so, for example, students come to possess a much richer view of the American Revolutionary War if they learn about the struggle from diverse angles: the point of view of the British, who were dealing with rebellious colonies; from the perspective of the French, who had litle interest in the colonies per se, but much interest in thwarting their British rivals; and from the vantage point of colonial Tories, who wanted to remain loyal to their motherland.

As the educational psychologist Lauren Resnick has pointed out, disconfirming experiences do not always suffice to dissolve faulty conceptions and to enhance understanding. Misconceptions can be quite robust, and they sometimes prove as insensitive to disproof as the belief system of a religion fundamentalist in the face of incontrovertible scientific evidence. Yet, for most individuals, the challenging of a deeply held belief at least compels their attention; and efforts to defend that belief, or to discover a better belief, line the most promising routes toward enhanced understanding.

3. A framework that facilitates understanding With my Harvard colleagues David Perkins, Vito Perrone, Rebecca Simmons, and Stone Wiske, I have developed an approach that places understanding "up front." The key idea is that understanding is a performance, a public exhibition of what one knows and is able to do. Students ought to be exposed from the start to examples of understanding; and they should be given ample opportunities to practice and perform their own understandings. Indeed, only if they have multiple opportunities to apply their knowledge in new ways are they likely to advance toward enhanced understandings in their schoolwork and in their lives beyond the schoolhouse walls.

Talk of a "performance of understanding" may seem a bit oxymoronic, since we usually think of understanding as an internal event, one that occurs in the mental representations between the ears. And we have no reason to doubt that much is occurring between the ears, as inadequate representations are being challenged and--should teaching and learning prove successful--more adequate ones are being constructed. Still, the focus on understanding as a performance proves salutary.

A helpful analogy can be drawn from the arts and athletics. Individuals would rightly smirk if the mastery of a young art student, musician, or athlete were assessed in an examination hall on a Saturday morning, with a standarized paper-and-pencil or computer-adaptive test. Rather, what typically happens in these realms is illuminating. Youngsters from the start observe more proficient (usually older) individuals performing the required actions and understandings: playing new pieces of music, practicing dance steps, engaged in scrimmages or in games against tough and wily opponents. The youngsters can see the "moves" that must be mastered; they can try them out; they can monitor their improvement and compare it with that of peers; and they can benefit from coaching, a pedagogical technique that indicates (often in quite individualized ways) how their own performances can be enhanced.

In an "understanding" class or school, a similar ambience is created. Novices see older individuals engaged in the performances which they ultimately must carry out-- writing essays, mounting oral arguments, debating with one another, explaining scientific phenomena, carrying out experiments, creating and critiquing works of art. They note the kinds of performances that are

valued and why; the criteria of evaluation that are imposed and why; the ways in which performances improve and the ways that they do not; the intellectual and social consequences of enchanced understandings. Some of the mandated performances will be enactments of models already observed; but a healthy proportion of them will require students to "stretch" in new ways. "Milieu is all" in education; the students are reared in surroundings where "performances of understanding" have become the coin of the realm.

Our work does not simply present a vision. It also features a particular pedagogical approach, which can be applied across the curriculum and can be used with students of different ages and approaches to learning. This approach to understanding was not merely worked out in camera by a group of ivy-covered professors. On the contrary, it emerged from a several-year collaborative project involving dozens of teachers in the New England area. In the intervening years, it has been tried out in many schools all over the country, and in Latin America as well.

The approach begins with a delineation of "understanding goals." These are simple statements about the understandings that one wishes to achieve over the course of a unit. There should not be too many understanding goals; a small number suffices. Let me draw on the examples elaborated on in this book:

*An understanding goal for a biology unit might read: A student will understand the way that evolutionary forces affect individuals, groups, and entire species.

*An understanding goal for a music course might read: Students will understand how Mozart and

his librettist da Ponte worked together to create a powerful and lovely score that captured the social conflicts of the era.

*An understanding goal for a modern history course might read: Students will understand the ways in which the Nazi Holocaust resembled and differed from other attempted genocides of this century.

Other examples from a range of disciplines might include what it means to be alive, the role of the Civil War in American history, how to discover the philosophical themes in the poetry of Keats, why we have negative numbers and how they differ from positive ones.

Next one identifies "generative topics" or "essential questions." These are initial lessons or provocations that satisfy two main criteria. First of all, they must be central to the topic, with its stated understanding goals. School life is short and there is scant time for lessons or examples that are peripheral. Second of all, they must engage students. If it proves too difficult to convey the interest and relevance of a topic to students, then one should probably seek another entry point. Of course, the better the teacher, and the more trusting the students, the more likely that almost any topic or question can arouse and sustain the curiosity of the bulk of a class.

For our three areas of investigation-- the theory of evolution, the music of Mozart, and the Holocaust-- there is no paucity of generative topics. Students in a biology class might be asked to explain why there are so many different species in the rain forest; students in an arts class might be challenged to figure out what is happening in a scene where three individuals are each

singing a different phrase to themselves in a foreign language; students in a history class might ponder why the leaders of what many regarded as the most civilized country in the world would decide to eradicate an entire population.

Third, and most fundamental, there is the identification and the promulgation of "performances of understanding." Put crisply, students must know what they have to do: they must be familiarized with the ways in which they will be asked to perform their understandings; and they must appreciate the criteria by which their performances will be judged. Far from being mysterious, (no tests under lock and key), students should be exposed from the beginning to performances reflecting various degrees of competence; they should be assured that they will have plenty of opportunities to practice the required performances and to secure helpful feedback; and they should be confident that the culminating performances will typically be occasions for pride, rather than for apprehension or shame.

Remaining with the above examples, performances might include a prediction of what will happen to a species given a radical shift in the local ecology; the creation of a song with lyrics that captures the generation gap in contemporary American society; and an analysis of a current virulent struggle between two ethnic groups, in terms of its similarities to, and differences from, the Holocaust.

The final component of our "understanding approach" features "ongoing assessment." Most assessment in most schools comes down to a single "secure" test at the end of a unit; students often do not know or care about their particular performances, they just want to know their final

grade. In contrast, in an understanding milieu, students receive continual feedback from teachers and others about the quality of their performances, along with concrete suggestions about how these performances might be improved. The criteria for evaluation are public, and students are welcome to discuss or to contest these criteria. They have time to reflect on their performances, to practice, to receive help.

Optimally, over time, the assessment no longer lies in the hands (or at the whim) of other individuals. Rather, like seasoned professionals or experts, students gradually internalize the criteria of assessment: they become able on their own to judge how well their performances stack up against an ideal, and with reference to peers (of greater or lesser skill). That is why, incidentally, the culminating performances should be occasions of pleasure. If (like practiced artists or athletes) the students have come to understand well, then these public exhibitions should produce "flow" for the students.

At first blush, our approach may seem behavioristic. As in behaviorist psychology, our focus falls primarily on the quality of student behaviors. And consistent with classical behaviorist terminology, our provision of unfamiliar materials as a test of understanding may seem like a measure of the degree of "transfer" of a skill.

But this approach is behavioristic only in the sense that all assessments must ultimately examine behaviors--one cannot directly examine mental representations. Viewed up close, this approach reveals its cognitivist assumptions and affinities through and through. To begin with, my colleagues and I were stimulated to tackle understanding precisely because of the discovery that

early mental representations are both robust and misleading; only a "full court press" is likely to undo these erroneous conceptions and to construct more adequate ones.

Next, the particular coaching techniques that we favor are ones that point up inadequate conceptions and that encourage students to confront, and, when necessary, to revise conceptions that stand in the way of adequate understandings. Talk about assumptions is quite explicit; how students think about their own learning fits comfortably into our understanding framework.

Finally, students are unlikely to be able to succeed regularly with new and unfamiliar challenges unless they have actually altered their initial, flawed representations of the key notions in a domain. The "acid test" of a performance view of understanding is the development of more adequate and more flexible representations; and this test could not be conceived of in behavioristic terms.

Like any new approach, "teaching for understanding" cannot immediately be implemented perfectly; indeed this view of understanding is itself deceptively simple and requires time to be mastered. At first the elements are dealt with quite separately; neither students nor teachers are sure precisely why they are doing what they are doing when they are attempting to implement the framwork. In contrast, expert implementation features a smooth dialectic among the four component parts, so that a lesson or unit encompasses the goals, performances, and assessments as part of a seamless whole. Best of all, teachers at various levels find the framework to be useful and are motivated to keep using it. And so do the creators of the framwork, including myself!

4. Multiple entry points to understanding My fourth and final approach to understanding takes advantage of the fact that individuals posses different kinds of minds, featuring different blends of mental representations and will, consequently, approach and master curricular materials in quite idiosyncratic ways. Stated formulaically, the fourth approach weds the "theory of multiple intelligences" to the goal of enhanced "performances of understanding." Here, I believe, lies the best way for us to achieve enhanced understanding with the full range of students. And, accordingly, "multiple approaches to understanding" form the primary focus of the chapters that follow.

Other Players

Goals must come first; and they must be kept in mind. But there are also important "other players." Given the regimes that I have outlined here, let me now introduce other members of the "ideal cast".

Well-trained, enthusiastic teachers: If one is to teach for understanding, it is crucial to have teachers who themselves are comfortable with and understand the material. Teachers need to feel expert, and they need to embody expertise in the eyes of their students. They must also believe that understanding is important and be prepared to embody that understanding in their own lives. Nothing more impresses students than the opportunity to witness informed adults make apt use of the material that is being introduced. That is why young musicians love to watch their teachers perform, and tennis students want to play with their instructors. And that is why students soon become disenchanted with teachers who fail to "walk the talk."

As educator Lee Shulman has insisted, knowledge of one's subject is necessary but it does not suffice. Two individuals can know their subject equally well, but only one will know how to present it to naive students in ways that engage them, dissolve the prominent misconceptions, and build up firmer and more flexible understandings. Teachers of teachers must help their students (who are of course future teachers) to gain such pedagogical knowledge and to draw on that knowledge regularly in their classroom preparations. Teachers must be ever on the alert for the most appropriate projects, lessons, questions, and forms of assessment--ones that dovetail with an understanding curriculum and that help to monitor the evolving understandings of students.

Moreover, it is not sufficient for teachers to rest on the laurels of their own training. All disciplines evolve, and some, like the natural sciences, change with daunting speed. The boundaries of disciplines change, and opportunities for interdisciplinary work arise both predictably and unpredictably. Teachers need to"keep up"-- optimally, they should want ardently to keep up. Again, students take note when teachers are themselves continuing to learn, and when they appear to be excited by new discoveries.

Of course, many teachers lack deep understanding of their topic, and some are not motivated to enhance their understandings. Education for understanding is difficult to pursue absent a group of teachers who are committed to understanding for themselves, as well as for their charges. The "good news" is that there are many ways for motivated teachers to delve more deeply into their discipline and to practice their own understandings. But the motivation to do so can only come

from the teacher.

Students prepared and motivated to learn A teacher's work is half done when students arrive at schools healthy, secure, and eager to learn. It hardly needs to be said that many students around the world, and many in the affluent United States, do not come so equipped. It is harder to admit that even students who are healthy and secure often display little interest in what school has to offer.

Faced with students who are not "turned on" to school, it is easy and tempting to blame parents, the students themselves, or last year's teachers. And, indeed, sometimes the job of keeping students healthy, safe, and motivated proves too difficult for any teacher or team of teachers to accomplish. But that is a conclusion that can only be reached after the fact. From day one, teachers must seek to motivate their students, even against the odds. And their own belief in the importance and the "rightness" of what they are doing can be a pivotal motivator.

Master principal Deborah Meier recalls how she and her brother used to go to Yankee Stadium in the 1940s to watch the great outfielder Joe DiMaggio. Meier admired his beauty and grace, while her brother wanted to play ball like "Joltin' Joe." Meier looks back nostalgically to the way in which so many of her generation were enchanted by DiMaggio and eager to follow his lead. She then pointedly adds, with reference to our students today, "We've got to be their Joe DiMaggios."

With knowledge changing so rapidly, students must become able-- eager--to assume

responsiblity for their learning. To the extent that students can craft their own goals, keep track of their own accomplishments, reflect on their own thinking and learning--where it has improved, where it continues to fall short-- they become partners in their own education. Even more crucially, once formal schooling has concluded, it should have become "second nature" for them to continue their own learning--sometimes alone, sometimes in a group setting-- for as long as they choose; indeed, one hopes, for the rest of their lives.

Technology as Helper In itself, technology is neither helpful nor harmful-- it is simply a tool. One can be equipped with the most advanced and speediest computers in the world. But if the software is mindless, and fails to engage understanding, it is of little help in our mission. Conversely, armed only with their minds, a few books, chalk, and a pencil, well-informed and motivated teachers can lead their students triumphantly down the road to understanding. Indeed, without so much as a blackboard, Socrates stimulated understanding simply by the shrewd questions that he asked, the order in which he posed them, and his often pointed reactions to the responses of those for whom he served as gadfly .

Still, we would be ill-advised to ignore the opportunities afforded us by the sophisticated technologies of today--videodiscs that draw students vividly into the world of mathematical problem-solving or the art treasures of the past; databases that allow students to collect and manipulate all kinds of information about their world, their community, and their own lives; electronic linkages that allow students to share interests and concerns with others from around the world; networked personal computers and scanners that permit students to create works of literature, diagrams, drawings, works of music, revise them as much as they wish, share them

with peers, and make them available to "experts" sitting in their offices or at their homes-- or, indeed, to the students' own subsequent review and critique.

Note that technology does not dictate these beneficent uses. Rather, skilled educators must examine goals and determine, on a case-by-case basis, which technologies, and which uses thereof, can help them meet their needs and which cannot. The search must proceed in an empirical way. Perhaps, before too long, "intelligent systems" will themselves be able to determine ways in which they have been successful with students, where they have failed, and how they might be reconfigured.

A supportive community Even when all of the necessary components are aligned within the classroom and the school, effective education is not guaranteed. Other stakeholders have a powerful voice in what happens, what is supported, what is thwarted.

The identities of stakeholders differs widely across educational contexts. Parents, school board members, key citizens of the community, the local, state/provincial, or national ministries of education, and the "general public" are all factors in the equation that yields a curriculum, a means of assessment, and a cohort of graduates that embody, or fail to possess, significant understandings.

Needless to say, education cannot proceed successfully if these stakeholders are ignorant of what is going on in the classroom, if they disagree vociferously with one another, or if they collectively find themselves at odds with a

goal-- be it the acquisition of core knowledge or the achievement of deep understanding. Moreover, even well-intentioned policies can wreck an educational program. For example: What is the likely fate of a program that educates for understanding, if the graduating or college admissions examinations sample coverage rather than probe the intellectual power of the curriculum and/or depth of understanding of the students?

Learning need not occur simply within the four walls of the classroom. Technology, of course, can take us all over the world, and back again. Support at home is crucial. The citizens and institutions of a community can make palpable contributions to the education of its children. These contributions may start with fieldtrips but they can and should not end there. Students ought to have the opportunities to assume mentorships, apprenticeships, work-study positions in community institutions; and experts from these institutions ought to visit schools, in reality or virtually. Work places are changing rapidly, and much of work now takes place at home, often through participation in electronic networks and "virtual" offices. Precollegiate education needs to assume the multi-faceted cast, constellation, and coloring of the emerging new world.

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In effect, I have presented a design for education: a central goal or mission-- in this case, education for disciplinary understanding; four major ways in which to proceed toward that mission and to adjust course, when necessary; and a complex of supporting factors that can ease the way toward the achievement of this ambitious goal.

There are of course many reasonable missions and goals: recall the potpourri of good schools introduced at the beginning of Chapter 5. One can even justify missions like the University of

Phoenix's-- while recognizing that it is antithetical to one's own. Moreover, even a singular goal or mission, like the one outlined here, can---and perhaps should-- be pursued in a variety of ways.

But for our study, the die has been cast. I have now described in general terms the kind of education that I wish for my children, their children, and, indeed, the children of the world. It is time that I become specific about how understanding might be achieved in three disciplinary areas: science, art, and history.