Part 3

Arranging to Know

The thoughts that follow in this final section of the book represent the very tentative efforts of one person in one field to suggest directions for trying to conceive a sort of unified field theory of learning. Surely everyone wants a *coherent* curriculum. Exactly what sort of *integration* that requires is what has to be determined. And where will this integration take place—in schedules and courses, in learning activities and materials, or in teachers' and students' minds? Indeed, we have to think through the relations among subjects before we can begin to understand, on which plane of action integration should take place.

Educational reform of the 1980s and early 1990s featured institutional restructuring and virtually ignored curriculum itself. Administrative change without curricular change is worse than meaningless—it can lock public education even more tightly into failed ways of organizing learning. The reform agenda of the federal and state governments simply assumed a curriculum comprised of traditional and discrete subjects. The Bush administration's effort to establish a national core curriculum through national assessment, Project 2000, included only math, science, English, geography, and history—not even arts or foreign languages or other social studies. Such an initiative prolongs both the biases and the incoherence of the schooling that is to be reformed.

Subject fields, furthermore, are not of themselves learning fields. They are expedient and logical classifications of content that do not take into account how individuals learn, as is shown in one way by

the very fact of their being conceived and purveyed essentially in isolation from each other. For educational purposes, subject fields have to cohere psychologically into a unified learning field structured around how people make or come by knowledge. Such a field would indicate how to restructure administration. And it would extend across the cultural and cosmic fields contemplated so far in this book.

Getting the Subjects Together

Working for the most part independently of each other, the various national school subject organizations began publishing during the late 1980s some books or pamphlets to promulgate as frameworks, guidelines, or standards the latest thinking about how the teaching in their respectives fields should be improved. (See the brief curricular bibliography on page 119.) In 1990 representatives of these subject organizations met to consider the relationships among their new curricular declarations, which were produced without collaboration except between science and math. Having read one another's documents as homework, members formulated at the meeting a joint statement about the commonalities they perceived across subjects and about what was missing. The commonalities amounted to a call for more:

- challenging content and standards for *all* students
- *heterogeneous* grouping of students
- responsiveness to the *diversity* of today's students
- *active* knowledge-making by students
- *collaborative* learning in small groups of students
- assessment of actual *performance,* less multiple choice
- *problem solving* and critical and creative thinking
- learning for *understanding,* less for grades or scores
- selection of *essentials,* less mere coverage
- *student-centered* organization of school time
- *teacher development* and teacher designing of curriculum.

Members considered this amount of convergence remarkable and heartening.

> On the subject of the national education goals put forward by the President and the governors, however, there was no consensus. Some participants felt it would be unwise to identify closely with a highly politicized initiative that might be short-lived. Many were concerned that such identification might suggest an endorsement of a national curriculum. Others felt that the national goals desperately needed professional input that could give them lasting substance. (From page 4 of "The First Curriculum Congress,"an unpublished summary of the first meeting, distributed to members during the fall of 1990.)

The documents did not add up to a complete curricular vision because organizations committed to a particular subject have rarely considered the part that each's subject would play in a total learning experience. This omission of the viewpoint of the learner—for whom all this exists, after all—was a grave deficiency in the documents, as most members realized, and remains a major problem in curriculum reform. The tell-tale fact is that these subject organizations had never met together before to consider the whole curriculum. In 1991 they climaxed a year of periodic meetings by officially organizing the Alliance for Curriculum Reform, whose mission is to play a major role in curriculum reform, reconceptualize the curriculum as a whole, sponsor joint projects, and disseminate effective programs.

It is a measure of the concern for curricular integration that, before the Alliance for Curriculum Reform had finished officially organizing itself, some school districts and state departments of education were already taking steps to replicate it locally by convoking their subject-area representatives to consider the long-range interrelations among their specialities. If such organizations sustain their forums long enough, they will force themselves to take more the learner's viewpoint, to envision a coherent learning environment, and to situate schooling within the broader learning fields of society and nature.

I was a member until members were defined, quite properly, as national organizations only. To witness the wary, ginger way in which these organizations first tried to talk across boundaries and to commit themselves to joint action illuminated for me a good part of the predicament of the curriculum to be reformed. Understandably, the representatives feared subscribing to statements or programs that their constituencies might not agree on enough to ratify. And of course the notion of coalescing subjects in some degree was bound to threaten organizations whose very existence was posited on

relatively discrete subject disciplines, as I discovered when I callously introduced the word "fusion" into considerations of integrating the curriculum. For the arts organizations, "integrating the curriculum" has mostly meant absorption into other subjects and loss of integrity, not to mention jobs. But despite this inherent inner conflict, the group took a historic step that may give educators themselves more control over the determination of curriculum in the face of governmental aggression.

The fact that the subject organizations had not been thinking *together* is most disturbing. It means that little work has been done to conceive curriculum as a whole. This is not to discount, however, many fine interdisciplinary projects and relationships that educators have worked on or worked out for many years. English and social studies teachers have jointly taught certain literary works, for example, and of course math is a necessary tool in understanding science. Two organizations represented in the Alliance, in fact, are spearheading the increasing integration of the latter. Project 2061, run by the American Association for the Advancement of Science, is not only integrating math, science, and technology, but working on ties with other subjects as well. And the Mathematical Science Educational Board exists principally to foster this sort of curricular coordination. Though for high school only, Ted Sizer's Coalition of Essential Schools features inquiry across subjects. The Collaborative for Humanities and Arts Teaching (CHART) is a consortium of various interdisciplinary projects funded by the Rockefeller Foundation. As a member during the 1970s of the so-called Faculty of the National Endowment for the Humanities, I had a chance to consult on many interesting school projects that NEH ran to promote some integration across those subjects in their bailiwick.

The very names of most of the above organizations or projects suggest, however, their limitations, though they sometimes test their boundaries. Such agencies and their mandates don't yet extend to *all subjects* for *all times* in *all ways.* Piecemeal efforts need to coalesce into a total learning environment ultimately conceived as such. Educators need to bring the arts and humanities together with the social and natural sciences and these in turn with languages and mathematics and the crafts and vocations.

Within the overriding purpose of providing learners a coherent education, several practical reasons impel us to reconceive the total curriculum with all subjects in mind at once. First of all, there would

never be world enough and time to make room in one curriculum for all the subject matter proposed in the separate wish lists of the subject organizations—so many required courses or hours per week in this subject or that, coverage of so many topics in this grade or that. To some extent, such promulgations are just fantasy. Even proliferating electives can't solve this problem, because to offer many of these topics as optional courses would overload the schedule and overtax faculty and resources. Besides, subject specialists want most of their proposed courses or topics to be required, which leads to disputes about priorities among the subjects.

So, second, if some integration of the subjects does not occur, the sciences, math and languages, humanities and arts, vocations and physical education will all fight among themselves for space. America suffers badly from a dearth of knowledge of foreign languages. Business presses hard for math and science. Concern about getting a job warrants vocational courses. A knowledge of history is supposed to prepare the student for participation in a democracy and to further understanding of other peoples. As the hardest to justify in such conventional practical terms, the arts are curtailed first when the budget is cut. The allotment among subjects is endlessly debatable according to equally worthy but competing values. If all are tooting their horns at once without regard for the interrelations among themselves and for the total impact on the learner, some will simply be omitted or mutilated, and the curriculum will continue to be decided by merely invoking some tradition or other, by compromising among special-interest advocacies, and by letting the rest fall out according to the motley contingencies impinging on schools.

Third, the goals of the different subjects overlap considerably, especially in such areas as thinking processes, investigative techniques, and means of proof and evidence. It is not as if only math or only science or only history will teach these; all will. But it's true too that investigation or evidence varies across disciplines according to unique aspects of each discipline. And it might be wise to build some redundance into the learning of such important abilities. But the present unpondered, uncoordinated curriculum does not distinguish happenstance overlap from meaningful redundance. Overall learning is bound to be inefficient so long as it can't benefit from perception about the connections among subjects.

Fourth, the aims and the means proposed in the subject organizations' documents to improve their separate curricula will require

more integration with other subjects than the organizations seem prepared for. New math and science guidelines, for example, advocate more realistic problem solving that draws on circumstances and subject matter familiar or important to students. At the same time, the new classroom scenarios play down the preplanned feeding of information according to some internal logic of the subject in favor of more leeway for student timing and discovery. To these emphases add another on student collaboration through small-group processes. If realized, these proposals will tend to replace traditional self-contained courses in math and science with interdisciplinary projects in which math and science are not only coordinated with each other but both in turn melded with humanities, social studies, and arts, since the difficulties of school math and science have concerned, precisely, their remoteness from human feelings and intentions. A group architectural project, for example, could bring all these together so that each could be better learned by allowing their natural interdependencies to become apparent.

In other words, part of what's needed for curriculum reform is an admission that school subjects positively *need* each other, not merely that they have interesting points of contact. The International Reading Association has set an example by publically stating that students can better learn reading comprehension through other subjects than through separate practice reading for its own sake, in which content is indifferent. Similarly, language arts teachers promote "writing across the curriculum," because they know that writing needs the realistic circumstances and authentic subjects and audiences that other subjects can supply. Just as you read and write for reasons that may involve any content whatsoever, you calculate and reason mathematically for purposes that inevitably go outside math itself as a subject. We will consider below this interdependence between languages and the experiential subject matter that languages symbolize.

The organizations representing reading and the other language arts as school subjects welcome curricular integration more than representatives of other subjects do. In fact, they constitute one end of a spectrum ranging from subject organizations least theatened by it to those most threatened by it. The more secure the position of a subject in the curriculum the less worried are its representatives about the possible effects of integration. As a prerequisite for the other "major" subjects, literacy enjoys the highest priority.

Math and science are the next most assured, because they undergird technology and hence the economy, which enlists great political support for them. But note also that math, science, and technology depend too obviously on each other and on literacy for their advocates to contest integration, at least among themselves. History, on the other hand, is a less secure subject, like social studies in general, and its representatives usually resist strenuously any move that would seem to reduce its sovereignty. History remains a required subject only to the extent that it can claim to teach for democracy and world understanding by transmitting American and Western heritages and by acquainting students with other cultures. But this sort of claim can't compete strongly with those of the preceding subjects. As basic practical knowledge, geography fares well only for a while in elementary school, like the other social sciences, which inherently interest young people but which barely exist in the curriculum beyond childish stereotyping. Foreign languages are rarely required in school, and most schools can't find or afford enough foreign language teachers to staff either a required or an elective program. The fact is that America is a big island where little need is felt for foreign languages, and, abroad, English has practically become the lingua franca. Accustomed to not commanding much urgency except for college admission, foreign language educators are not so much threatened by integration as resigned to a low priority.

Most threatened are arts educators, who are traumatized by decades of seeing their subjects slighted, deleted, incorporated, or made adjunct to subjects enjoying secure dominion in the curriculum. The arts are at the losing end of the subject spectrum because personal development ranks low among the various goals invoked to justify subjects. Clearly, the degree of threat that curricular integration poses to educators is directly proportional to the strength of their subject's place in the curriculum—how much of it is required or offered according to the mostly utilitarian standards preferred by government and business.

This spectrum is a value scale. In the squabbling for curricular space that constitutes a major theme in the history of modern common schooling, educators have kept trying to argue that their subject fulfills one or more of the handful of justifications that this society warrants for school inclusion. Thus when Latin could no longer be justified on the old grounds, it was then alleged to teach thinking,

always a good rationale. Likewise, history teaches logical inference, we're told (and I accept), through the rules of evidence and proof (whereas a better justification in kids' minds would be that it's full of appalling and appealing stories). Literature is supposed to refine the moral sensibility. This strikes close to that old goal of making good citizens, which learning about "our" heritage of freedom will also further. Math and science will, nationally, increase the industrial and economic productivity and, personally, get you a good job. These utilitarian justifications, which make up most school goals, barely rise above political sloganeering. Personal development or fulfillment figures among these justifications but usually near the end of the list and clearly, as the spectrum above shows, at the bottom of school priorities.

Part of why we need to rethink the total curriculum is to reconsider these justifications and their underriding values. If, for example, math and science were construed more humanistically and taught in closer relationship to other subjects, they might further personal growth as much as they might the gross national product. Most often, one chooses to study a foreign language for personal reasons. And recognized as modes of cognition, the arts may teach thinking as much as the other subjects. The question, in other words, of how much a subject is worth depends not only on the society's professed values but also on how the subject is ultimately understood, in depth, in consideration with other subjects. Educators have to take a big step back and ask, "What part does my subject, or might my subject, play in personal development and social evolution—in consciousness and culture?" But each educator is not going to be able to answer this without pondering it with colleagues in other subjects. As it is, schooling is running on a lot of dead assumptions about the subjects based on historical fallout, governmental pressure, bureaucratic distortion, and . . . the absence of a *learner* advocacy to put the subject advocacies in their places within a total learning enterprise.

The professional subject organizations are in a position similar to that of modern nations fearing to yield some sovereignty and identity to an international governance but participating in global economic or ecological activities that any one of them cannot deal with adequately within its own jurisdiction. Trying to maintain the old boundaries contradicts somewhat the higher aims and the more realistic methods that the recent curricular documents rightly advocate. A continuous forum about the total curriculum carried on among educators in all

subjects, such as the one instigated by the Alliance for Curriculum Reform, will gradually bring out many unexploited and even unsuspected ways in which traditional subjects can help each other realize their goals. In fact, it is in the nature of the best education that it can't happen without some greater integration than institutions of learning now permit of the arts, sciences, languages, humanities, crafts, and vocations. However expedient it may be for institutional and professional purposes to apportion knowledge and knowledge making into departments, no school reform effort will succeed if it doesn't acknowledge how these artifactual subject divisions thwart the naturally integrative functioning of individual thought.

Finally, the master argument for curricular integration is simply that life is not divided into subjects. This argument may be grounded in either personal or social reality. That is, academic departments fit neither the way individuals build their personal knowledge structures nor the way societal problems arise to which knowledge may be applied. Learning and doing cut across at myriad angles the subject areas established by universities for purposes of scholarship, research, and accreditation—divisions that no longer accommodate well even those ends. For precisely these realistic reasons, that both inner and outer life intermix subjects, language educators now believe it's better to integrate listening, speaking, reading, and writing; science educators, biology, chemistry, physics, and earth sciences; arts educators, drama, music, dance, and art; math educators, arithmetic, algebra, geometry, and calculus. Perhaps it's time to intermix these major subjects themselves.

The threat that merging poses can be justly offset by not only looking for commonalities and overlap and significant "fits" among the subjects but also by insisting on searching for the uniqueness of each, for what it does or offers that makes it complement other subjects and fulfill an individual's education as nothing else can. Uniquenesses will help us consider what we mean by "integrate." We can imagine a spectrum of kinds of integration going from subjects being barely tangent to their being virtually congruent. It may be that for some learning purposes integration will mean merely *interrelating distinct subjects* so as to make them reveal each other better. Or it may mean *softening some boundaries between them* for a time in order to accommodate the personal and social nature of learning, which is not necessarily subject-oriented. Or it may mean *smelting all subjects down together and recasting them as a single curriculum.*

Which form of integration is appropriate no doubt depends partly on child development and on personal maturation. Schools are forced to be child-centered in primary school and to center on discrete subjects only gradually. Interestingly, the learning slump referred to earlier occurs about the same time that schools start to break learning into math, science, social studies, language arts, and other arts. When, in middle school, subjects are allocated to separate classrooms and separate teachers, student centering yields so thoroughly to institutional anonymity that many students never recover and nearly all shrink their minds to the constraints of the situation.

Howard Gardner (1985) has suggested that child development may alternate between specialized and generalized knowledge according to five periods of the first half of life. Like other concepts of child development, this would most likely be translated into curriculum in group terms, that is, as all children alternating at the same time. Gardner himself seems to imply a rough synchronization of children of the same age, but it is the failure to individualize child development that has caused schools to misuse such research. Not only may children arrive at the same stages at different ages but their personal histories and individual penchants may count for more in their educational needs than a generic pattern of "child development," which in any case these personal factors may modify considerably.

So the quest for the appropriate degree of integration—from casual cross-reference to fusing crucible—must consider not only a developmental dimension along time but the accommodation of individualized learning. Those experimental private schools or alternative public schools that best serve as some sort of beacons for school reform have found ways to pluralize curriculum—to think of *the* curriculum as a learning field in which to work out individualized *curricula* that differ from student to student. In other words, the matter of how to integrate the subjects is partly a factor of how to make up personal programs according to particular knowledge structures each individual is building and according to the modes of knowing each tends toward. Understanding the nature of the subjects and of their interrelationships cannot be separated from understanding the nature of learners as individuals.

Individualized learning and an integrated curriculum are inherently related, because the perspective of the overall learning field

correponds to the viewpoint of the learner, whose growth moves forward on all fronts and all planes simultaneously all the time. The chief issue concerns assimilation—how kinds of new knowledge become structured into the old and into each other, given that this must occur in unpredictable individual ways. How do you do this so as to preserve the integrity of both the subject and of the individual? Traditional schooling has far overfavored the integrity of the subject, as with full-year courses in algebra or biology or American history that present the subject self-contained according to its internal logic but that are difficult to assimilate. These can be admirably cogent and elegant but equally indigestable and forgettable. The real test here is how many students have got good grades in such courses but remembered or applied little of the material later.

All we alumni and alumnae take this loss for granted and even joke about it the way we do other commonalities of schooling or growing up, but this chronic bad timing or unassimilability explains the inefficiency of schooling as much perhaps as any single factor. Presenting subject matter self-consistently, to a generic student body, in large prescheduled blocks, bores and boggles students, to whom this all appears arbitrary. In other words, to sacrifice the psychology of the learner to the logic of the subject is to jeopardize not only the meaning the subject may have for the student but the meaning the subject may have for the specialist as well. The subject may be public knowledge, but for better or worse, the learner digests it personally.

So if only to make individualization possible, or if only to take the learner's point of view, or if only to think coherently about total education reform, we must at least *consider* smelting down conventional subjects and methods and, without losing anything of value unique to any of them, recasting the whole learning process as fundamentally and universally as possible. Again, the place and form of this recasting remain to be determined by much deliberation. Somewhere in this exploration we can perhaps discover how to do justice to the integrity of both the student and the subject. Maybe they will never be other than factors of each other. Maybe those students most honor the integrity of the subject who learn it most personally. At any rate, suppose we approach the known and the knower as inseparable, as in Yeats's question, "How can we tell the dancer from the dance?"

Verbal and Nonverbal Learning

The curriculum should integrate such wordless learning as arts and crafts, and physical and practical activities, with discursive or academic learning, which needs to be both counterbalanced and nourished by nonverbal learning, for the sake of the total development of the individual. Besides, intelligence operates through many modalities—sensory, kinesthetic, spatial, and emotional—that feed in and out of each other and the verbal mode. Finally, academic subjects have practical applications to various vocations that, in return, supply the realistic problems and circumstances that educators now say best help students understand the subjects.

How do verbal and nonverbal learning interplay? This question should hang before us constantly as we go about integrating the curriculum. Except for sports, shop, and home economics, which are so sharply separated from academic subjects as to form almost a separate curriculum, schools have seldom bothered much about learning divorced from language. Most traditional subjects are cast into language and cannot be learned without words. Literature, history, and most math and science are taught mainly through texts and talk.

By contrast, playing a piano or making a puppet requires sensory and kinesthetic skills. But virtually no sort of learning is purely verbal or nonverbal if you consider it fully; some aspects of math are visual—like graphs and geometric shapes—and the information of the natural and social sciences builds on observation of wordless phenomena. On the other side, verbal coaching is a part of most sports and crafts, and learning to read music is usually, at some stage, part of learning to play a piano or trumpet.

Schools have made some subjects more verbal than they should be in order to format them into standard courses with books and lectures and have made students such passive information receivers that "book l'arnin' " seems to be about all that's required. Viewed only as content, as amassed bodies of information, science and social studies appear almost entirely bookish. To the extent they are construed, however, as the investigative processes by which knowledge in these fields is *made,* then sensory, kinesthetic, and intuitive learning are definitely also in order, though not favored by public education because student investigation seems hard to organize and control within the conventional school framework.

According to a bias of our culture and therefore of our schools, thinking is mostly or entirely verbal, that is, it depends on words. Or if nonverbal thinking exists, it's concrete and hence not very important. One could make a very good case that the really important thinking is nonverbal, because the most original ideas come from intuition and are cast first in a form of feeling or imagery that only later takes on the labels and structure of language (which tends to standardize thought). We usually assume that if a lot of language is being used, a lot of thinking must be going on. But it's clear that words can be used to avoid thinking or to control the thought of others—both serious problems in mass institutions. Students should read and write vastly more than they do, but making literacy second nature should not be confused with reducing education to book learning.

Students need to interact directly with the things of the world that prompt thoughts, the social and natural environments, from which public education actually insulates youngsters by segregating and immobilizing them off in special buildings. The minds even of lower animals atrophy without plentiful stimulation. No matter how provocative a teacher or textbooks might conceivably become, they could never provide the thinking fields that real environments can. Learners need to exchange with nature and society, and public education has to arrange for them to do this.

At the same time that students are learning to cast this experience into ordinary and mathematical language, they should be practicing the nondiscursive arts such as film, painting, music, and dance. To think is to perceive relations. This may be done with and without words, in various media, sometimes rationally, sometimes intuitively. Surely education must include alternative ways to have thoughts and to cast thoughts. The best curriculum would enable learners to interconnect things as much as possible by keeping all subjects, media, and modes of knowing in play all the time. But it shouldn't make the connections itself. The one who does *that* is the one who's thinking.

Languages and Subjects

To integrate the curriculum, we have to understand the differences across which we are connecting. Some school "subjects" are not really subjects at all but *languages,* by means of which we can discourse

about *any* subject. So let's make a major distinction between content subjects and languages, but only in order to relate them anew. As languages, Spanish and English and mathematics differ entirely from subjects based on material content like government, economics, history, chemistry, and psychology, which are both bodies of accumulated information and disciplines of ongoing investigation. (It's in a different sense—metacognitive—that English or math can also be said to have bodies of content and disciplines of investigation.) By treating languages and subjects alike—formatting and teaching them in similar "courses"—schools have made all "subjects" harder to learn in themselves and to relate to each other.

The difference between languages and subjects is precisely what relates them. Languages symbolize subjects. This relation of symbolizer to symbolized should inform the whole curriculum. To the extent subjects are cast into language, students have to learn the language and the subjects together. Languages, for their part, can't in fact be learned without some subject matter as wherewithal to symbolize. Sensing this but hell-bent nevertheless to teach English and math as separate "subjects" like the others, schools have trumped up arbitrary material to exercise with, "topics" for composition and "story problems" for calculation.

English courses have made a monster out of grammar and spoiled literature by commandeering these in the misguided search for a specialized content when any subject matter whatsoever will serve as something to talk, read, and write about. The main thing is that the material should involve the hearts and minds of the learners sufficently for them to practice these language arts realistically. In drawing their subject matter from experience, students are in fact dealing with people and nature anyway and therefore working with traditional curricular topics now allotted to courses in social studies and the sciences.

Math courses have suffered from a virtual absence of any subject matter except math's own rules of operation. It is mainly this disconnection from nature and people that maintains the famous mental block on math shared by most Americans, because the main school problem with math is its abstractness. By its nature, abstraction disembeds objects from their familiar context in order to consider only one aspect or quality of them. By abstracting only the quantitative aspect of things, math operates so high up in the realm of pure

logic that most people can't relate to it except through the medium of some familiar content.

Without a subject matter other than itself to operate on, furthermore, math does not come across as a language or symbol system, certainly not one to use in everyday life. Good texts and teachers have of course always tried to show something of how math can be applied, but this is too time-consuming to do much of within the framework of a course obligated to cover certain math "content" like algebra and geometry, and these sample applications just reinforce the arbitrariness of the rest of the canned curriculum. Like English, math needs to be practiced constantly in direct relationship to the familiar phenomena of life. The curricular movement called "reading and writing across the curriculum" tries to wed languages and subjects in just this way but cannot surmount the doggedly held school practice of segregating all of the languages and subjects into separate courses.

What Languages Share

Mathematical symbols and expressions can be spoken, read, and written. These symbols are variously combined to "spell" the equivalent of words, which are in turn variously combined into the expressions that compare to phrases, which are in turn predicated into formulas and equations that make statements like sentences. Math and English can be translated into each other—at least up to the point where ordinary language can no longer keep up with the greater abstraction and finer logical precision of mathematics, which are of course what require the different symbols and syntax. Perhaps we should think of math as a special sort of second language but one learned very early.

What ordinary and mathematical languages basically share is logic embodied in vocal and written symbols. Math is a purer form of logic that extends ordinary language into a higher range of abstraction. Whereas English, say, starts by *naming* physical objects and concrete experiences, math starts by *numbering* them. Both refer at first to the familiar world, but referring to the qualities of things keeps ordinary language much closer to this world than referring only to the quantities of things, as math does. Continuous on an abstractive spectrum, the qualitative and quantitative languages complement each other beautifully.

This complementarity reflects the human brain's dual approach to codifying reality. By interrelating the qualities and quantities of things, people make knowledge. Nothing could be more important for education than coordinating the development of these two kinds of language. This can be done by applying both, at once and all the time, to the topical subjects.

Seriation

Consider also that writing began with recording, which consisted of *1–2-3*'s, as well as *a-b-c*'s. In antiquity the letters of alphabets long served for numbers, as early writers registered both counts and acts. The first writing seems to have been a form of book*keeping*, so that earlier people identified storytelling with counting.

The word *bookkeeping* itself refers to a book in the sense of a ledger. The double meaning of *book* exactly matches the double meaning of *account*. In a story book we give an account of some events, and in a ledgerbook we keep accounts of numerical transactions. Vestiges of this identification between tales and tallies are fixed in the language. In Keats's "Eve of St. Agnes" the fingers of the holy man "told his rosary," that is, counted the beads to tally his prayer repetitions. In other languages than just English, telling is recounting, as in the French *raconter* or German *erzahlen*. Why did our forebears treat these as intrinsically connected?

Today we may be used to thinking of numbers as very different from words—figures from figures of speech. But narrating and numbering have in common something terribly fundamental—serial order.

Chronology is the order in which events happen, the very definition of time. The fact that *this* act happened before *that* one is not to be tampered with. Start in the middle of the story, if you like, as Homer did, and flash back to earlier events, but do that only to make more, not less, out of what came first, next, and last. Without their serial order numbers too lose meaning. What "prior" and "later" are to narrating, "more than" and "less than" are to numbering. In any sense of "tell" it's essential to get the sequence right.

Without seriation, a number is just one primitive way of clustering things that seem alike—five nuts, five fingers, or the number of sheep matched off with pebbles dropped in a bowl as they pass into the pen. By itself a number is just a class of things, threeness or

twelveness. Without seriation you can't say or learn anything more about this class because it is not in relationship. A number not ordered can't even be added, subtracted, multiplied, or divided. Where does it stand? It's a noun that can't be put into a sentence. A number *series,* on the other hand, starts to supply predicates in the very idea of "before" and "after."

Even the notion of causation seems built on sequence, as we can see in the double meaning of "since" as either "after" or "because," of "while" as "during" or "whereas." Our language and our thinking chronically blur temporal and logical sequence, as in our notion of "what follows." A "conclusion" may come after the climax of either a sequence of events or a chain of logic. What goes before seems to determine what comes after, as we can see somewhat comically in even the technical term "entailment" from symbolic logic.

The what-happened-next of "then . . . then" leads quite comfortably to the "if . . . then" of reasoning. The stages are marked by sentences like "If you allow water in the gasoline, the engine sputters" (cause-and-effect time sequence) and "If the other two angles in a right triangle are equal, they are 45 degrees each" (a relating of measurements). Here "if" is almost interchangeable with time-space words like "whenever" or "wherever."

It's easy to understand how sequences of events could become synonymous with causes and effects, but a number series seems too mechanical to be parallel to causation. But actually, each number is not merely like the one before it except larger. Across the steady beat of one more being added to the previous number there fall various counterbeats that create different rhythms.

To begin with, every other number in the whole number series is odd and alternates with even numbers, which can be divided in half. Three is not merely one more than two but a prime, or indivisible, number in the subseries 3, 5, 7, 11, 13, 17, etc. Four is not merely one more than three but a square number in the subseries 9, 16, 25, 36, etc. Six is not merely one more than five but the first in the subseries of "perfect" numbers, each of which is the sum of its factors ($1 \times 2 \times 3 = 1 + 2 + 3$). The famous Fibonacci series (1, 2, 3, 5, 8, 13, etc.), formed by adding two adjacent numbers, beginning with 1 and 1, to obtain the next number ($1 + 1 = 2$, $1 + 2 = 3$, $2 + 3 = 5$, $3 + 5 = 8$, $5 + 8 = 13$), corresponds to certain ratios in geometry and biology. What is the frequency or pattern by which prime or square or perfect or Fibonacci numbers crop up within the whole numbers series? (With some exceptions the prime

numbers fit between the square numbers.) These subseries ripple across each other in fascinating relationships and sometimes also express phenomena in the material world.

Since position in the number series determines the quantity and hence the traits of a given number and how it may relate to others, this determination might be compared to some sorts of causation in stories by which earlier events are held to "entail" or "lead to" later ones. Like the chronological order of before and after, the numerical order of more than and less than generates out of its simplicity a more complicated conceptual overlay. This occurs because both chronology and number contain a secreted logic that manifests only across some extended segment of their respective seriations. In math it generates periodicities, intervals, and progressions that have intrigued mathematicians since antiquity, as they can students, who also enjoy puzzles and surprising revelations.

Limitations of Language

Seriation is of course only one aspect of the linearity of language that math and English share. The sequence in which words or mathematical expressions are placed generally makes a difference, though both systems allow some leeway or options in order. More important, the statements made in both sorts of language proceed step by step, from sentence to sentence or equation to equation. They feed ideas to us cumulatively, so that each adds something to its predecessors. Consecutive processing has its limits, however, which is why one hemisphere of the brain specializes in handling material simultaneously.

One reason why education must honor nonverbal learning is to offset the limitations of languages, of which linearity is one. A tune spins out one after another the same notes that its chord sounds simultaneously. The tune is a plural version of the unity of the chord. You do not fully know the notes until you hear them sounded together as well as separately. Full knowledge combines both melody and harmony, succession and simultaneity, plurality and unity, both hemispheres of the brain.

But tunes and chords don't merely balance each other. A chord is a matrix from which many tunes may be generated by permuting the notes in various orders. All melodies so derived share the tonal qualities of the chord—its particular set of intervals—and yet differ from one another by virtue of stringing differently the same notes.

These melodies amount to different statements, even different interpretations, of the same matrix or matter. They are like sentences about a subject.

Statements in language, like melodies, can only partially render the matter, because if more than one sequence is possible, then any sequence represents a preference, a value judgment. One might try to do justice to the potentialities of the chord or other matter by deriving multiple melodies or statements from it, but if presented simultaneously these would create cacophany. Besides, in some cases the number of melodies or statements might be virtually infinite.

But we are not dealing here merely with sequence alone, which is meaningless without considering the individual values of the notes or words being sequenced. Just as each note has a certain frequency and duration that interplays with neighboring notes, words have certain meanings that combine syntactically to produce cumulative effects. Short sequences like phrases are sequenced into longer units or statements that are in turn sequenced into complete musical or written compositions. But all this organization of successions succeeds only because the basic units—notes and words—have individual value and meaning that collectively express the plurality of the world. Sequencing, in other words, requires some particles to be sequenced and hence presupposes some breakdown of whole into parts. A melody analyzes a chord into its constituent notes. Language distorts life not only by processing it sequentially but by fragmenting it into artificial particles in order to do so.

Moreover, the concepts embodied in words are human-made and cut up life into "things" or "actions" that falsify its parts and obscure its unity. The world itself is wordless, unconceptual, nonverbal. In talking about the world we strip out only some aspects from its infinite possibilities, some that interest us. To perceive is to select, and to verbalize perception is to confine it to the finite, ready-made concepts of vocabulary. The number of words, of concepts, nowhere near equals all the possible perceptions of things. Furthermore, not just the concepts are limited. The ways in which we can predicate our little stock of concepts into statements falls dangerously short of rendering the infinite intricacies of the nonverbal world. Syntax suffers from the same crudity and partiality as vocabulary.

For these and other reasons, language cannot match reality. This truth applies no more to the nuances of sensibility than to the

subtleties of matter and energy. The more we can acknowledge this truth, the less it is a problem. The problem arises from thinking that everything can be said. But traditional schooling has been far too unsophisticated to acknowledge the limits of discursive knowledge. In fact, it has tended to glorify verbalism and bookishness to the point of actually undermining language, which can't be mastered without understanding its imperfect relationship to the nonverbal reality it's basically about.

What language can and cannot do is best learned, moreover, by practicing it alongside nonverbal media such as film, painting, dance, and music. More even than in the past, schools shunt the arts aside as frills that take time away from "basic skills." This is the kind of ignorance that the curriculum passes down because the fusion of all its subjects has never been sought for and thought out. Of course students should practice all the arts for their own sake, not merely to compare them with language, but in allowing students to connect all things with each other, curricular integration naturally enables them to find out how the various media complement one another. The graphic and lively arts symbolize experience too; they too make and transmit knowledge. Schools have to get over the idea that the arts just entertain and must accept them as *alternative modes of knowing*. Not all knowledge is discursive, and without the context of these alternatives we don't know what to make of discourse itself.

Languages have ways of escaping their own limitations, but to understand these we have to refer the language arts to the other arts. Art connects the verbal with the nonverbal and provides language the means to correct itself in some measure. For this point let's resume the search for what languages share.

Transformations

Both mathematical and ordinary languages feature alternative ways of symbolizing something. They do so not for the sake of mere versatility but because putting the same thing in different ways allows us to think about it differently. This is essential to developing ideas and minds.

Any definition that's of use, for example, tells you what something means by recasting it in other terms you may already understand. Dictionaries define a word by supplying us one or more

synonyms for it, by giving us a phrase that's equivalent, or by explaining it in a sentence. All these ways of defining put the same thing in different words, which in logic is called tautology. A great deal of talk and writing consists of defining, which may elaborate an object or idea or bring out its details and implications. Sometimes authors spend whole paragraphs, essays, or books defining something. Much of our discourse puts something another way in order "to go into it."

The equivalent in math of definition is equation. Some expression on the right side of the equal sign recasts what is on the left. The equation 25 = 75/3 puts 25 in other terms so as to bring out some aspect of it not evident in its initial form, namely, that it's the same as one third of 75. To bring out some other implications, we might write $25 = 4^2 + 3^2$, an equation which reveals that the square of 5 comprises the squares of its two antecedents in the whole-number series, 4 and 3—a very different definition of 25 indeed.

Most mathematical operations occur through series of equations that end in something very different from the beginning. By stating that *this* is really the same as *that,* which in turn is another way of expressing something else, and so on, a series of equations keeps recasting terms until they yield an "answer," that is, some form of the original that is desirable. Besides the solving-for-x type of vertical series of equations that students are familar with, there is the horizontal sort where the right-hand side of an equation simply becomes the left-hand side of another equation in an open-ended continuity that follows out the implications of the first formulation as far as one can or wants.

The second, or open-ended, series of transformations is really a sequence of logical deduction that starts with a kind of premise, the original formulation, and parlays this in stages to some unforeseen conclusion that is a new truth latent in the original expression but not apparent except through the transformations. This is tautology at work, and it is the essence of math, but in less pure form it is central also to ordinary language.

Syllogisms, for example, work much like series of equations. If statement A is true, and if statement B is also true, then what else must "follow," must be true as well? If lowering taxes encourages people to spend, and if spending strengthens the economy, then lowering taxes strengthens the economy. The conclusion restates the first two statements, the "givens," just as the right-hand side of an

equation reformulates the original formulation on the left. In both cases these logical chains may continue very far indeed and end in startling discoveries even though no new factual information has been introduced. Such is the power of logic.

Besides definitions and syllogisms, the tautology of ordinary language works in another way, one that can enable it to escape somewhat its own limitations. This is metaphor, which also puts things another way so that we can see them differently. If we refer to a tree as a sentinel, we are setting up an equation that brings out new aspects of the tree. Suddenly we see it as protective and exposed, like a soldier posted alone to stand watch over others. Like equations, metaphors tranform some given thing by selectively cuing off of certain of its qualities. Gerard Manley Hopkins begins a poem, "Glory be to God for dappled things" and then likens a number of speckled and checkered things to one another. He thus creates a new class that cuts across conventional categories and reorders our mind, as creative equations do.

At the same time, metaphor offsets the linearity of language by referring simultaneously to more than one thing, since an equation like tree/sentinel has at least two terms. Figurative works of literature may thus tell a story and make a statement at the same time or, like *Moby Dick,* simultaneously tell several stories and make several statements by building up a rich complex of metaphor. A metaphor like the white whale keeps acquiring referents as its increasingly denser context places it in association with more and more things. Each of Moby Dick's traits—its whiteness, its gargantuan size, its ferocity, its adaptation to the sea—come to stand for associated qualities in humanity and the environment, so that whenever Moby Dick is referred to, these qualities are also referred to and cross-referred among themselves. This multiple reference resembles a musical chord: just as plural notes are sounded together when a chord is struck, plural meanings are indicated at once when the metaphor is mentioned.

Thus tautology can allow a language to undo itself. This possibility is inherent in putting something another way, because once you have equivalence—two or more things assigned equal value—you are only a step away from equivocation—two or more things assigned the same symbol. This simultaneity offsets the linearity of the consecutive words and statements. In linking together disparate things by certain shared aspects, metaphor restores the unity of the nonverbal world that language otherwise fragments.

Nonverbal Aspects

Language has its nonverbal aspects, then, and metaphor is one of them. Creating metaphors partakes of a general mental capacity for seeing likenesses that does not depend on language. I'm sure that before human beings developed speech they likened other objects to each other on the basis of one or another shared trait. And even most animals can recognize a new instance of some creature or object because it looks *like* other instances they have seen previously. This requires some capacity to cognize similitude, which is the basis of metaphor, as indeed it is of all classification.

However much we may associate metaphor with language and literature, this classifying capacity belongs to thinking before it does to speaking. Words stand for classes of things and usually derive—metaphorically—from names for concrete objects. And the use of metaphor makes up a goodly part of the art of literature. Imagery in general plays a major role in writing, but physical vision is not verbal merely because it can be verbalized. Figures of speech are just figures before they are figures of speech.

Language can overcome its verbal limitations to the extent that by its nature it includes nonverbal elements. Both ordinary and mathematical languages refer to physical things, though math does so much more abstractly through its quantification and its idealized geometrical shapes. The nonverbal world necessarily influences languages because the function of languages is to symbolize reality so we can make our way in it. Of course languages are structured to fit the human mind that creates them, but they also have to accommodate what they symbolize. What they fit well about the nonverbal world is its pluralism, the profusion of nature.

Hence ordinary language features the diverse qualities, the many traits by which we cut up the world into classes of things that we name with words and relate into sentence statements. Math does justice to the pluralism by counting and measuring things and then by laying these counts and measures over against each other in various ways such as ratios and equivalences. Though qualifying and quantifying inhere more in the mind than in the objects symbolized, they do reflect with some fidelity this material profusion of the environment with which people have to deal. In fact, it must be the case that human beings are outfitted in the first place with these capacities to qualify and quantify precisely

because we need them to map our way amid the prodigality of nature. The ordinary and mathematical languages are capable of such sophisticated operations that they can in some measure correct for their own distortion. In the hands of great logicians and poets these languages seem to render reality justly despite the limitations of discursive media—at least to the satisfaction of the current culture. But truth has a way of evolving with the culture. Logic may be a basic human faculty and math a universal language, but logic can be put into the service of the most parochial or partisan enterprises, and if deduction starts with partial premises it will not arrive at impartial conclusions.

Knowing the world only via symbols is dangerous, because the essential dynamism of nature can't be known that way. Many languages themselves acknowledge this by specifying two different verbs of knowing, such as *connaître* and *savoir* in French and *kennen* and *wissen* in German. The first of each pair means to know directly from experience, as to know a person or a place, to be acquainted with, whereas the second means to know intellectually, as a fact, to know *that* something is so. Language can do nothing for the direct, experiential knowledge and can even get in the way of it, but at least it can talk about it, as I am doing here, and thus bend back upon itself and become a metalanguage to in some way counter itself.

But of course nothing substitutes for nonverbal experience. Language creates verbal circles that seem true because they are self-consistent. And because words refer to things, they delude us into believing that what they say about things is necessarily true. Language refers to itself as much as to things outside itself. To some extent it represents the mind talking to itself. The truths it formulates about reality are always a "manner of speaking," biased by the cerebrality that created discourse. Thoroughly understanding this, as even very few well educated people do, makes the difference between being the master or the dupe of language.

The abstractive process of symbolizing is both valuable and dangerous. Any medium—verbal or nonverbal—will refract reality according to its particular nature. Language is no exception. Nothing could be more important for students to learn than this double-edged potential of symbolization. This is why the entire curriculum must keep the gains and losses of each medium constantly in the learner's consciousness. Truly integrated learning puts all media in play all

the time, without prejudice, so that learners find out what each of the alternative symbolizations—language arts, graphic arts, and lively arts—can and cannot do.

But of course this works only if learners can interact at the same time with the material and social worlds that these media symbolize. By insulating young people for twelve or sixteen years or more in a verbal world, schools have not only cut off the academic subjects themselves from the nonverbal material they're founded on but have distorted through the lens of symbolization the nature of reality itself. Professors and school teachers are wordmongers because they make a living essentially through talk and books, which, moreover, accommodate institutional controls very well when directed from the top down, as in schools. This bent may make it especially hard for educators to right the imbalance in schools between the verbal and nonverbal. But we cannot understand language itself without silence, much less the silent world it symbolizes. Learners simply must experience life part of the time unmediated by culture, which, God knows, has its say through not only language but through a society's whole "cake of custom."

Even in the most hard-bitten culture of poverty where few people read and most are forced to confront some realities very directly indeed, people are still imprisoned in the conceptual cage of the local society. In fact cultures of poverty perpetuate, notoriously, a narrow view of the world. Many teachers may say, "Well, my job is to give students language; they get all the nonverbal experience they can deal with out of school." But people who use language less are no less bound by the oral culture they grow up in. Actually, their thought is more limited because they don't develop language to the point where it mitigates its limitations, *nor* do they acquire the broader nonverbal experience that the affluent enjoy. The disadvantaged need more of both, and if this is to be provided during the formative years, public education will have to arrange for it.

The problem for learners of any economic level is how to compare social versions of reality with nonverbal experience of it and thus how to sort out culture from the rest of nature. This is not a neat matter, because people become acculturated so early and so thoroughly that even when experiencing the nonverbal world "directly," they are in fact peering at reality through a cultural filter, which they have internalized along with the language and other social behavior. Traditional schooling sacrifices the

truth quest for social knowledge deemed to be more practical. But culture is humanly fallible and without the self-awareness that comes from standing outside itself drifts into the most impractical conditions, including self-destruction. Culture must evolve to save itself. It will only if the young can see through it enough to change it. This means slipping the limits of discourse, which are locked into the limits of culture.

What Subjects Share

Though they differ in what they are *about*—in their information—government, economics, history, chemistry, and psychology share some common processes for making their information, for investigating. These are processes of observing and reasoning that characterize the human mind and determine how we make and store knowledge, although each field has its own concepts and frameworks that influence in turn how its practitioners observe and reason.

Methods of Investigation

All the knowledge studied in schools as social studies and the natural sciences or, say, as nursing or economics was constructed and is still being constructed by common ways of investigating and interpreting that learners should practice themselves. Public education has preferred to emphasize *what* a field has established rather than *how* practitioners in the field come by this knowledge. A bureaucracy can much more easily purvey to students the established content of a field than it can let them experience the investigative process by which that content becomes established. Authentic inquiry doesn't fit the passive stance that schools keep students in for control purposes or the manipulative managerial systems built into the canned commercial curricula prevailing in schools.

But content is only part of the "subject," as professionals in the field would be the first to say. Students should of course learn as much as possible of the information and concepts of biology or anthropology, but they should also do some version of the investigation that the practitioners do. In fact, role-playing professionals is one of the best ways to learn the content, because investigators have to situate their project within what is already known.

To investigate something, you go and look at it, go and ask about it, or go look it up. If what you want to know can't be found out by observing somewhere, asking someone, or consulting some sort of documents like books or films that store information, then you set up an experimemt, that is, some special circumstances, so you can have something to observe not otherwise available. Investigative journalists routinely do all of these except perhaps experiment. They visit, they interview, and they read or view what previous investigators have found out. Like researchers in the social and natural sciences, they may combine all of these or, depending on the project, utilize only one. Folklorists may attend ceremonies or interview oldtimers or look up archives.

These methods are basic because the environment and other people are the main sources of information. What have people found out before you? What do you need to see for yourself? Sometimes living individuals know what you want to know. Sometimes the information is collectively known and has been pooled in repositories. Students should learn these basic firsthand and secondhand methods, including experimentation, and employ them for inquiry into both new and established subjects. Becoming an investigator yourself changes utterly how you may feel about and assimilate the contents of traditional school subjects. In addition, the more students feel that these basic processes of inquiry constitute a common denominator for all subjects, the more they can integrate knowledge themselves.

Chemistry or biology, government or sociology, also share with each other—and with typing, computer programming, and nursing—the possibility of practical application in, say, curing disease or improving the national economy or giving psychotherapeutic counseling. So besides being distillations of acquired knowledge and procedures for increasing that knowledge, the true "subjects" feed their knowledge into the marketplace and world of emerging affairs. Application too is part of what a student learning a subject should find out about that subject.

Whether "academic" or "vocational," any field of knowledge has political and economic implications that young people should become aware of. Consider how rapidly discoveries in genetics become technology, which in turn becomes business, all the while raising legal and moral issues. Or consider how sexism and certification in nursing affect what may be known in the field and indeed how the field

is defined. Typically, schools have avoided sensitive issues that might arouse complaints from some interest groups and have pretended to an impossible neutrality.

But schools don't have to take or avoid a stand on controversial matters. All they have to do is teach students to investigate the environment, to think for themselves by visiting the sites, interviewing the practitioners, and reviewing the literature concerned with these fields and issues. As a matter of fact, this is also an excellent way for young people to research career possibilities. Apprenticing of course also permits investigating a subject as it's applied. People and places concretize a subject for learners—impel them to learn both the content of a field and the role it plays in society.

The young need to "enter the world" long before they leave school and seek a job. Keeping students naive and ignorant of what we do with knowledge is one way schools infantilize their charges. Actually, the years prior to serious employment provide the only time when people can look over and reflect on the various fields without the bias acquired after they have committed themselves to one as a living. Most needed social changes are blocked by material and psychological investments that people make as they work in a certain field that not only provides a living but also submerses them in a subculture with its own frame of reference. Serious redirection of society will probably not occur if we don't enable some generation to investigate—during this stage of life when minds are least committed—both how we are making knowledge and how we are applying it.

Maybe we're partly ashamed for them to discover what we are doing until it's too late for them to do anything about it. But this is an era of declassification—for good reasons. We can't afford any longer to keep secrets that affect the welfare of all.

Kinds of Discourse

The other major common denominator of the specialized subjects is their expression in languages, ordinary and mathematical, which symbolize qualitatively and quantitatively whatever one is observing and reasoning about. So what makes a language different from empirical disciplines also makes it common to all.

Law schools, we're told, regard English majors as good candidates for admission, because in studying literature they have devel-

oped some sophistication about interpreting texts. Lawyers have to think of many possible interpretations of statutes and judicial decisions. Who else besides legal and literary professionals must do close textual analysis—look for ambiguity, spot implications, read for subtexts? Priests and preachers, interpreters of holy writ. Indeed, some scripture, like parts of the Old Testatment *is* law, and the long rabbinical traditions of arguing religious decrees on the basis of the Torah and the successive commentaries on it—the Talmud, and the Midrashim—may account for much of the affinity and ability Jews show for legal practice.

Literary critics, lawyers, and exegetes all practice the art and science of hermeneutics, of close textual analysis and of disputation citing not only some primal text like a poem, law, or scriptural passage but the texts of previous commentators. This art/science practiced across such different subjects requires bringing an extensive intertextuality to bear on intensive interpretation of a single text. For an example from one other profession, the analysts in diplomatic and intelligence offices also have to do exactly this when they interpret for their government the speeches, policy statements, and news releases issuing from foreign countries. Insofar as they have been cast into language and into text, different subject matters call for the same interpretive faculty regardless of the nature of the professions involved.

Discourse is a medium in which all subjects may be symbolized, however nonverbal may be their perceptual underpinnings. Putting knowledge into language tends to make all knowledge somewhat alike, because language imposes its forms and limits on it. This is true not only at the sentence level, where propositions are formulated, but at the level of a complete discourse.

A discourse is any kind of oral or written communication that is complete for its purpose—a dialogue or lecture, report or memorandum, poem or ad. Many kinds of discourse are common to all disciplines. Logs and journals, for example, may be kept about any topic by any observer who is in the middle of the events. Likewise, a news report, a psychiatric case history, an account of a physics experiment, an eyewitness deposition at a trial all run the gamut of subject matter but all share the narrative form of discourse, a story told after the conclusion of the events.

Essay imposes an organization different from either blow-by-blow journals or after-the-fact narratives. In an essay, statements follow an order of ideas, not an order of events. The dominant tense

is not the progressive present ("the snow is falling") or the recent past of journals ("I have noticed lately") nor the past perfect of narrative ("she slammed down the phone and darted out") but the present tense of generalization ("doctors usually come from middle-class backgrounds"), which exists not to indicate time but to assert general propositions. Essays may contain stories but only to document statements. This form of discourse—generalization-supported-by-instances—may be employed to make statements about any subject whatsoever.

More abstract still is an argumentation, an essay not merely asserting and supporting a generalization but combining several generalizations so as to derive further generalizations. As narrative form mimics chronology ("then this and next this"), the essay of argumentation mimics the logical syllogism ("if this and this are true, then this must be true as well").

So in tracing the point that kinds of discourse keep their identities across different subject areas, that they in fact fit the subjects to themselves, we realize that by virtue of sharing these kinds of discourse, the various disciplines are related to one another and even become alike in some respects. This is so because kinds of discourse are really different vantage points from which a subject may be viewed or levels to which it may be abstracted. Kinds of discourse are ways of perceiving and thinking.

In fact, one revealing way to organize learning that cuts across subject areas is around kinds of discourse. I have for some time recommended this curricular change in the language arts so long as language should remain a separate subject in school. Students saturate themselves in one kind of discourse at a time, reading and writing and talking about a variety of subjects in the form of, say, dialogue or journal or report or short story or review or editorial.

Such reorganization would prove even more valuable for a totally integrated curriculum, especially when combined with another reorganization around interdisciplinary projects, as explained later. Allowing for differences in individual development, it's possible to sequence kinds of discourse so as to move from concrete to abstract and hence to exercise increasingly sophisticated mental faculties, as should become clearer in what follows below—the same faculties needed to carry out progressively more demanding interdisciplinary projects.

Levels of Abstracting

Take the forms of discourse mentioned above. Let's call the account told from within the events "recording" (the log or journal), the story told after the events "reporting" (the news story or case history), the thesis essay "generalizing," and the argumentative or syllogistic essay "theorizing." There are of course other sorts of discourse, and these four may often be found in mixture with these others as well as with one another, but the activities of recording, reporting, generalizing, and theorizing characterize the main spectrum of discourse and characterize it as successive ways of knowing something that carry a subject from observation through recollection to intellection—from sensation through memory to reason. For convenience, let's speak of these stages as successive abstractions and of these human faculties as various ways of abstracting experience.

What is common to the various subjects or disciplines is this abstracting or knowledge-making process, which the varieties of discourse reflect in a staged fashion correlating with the successive faculties and logics employed to make knowledge.

Recording and reporting are based on *chrono-logic,* time order, the "logic of the events." The essay of generalization is based on analogy or similarity among events or things, on the logic of classes, which we may call *ana-logic.* The essay of argumentation is based on the logic of propositions, on equations whereby saying this is tantamount to saying that as well, which we may call *tauto-logic.* We forge from the known to the unknown this way, by reasoning. The next step indeed is math, for verbal equations and syllogisms represent the threshold between the ordinary and the mathematical languages.

This progression also carries us from induction—distilling particulars into generalizations—to deduction—reasoning from one generalization to another. Inductive and deductive reasoning operate throughout all the empirical or worldly subjects we're considering here, which are based on thinking from sense-derived information. Surely, the investigative processes of observation, recollection, and intellection should undergird the general discursive curriculum, applying as they do from nonverbal perception into discourse and across the abstractive spectrum.

Kinds of Knowledge

But placing the subject-area disciplines along this spectrum of discourse also brings out what is unique about each and how they relate to each other. History, for example, is basically reporting, science basically generalizing, and philosophy basically theorizing. Mind you, these do overlap. When historians generalize about their narratives, they become social scientists. When scientists theorize from their generalizations they become philosophers. And when philosophers speculate about metaphysics, they become . . . mathematicians, as nearly all the great philosophers have been. Thus history, science, and philosophy differ by level of abstraction so as to form a continuum of knowledge-making bridging from particulars of the past to perspectives embracing all time.

This expansion across time and space is in fact a way to measure increasing abstraction. Each successive stage of it subsumes and builds on previous stages. In any subject, history leads to science, and science leads to philosophy, in just the way that records and reports provide the instances to generalize from and generalizations provide the propositions to syllogize with. Observation provides the material for recollection, and recollection provides the fodder for intellection. So, backwards, reason relies on memory and memory on sensation.

Going down the abstractive scale from history, we find the kinds of discourse of which history is made—biography and chronicle, which rest in turn on autobiography and memoir, which rest in turn on diaries and letters. "Source documents" become increasingly particular and personal, shrink to points in time and space, either the names and dates of archives and the entries in logs or the viewpoints of individuals ensconced in certain times and places.

Students reading and writing in these types of discourse are definitely studying history but also learning historiography, how history is made from successive distillations progressing from personal to public as it synopsizes more comprehensively across time and space. As narratives get more abstract they shift from first person to third person, from firsthand to secondhand and more remote sources. Working narrative at different ranges of the abstractive spectrum will teach students what kind of truth value to assign to the various stages of the cumulative cultural creation we call history.

Science is built on records and reports, but it abstracts particulars beyond *what happened* to *what happens*—a different order of

fact and truth. The famous inductive or empirical approach of modern science consists, at least in principle, of observing first and reasoning later, of noting what happened on such and such occasion under natural or experimental conditions and of generalizing only after these field or laboratory notes have accumulated enough instances to generalize from. An anthropologist does not assume that a certain behavior is characteristic or ritualistic until she or he has seen it happen many times. These records are periodically reported in professional journals, say, as summary narratives followed by tentative generalization, an hypothesis to be borne out or not by subsequent observations by the same or other investigators. "Controlling the factors" means ruling out local contingencies that might account for what is observed and might thus defeat efforts to generalize across particular dates and places.

This disembedding of something from time and space partly defines the abstracting process. Thus many stories become one statement of fact. But as induction generates many such truths deduction comes into play to combine these so as to make them yield the hidden or implicit truths they collectively contain. These logical manipulations can occur at such a high level of abstraction that they can be carried out only in purely logical language devoid of all particularity, in mathematics. And so on with philosophy, the leaders of which have usually been mathematicians.

Organizing Around Projects

These ways of gaining and making knowledge are ultimately more important than particular contents, because a person well versed in inquiry processes can always become well informed about a certain subject, but someone who has only acquired information without learning how knowledge is made depends too much on memory and stock sources and does not understand, furthermore, how fallible and malleable knowledge is.

Besides, so much information exists today about so many subjects that decisions about which topics to present to students have become arbitrary. Which are "basic"? Which will be needed in the future? Then too, the concepts and information of the various fields change rapidly, and schools have always been the last to know, because specialized courses, textbooks, and teacher training change

far more slowly, locking in the old and delaying the new far too long. Finally, decisions about which contents to offer, which to require, and which to leave as electives inevitably entail partisan preferences. Political, religious, ethnic, and commercial factions disagree about many of these decisions, which please some people only by displeasing others. In fact, the very incoherence and arbitrariness of traditional curriculum comes about in the first place from patching together concessions to such factions. Make no mistake about it, public education as we have known it is a political construction either favoring some classes and interests or frustrating all of them through compromise.

All this suggests a reorganization of curriculum away from teaching languages separately from contents and away from teaching contents in isolation from each other. Thus math and English would be practiced constantly through the content subjects, and the content subjects would be learned partly as factors of one another. But how to teach all the languages and contents through one another? Let's take our cue from the common denominator of the experiential subjects—knowledge-making itself, which combines such inquiry processes as observing and reasoning with the symbolization processes of the languages as they qualify and quantify the subject matter. Organize around projects that entail all these processes and that cut across subject areas. For these projects, students would investigate something, create something, or improve something. Instead of canning projects in advance, teachers would help students learn how to conceive and execute projects that embody their curiosity, aspiration, and practical intention.

This amounts to giving priority to the symbolizing rather than to the symbolized, to knowledge-making over some given knowledge. But of course students could not spend so much time learning how to learn without learning in the process a lot of information, more in fact than they acquire traditionally when information is programmed for them, because projects immerse the participants in some area of knowledge and entail further fact-finding.

A project can be short or long, done by a group or an individual. It does not focus on a field in the academic sense but rather, by embodying some desire to do or know something, usually cuts across fields and across divisions between verbal and nonverbal, mental and physical, or academic and vocational, as a project to counter some environmental pollution or health problem would naturally do.

Suppose, for an investigative example, some children are running an experimental project to find out which plant nourishment works best for certain plants in their windowbox garden. This entails keeping a log of the amounts and frequencies of watering and feeding with each food, setting up control samples for comparison, obtaining the plant foods, reading up on or asking around about the characteristics and needs of the plants, and disseminating project results partly through writing and the use of graphs and charts. Or a group wants to test various brands of batteries to see which are best and to do a consumer's report on batteries for other people to read. This could entail surveying consumers of batteries for their experiences and requirements, testing various batteries in various devices, reading what manufacturers say, reading up on the electrochemistry involved, taking apart and analyzing batteries of different brands, and so forth, in addition again to record-keeping, calculation, and dissemination of results in some medium. Such projects constantly call for new knowledge and skills in all areas, and students can be helped by older students and adults to find out what they need to know as they need to know it.

One project naturally leads to others, and all these concatenate into knowledge networks spreading well beyond the participants as others use or enjoy the creations or read or hear about what the participants found out. The rub-off effect from one working party to another is unbelievable until you have seen it. It alone would validate the principle of not teaching everybody the same things, of letting different working parties do different things at the same time.

Reorganizing curriculum around projects rather than around "subjects" would of course mean changing heaven and earth in schools. Students would be learning about all subjects via all symbol systems all the time. Fusing the curriculum can't possibly be separated from overall school reform because it calls for far more than just reconceiving what is to be taught. The very processes and organization of schooling itself have to be reconsidered and drastically altered. An entire set of conventional practices will have to be challenged—courses, classes, grade levels, textbooks, exams, and certification.

Scheduling biology or American literature once in a lifetime *looks* efficient in district curriculum guides because such courses present essentials in a systematic way, but in practice even students who receive A's in them forget most of what they learn because the very

compactness and coherence by which the subject is presented makes permanently assimilating it very difficult. Where are the connections with other subjects, with real life, and with the individual learner's cumulative knowledge structures? Connections make all the difference. Making each subject self-contained and presenting it once, all at once, are very much to blame for the ineffectiveness of schooling. Good grades in the courses and good scores on the standardized tests merely mask this long-range ineffectuality.

But project-centered learning need not rule out some brief systematic presentations if these are elected by students at significant junctures in their knowledge-making. Such presentations need not be classes but could be a program of nature films, a videotaped lecture series, a set of activities on computer, laboratory practice, focused reading and discussion with a small group, or field experience working with professionals.

To combine the two main recommendations made above, subject matter could be reorganized at once around kinds of discourse and around interdisciplinary projects. This automatically grounds the curriculum in what subjects share—inquiry and discourse, that is, ways of investigating and ways of symbolizing. This also brings together subjects and languages, nonverbal and verbal learning.

In conceiving a project, the learners and helpers would consider how wide a range of the abstractive spectrum it might best span both to accomplish its practical objective and to teach the most. The two projects described above as examples could span a considerable range, since participants might be observing and recording, summarizing and reporting, generalizing and inferring as well as talking and reading at several levels of remove from physical objects. Much depends of course on the maturity and experience of the learners. But often the members of a working party carry out different parts of the project according to their wants and lights. And if the working party comprises people of different maturity levels, as it should, then every project could span an educationally useful range of thought and language. Less developed learners grow rapidly when collaborating on a project with more experienced colleagues.

The other main consideration in conceiving projects is experiential. The very idea of a project—to create, discover, or ameliorate something—keeps open all the possiblities of interaction with people and things—and of interaction between verbal and nonverbal. Methods of investigation derive in fact from basic sources of information,

which are, precisely, people and things and previous people's investigation of things stored in the social environment. Projects keep languages and subjects in their right relationship of symbol systems to raw material.

Making, investigating, and ameliorating naturally overlap, whether the creation is a timing device for watering that windowbox garden over the weekend when no one is around or whether it's a book or performance. A project to create a multimedia performance is one way of researching personal or social experience and may at the same time be a way of initiating practical action such as helping children and seniors at risk. Because projects start with authentic motives to do and know, learners will either be simultaneously creating, investigating, and taking action in a single project or alternating these as one kind of project leads into the other. Art explores. It represents one mode of knowing that combines inquiry, human concern, and creation.

Rhythmic Curriculum

Mathematics requires special consideration in the curriculum. It is neither a factual subject nor is it a language learned spontaneously from infancy like English or Spanish or Russian. As the logical extension of any native language into higher realms of abstraction, it is the one truly universal discursive language. The farther the abstractive process removes things from physical reality, the more they come together. "Everything that rises must converge." This is as true of languages themselves as of the things they speak of. Just as mathematics subsumes the plurality of native languages into one purely logical language understood in all countries, so abstraction reduces the world from multiplicity to simplicity.

The remarkable thing, however, which needs examining now, concerns how the very abstractness of math as the quintessential logical language leads back again to concrete experience and the arts. *If seen in all its aspects,* math could act as a unifying field for a new curriculum, because it makes contact on all sides with other knowledge.

But to appreciate the point of this exception, we have to construe mathematics in a far broader way than is customary in the modern world, where it has been valued mostly for its practical applications and regarded as an adjunct of science. Seeing it only as a technical

tool dehumanizes it and makes it harder to learn. But the very abstractness that seems to divorce math from basic human concerns was seen by the ancient world as a way of relating very different aspects of life to one another—music, for example, to astronomy, and both to the human body, the social body, and the body of this world they built on and navigated.

Math begins with counting and measuring physical reality and symbolizing these quantities in simple numbers. The calculations with these numbers that make up arithmetic are more removed but still relatively concrete. They allow us to manipulate counts and measurements of tangible things. Algebra abstracts arithmetic a step further; the same operations are used as in arithmetical calculation but operate upon letters, which stand for unknowns, that is, hypothetical quantities.

Math takes off from at least one other aspect of the material world than quantity alone—form. As its name says, geometry derived from measuring land. Being the study of shapes, it remains relatively close to materiality, although the shapes themselves, like numbers, do not designate physical objects but represent *classes* of objects. In adding a third dimension—volume to area—solid geometry increases the mental complexity but doesn't necessarily raise the abstraction level. Trigonometry is essentially just a practical means of using the constant relations of right-angle triangles to solve spatial problems—a specialized bit of geometry.

Except in rare advanced courses, unfortunately, these are the only sorts of mathematics usually attempted in public schools. (The movie *Stand and Deliver* told the true story of an inspiring exception.) Indeed, parents, teachers, and employers would be delirious if most students really learned these. Calculus, symbolic logic, and other sorts of higher mathematics that combine or build on one or more of these are usually reserved for college, where only math or science majors ever take them.

If math education were reorganized to bring out traits of it that connect well with familiar experience and with other sorts of knowledge, it would become easier to understand in itself and at the same time aid in understanding everything else. By taking advantage of math's many points of departure from physical reality and from ordinary language, and of the many connections among its own various forms, more of it could be learned in school, and better learned, than ever conceivable before.

Math's exceptional nature may justify some sorts of direct and continual presentation in schools that cannot be warranted for topical subjects and that is not necessary for the native language. But the nature of this new way of presenting needs to be deeply considered. Traditional courses will not do. Math in all its potentialities must pervade other learning and relate obviously to personal interests, for the rest of one's life.

Math and Literature

Accustomed as we are to thinking of reason and imagination as contrasting, or even opposing, we may have difficulty recognizing how kin math and literature may be. But consider that both reason and imagination reconstruct material reality in the mind and that both do so by abstracting it in some way. By the logic of classes, reason sorts the things of this world into mental bins, and then, by the logic of propositions, it states quantitative and qualitative truths about these classifications. Thought builds interlocking knowledge structures by combining these propositions in various logical ways to generate further propositions.

Imagination too disembeds and rearranges the objects of experience so as to form new constellations that in some way represent or symbolize the original reality. A novelist collages scraps of setting, incident, and character drawn from here and there, that is, "makes up" a story. But he or she reassembles reality for the purpose of charging it with meaning, just as the mathematician or scientist restates experience to reveal relationships not manifest before the particulars were disembedded. So both reason and imagination are creative and inventive. They differ only as alternative modes of knowing. After writing this section I became aware of Scott Buchanan's *Poetry and Mathematics* (1962), originally published in 1929, in which he argued that "each human being is both a poet and mathematician" by drawing parallels between aspects of literature and figures, numbers, proportions, equations, functions, and symbols.

Science employs public ways of classifying and syllogizing to build communal knowledge structures, whereas artists create idiosyncratic visions that are valuable because they supplement communal understanding with individual perception. But scientists contribute also out of personal intuition, and artists work with

continuities passed on to them through the culture. And both are probably working off of archetypes common to everyone's mental life.

More specifically, math and literature have several affinities, ignored in the recent past, that a new curriculum should bring out. Both function through language, but both specialize language into a certain sort of discourse. Math moves language away from imagery and familiar objects toward logical purification, to the point of requiring special, abstract symbols. The language of literature continues to refer to familiar objects but makes of them "figures of speech," that is, refers *through* them to other things analogous to them. Thus fictional personages, events, settings, and objects become metaphors for counterparts existing in other times and places or on other planes of being. Plots are propositions, stories statements. Logic in literature is secreted—embedded and embodied in the character relations and the actions. While telling *what happened* (*once* upon a time) the fictioneer says *what happens* (*all* the time).

Both math and literature generalize reality, but the one does so through explicit abstraction that bares the thought process as nakedly as possible, the other implicitly by a kind of pseudoconcreteness that actually compresses several layers of reference into one set of referents. Metaphor does just this—refers simultaneously to two or more things that share some quality in common but that may lie in very different domains of experience. In literature, for example, twin siblings may symbolize any inner or outer thing that fluctuates between being one thing and being two, integer or fraction, or that may be seen sometimes as a whole, sometimes as separate, like two aspects of one person manifesting as independent behaviors.

Whereas math strives to eliminate ambiguity, literature exploits it for resonance. Math and literature both cast something in a new way so that it can be seen afresh. Math does this through explicit equation, literature through implicit comparison. Behind both is analogy. Both reassemble reality to know it better.

But literature relates to math not only discursively, as one specialized language to another, but also nondiscursively, as one art among the others. Literature differs from other uses of the native language not only in being more figurative but in being more rhythmic. What makes it artful are its nonverbal traits that it shares with music and dance, painting and sculpture—its proportions and periodicities, its rhythmic dynamism. Because ordinary language refers to things that can be seen, it evokes imagery. Because it can be

vocalized, it can be rendered as sound. Because it is sequential, it moves in time. Sights and sounds, ideas and actions, can be played with like the stuff of any other art medium. What comes out in the sentences of literature as meter and cadence, rhyme and other sound play, comes out in the whole structure of a literary work as bigger forms of repetition and reversal, ratio and rhythm.

In fiction, drama, and poetry, the characters, events, settings, objects, or themes may all be orchestrated to create *patterns.* Characters may have foils or counterparts or exhibit telltale recurrent behavior. The personages and their actions may be counterpointed and harmonized to run the gamut of consonance and dissonance. Plots comprise all the dynamics, in fact, indicated in musical scores, such as accelerando and retardando, crescendo and decrescendo, largo and allegro, staccato and legato. Stories not only have themes but variations on a theme, which indeed is usually the very structure of a play or novel. All this is *patterning,* and both math and literature achieve what they do through it. The art of art is patterning, whatever its medium or material. By a marvelous arching out from ordinary discourse, math carries us beyond language and logic into what seems like a very different domain—the arts.

Math and Music

Music is the art of arts because it comes closest to pure self-referential structure and pattern. This basis in number—periodicity and proportion—constitutes its main affinity with math, which is also a mostly self-contained system. Because structure and pattern underlie both logic and art, they afford an invaluable bridge between activities generally thought to diverge as much as, stereotypically, accounting does from musical composing.

These aspects of math and music deserve special consideration inasmuch as this most transcendent art and this most abstract language both derive, paradoxically, from distinctly sensory experience. Tones are acoustical, and music is organized sound. Math begins, materially enough, with the counting, weighing, and measuring of things of this world, and through geometric shapes, graphs, and diagrams it combines visual with verbal. As its alliance with science and technology shows, it can be limitlessly applied to material and practical endeavors. It is both discursive and nondiscursive. Math and music are international semantics, one specializing in space, the other in time. They

both concern the basic human sense of symmetry and asymmetry, consonance and dissonance, congruence and incongruence, equality and inequality. In quintessential form, these are expressed respectively as equations and ratios (balance and imbalance).

Like math, music deals with relationships. Even the tones of which it's made are just variant frequencies on a vibrational gradient. Their value or effect is relative to the other tones with which they are juxtaposed. A melody is just a series of shifts in pitch, of intervals, that are created by placing certain tones in a certain order. These pitch intervals are relationships among adjacent notes. So both tones and tunes are generated relationally.

The other main element of music is rhythm. In popular parlance, rhythm is a steady beat, but it is not merely that. It is two or more beats overlaying each other. Tap your foot at a certain constant rate. That's a beat. Now on every third tap pat one hand on some surface. Now you have rhythm, because regularly stressing a certain count creates a second beat overlaying the first. An overlay is a ratio between the frequency with which one beat falls and the frequency of the other. One stress every three counts is a waltz ratio. Melodies too generate beats that become part of the rhythm. The fact that some notes last several times as long as others sets up additional stress patterns. In other words, ratios of duration as well as of frequency may produce rhythm. Both concern timing—how often or how long something occurs in relation to when something else occurs. "In relation to" is the key.

But music has no exclusive claim to rhythm, which is a major constituent of all the other arts as well—not just the temporal or performing arts like dance but the spatial or graphic arts like painting. Things are measured or laid out against each other in either time or space—or space against time. When we speak of rhythm in the lines or color play of a painting, we do not even need to feel we're employing a musical metaphor. We know it means some kind of repetition or "echoing" of these lines and colors *in relation to* other elements in the painting. Rhythm is ratio—for so much of this, so much of that. By interrelating quantities it gives them qualities. It "puts things in proportion." Being entirely relational, in fact, rhythm transfers from one material domain to another, like number.

Both math and music are based on measure, ratio, and frequency. Actually, any measure is a ratio, because you can only measure something by placing it against something else, whether you're

measuring time by a clock or space by a yardstick. For so much of this, so much of that. For every revolution of the earth around the sun we count 365 and a quarter rotations of the earth on its axis (days). For every half note, two quarter notes. For every quarter note, in 4/4 time, one beat. For every third beat, say, a stress. One thing is laid against another. Dividing thirty by six asks the ratio question, "For every thirty how many sixes are there?" ("How many sixes are there in thirty?") Percentages, fractions, and decimals are just different ways of expressing ratios: 30 percent means 30 for every 100, as do 30/100 and .30. Arithmetic is rhythmic and would be easy and pleasurable to learn if approached that way.

Math as a Humanity

The classical liberal arts quadrivium (of arithmetic, geometry, music, and astronomy) derived via Plato from the Pythagorean cosmology of musical/mathematical harmonics, which Pythagoras had transmitted from the East. Musicologist Ernest G. McClain has treated the Greek transmission of these cosmic harmonics in *The Pythagorean Plato: Prelude to the Song Itself* (1984), in which he argues that modern philosophers slight this key dimension to Plato's dialogues. In *The Myth of Invariance: The Origin of the Gods, Mathematics and Music from the Rig Veda to Plato* (1985), McClain demonstrates by means of tone-mandalas and tuning systems how central a role number and harmony played in antiquity's synthesis of knowledge, from India to Egypt. McClain took the "myth of invariance" from another original work on epistemolgy, *Hamlet's Mill: An Essay Investigating the Origins of Human Knowledge and Its Transmission Through Myth* (1977) by Giorgio de Santillana and Hertha von Dechend. They argue that under the countless myths of cultures all over the world can be discerned some constants—invariants—that, with the aid of numbers, the ancients had generalized about the world and had registered in myths, the story-statements through which they uttered their science. In the Preface, Santillana describes how this insight dawned on him.

> What is a solstice or an equinox? It stands for the capacity for coherence, deduction, imaginative invention, and reconstruction with which we could hardly credit our forefathers. And yet there it was. I *saw.*

> Mathematics was moving up on me from the depths of centuries; not after myth, but before it. Not armed with Greek rigor, but with the imagination of astrological power, with the understanding of astronomy. Number gave the key. Way back in time, before writing was even invented, it was *measures* and *counting* that provided the armature, the frame on which the rich context of real myth was to grow. (p. xi)

In *The Dimensions of Paradise* (1988), John Michell relates this astronomical measurement to terrestrial building. Preliterate cultures constructed their pyramids, temples, henges, and other stone- or earthworks not only according to seasonal astronomical alignments but also according to other "invariants" such as universal units of measure and certain ratios like pi and the golden mean that constituted a cross-cultural "sacred geometry." But to complete this curriculum of the ancients we have to return to music. To their applied sciences of planting, navigating, and building, which all depended on measuring time and space, we have to add the tuning of musical instruments, which required establishing tone scales based on ratios between acoustical frequencies.

A fusion of math and music unified this curriculum within the cosmology referred to in Part 2—the spectrum of rarer to denser planes of reality. These successive emanations, each "begot" from the one before, were mythified sometimes procreatively in the form of a *genealogy* of "gods" as transmitted through Homer and Hesiod or of more abstract spirits like Pronoia, Ennoia, and Sophia as transmitted through the Gnostics. Actually, when the names of these deities are directly translated—Chronos into Time or Pronoia into Foreknowing—we see the generic nature of what they personify. Given the supernatural capacities attributed to figures like Moses, the Biblical genealogies of ancestors served, like those of the deities, to symbolize a sort of Jacob's ladder between higher and lower planes.

As transmitted by Pythagoras and Plato, on the other hand, these successive emanations were expressed musically as overtones and undertones of each other and mathematically as multiples of each other. In combining math and music, this more abstract mode of expression not only avoided the pitfalls of literalism inherent in stories and personifications but did better justice to the cosmology. That is, the emanations are not really "successions" in time but octaves of reality generating each other only in the sense that one octave is a whole-number multiple of another—440, 880, or 1760

cycles per second, for example. Thus the multiple realities exist simultaneously and everywhere, intervibrating, so that everything and everybody is comprised of all octaves all the time.

In *Stalking the Wild Pendulum* (1977), engineer Itzak Bentov speculates brilliantly that successive emanations or octaves of reality could be created by means of what scientists today call "beat frequencies." That is, when a higher and a lower frequency intersect, their interference pattern creates a new frequency lower than either of the "parents." Thus any two adjacent frequencies could emanate a third, which could continue so propagating with still another until the subtlest reality were manifested in this way at the grossest level. Bentov proceeds to translate esoteric harmonics into modern harmonics, both represented by the oscillation of pendulums.

At any rate, it was that fusion of math and music that integrated the preliterate curriculum of antiquity. The world is very different now, and yet scientists speculating recently on the nature of the universe have begun to restore to math its earlier metaphysical function as the ultimate connector. If specialists in math, science, and music were willing to work with educators to explore the technical aspects of their disciplines within a framework of harmonics, once again construing math multidimensionally and humanistically, I feel that it would provide many leads toward creating a unified learning field.

Making math a humanity again comes down partly to restoring the overtones and undertones of number and measure. For the ancients, for example, numbers had qualities as well as quantities. Number one was wholeness, integrity, self-sufficiency, self-creation, divinity. Two was dichotomy, division, sexuality, and birth. Three was balance, unity across duality, mediation, and justice. As number one represented a point, two a line, and three a plane, four stood for volume, solidity, stability, and a pragmatic four-square orientation. Five combined the qualities of the numbers it summed—duality with trinity and quaternity with a new unity. (These were only some of the meanings of these numbers.) And so on, always extrapolating through resonance the quantitative traits of numbers into comparable qualities.

Things of the same quantity have similar qualities, no matter how otherwise unrelated. Think of the dynamics of threeness, whether the three items are vectors in a force field, participants in a discussion, or parties to an eclipse. Tracing the essential quality of

a number across different items or subjects can create a fascinating cluster of meanings. Seven seems to be a fundamental period, as in the musical scale, the colors in the visible spectrum, and the maximum number of electron shells around an atomic nucleus. Things turn over on the octave, which may be why seven dominates the *Book of Revelations.*

The Theology of Arithmetic, attributed to the Neoplatonist Iamblichus, develops at length in this way the resonance of each number up to ten, one at a time. In *Number and Time: Reflections Leading Toward a Unification of Depth Psychology and Physics* (1974), Marie-Louise von Franz parlays this approach into an astonishing synthesis of esoteric harmonics and numerology with atomic physics, math, myth, and psychology, among other fields of knowledge. If this book alone were translated into curriculum, we would have the education of the future insofar as the integration of disciplines is concerned. She certainly makes the esoteric metaphysic respectable in terms of modern thought and knowledge, but she goes farther than this in utilizing such a cosmic framework to explore all the interrelations of the physical and the psychic.

To acknowledge that numbers have qualities would open up math education in one direction it needs to go—toward recognizable human experience. So far schools have attempted to connect math to life by applying it to practical problems as in arithmetical, algebraic, and geometrical calculations. Youngsters must indeed learn these—far better in fact than they traditionally do. But children don't start learning something for adults' practical reasons; they need personal connections. They can learn the number relationships from such concrete experiences as working with different numbers of partners or building structures with varying numbers of sticks—if the *meanings* of numbers are made a learning issue. Quantifying will be better learned through association with qualities. The deeper nature of math that made it part of the humanities until the scientific-industrial age should be restored, on peril both of perpetuating the current mental block against math and of not utilizing its natural potential to unify learning.

Reason as Rhythm

Of course a central strategy of math is to relate two different forms or expressions as an equation, which is a special one-to-one ratio,

another way of laying one thing against another. Putting things in a ratio or an equivalence to each other constitutes so much of reasoning that the words *reason* and *ratio* stem from the same root—*ratio, rationis.* "To figure out" catches the connection between number and logic. The root idea of "reckon," underlying its double meaning of "to calculate" and "to reason," is "to bring together." And the etymology of both "reason" and "rhythm" reveals their kinship in the concept of *measure.* To "size up" something is to draw a conclusion about it.

But isn't this placing of things beside each other just what we also do when we make comparisons? Looking for similarity and difference results in the creation of categories or metaphors, in analogy, the logic of classification. Similarly, if inferring and syllogizing are ways of juxtaposing things so as to bring out their implications, then we may also regard the logic of propositions, tautology, as derived from the measuring of one thing against another. Thinking is relating, and the protoype of relating is the laying of one beat over against another to create a rhythm. This is the basic connection between math and music, the two most purely relational mental activities. Reason is rhythm.

For the ancients, ratio was not merely the fraction you get when two things are unequal. If things were not identical or equal, reason put them in relation by placing one over against the other, by measuring them against each other in the broadest sense. Humans deal with the bewildering pluralism of nature by matching and sorting things according to some private or public criteria about similarity and difference in form or function. Different objects mentally fitting the same quantitative or qualitative category, like statements saying the same thing in different ways, are equal or at least equivalent. Ratios are relations among things that do not match, that are not unitary, as symbolized by their being linked as a fraction. Far from negative, ratios make sure that everything is related to everything else despite differences. Ratios are rhythms—so much of this per so much of that. Reason is the great relater that harmonizes things across their differences by putting them in some rhythm to each other. It is therefore apt for dealing with the pluralism of creation, for making sense of it. In this fundamental meaning, ratio is not merely numerical nor reason merely formal.

True, it is reason itself that fractionates the world in the first place by cutting it up into objects not existing in the original unity of nature. But it balances this differentiation by integration, analysis

by synthesis. At the very moment of sorting and matching, the mind is already relating—rebuilding—by virtue of the very system of categories and knowledge structures by which the sorting is carried out. Perhaps all building is rebuilding an underlying unity that for utilitarian purposes people have to dismantle to deal with. This concurrent tearing down and rebuilding compares to the processes of catabolism and anabolism that together make up metabolism.

As Plato said that the soul of the world is built on basic ratios (corresponding to the intervals of the octave, the fifth, the fourth, and the whole tone), scientists today tell us that reality is best understood as variations in frequency. A frequency is a ratio laying time against space—for every second, so many vibrations. At a low enough frequency, energy becomes matter. When you get to the bottom of things, *things* aren't there any more. All is relational. So the rhythmic view holds well for matter as well as for thought. The ultimate definition of reason—as rhythm—may base itself on a resonance between mind and matter, on the infinite connectedness of nature that mind, as a part of nature, discovers as it rebuilds nature within. (Part 1 of *Number and Time* (1974) is titled "Number Is the Common Ordering Factor of Psyche and Matter.")

Curiously, then, the generic, structural nature of mathematical language not only makes it continuous with everyday language but also makes it akin to the nonverbal arts and in fact to the rhythms of life itself, from the pulsations of blood and breath to the whirring and wheeling of stars and atoms. Perhaps abstraction does not remove us so far from life as first appears—something students should be learning over and over through myriad examples of the patterning that characterizes both thought and art.

Thinking as Making

Discursive learning should not be elevated above or otherwise separated from the learning of arts, crafts, and vocational skills, all of which require and develop the human functions we call thinking. However much we may not understand about thought—and may never understand—we can readily observe that it develops in coordination with eye, hand, ear, and other physical faculties. It is as if thinking occurs not just in the brain but across neural networks connecting the brain to other parts of the nervous system, which generally operates in holistic fashion. Furthermore, artistic and

practical endeavors give people motives to think and other authentic circumstances in which to practice using their minds. This realism would of course be a major reason for organizing curriculum around projects.

The very notion of thinking seems grounded on making something, on *growth,* by analogy with a seed running its course from latency to fruition. Thus we speak of the ramifications (branchage) of an idea (germ of an idea). Above all, logic makes the "implicit" "explicit," terms whose etymology also reveals a growth model of unfolding. Likewise, in formal logic we deduce propositions from premises via syllogisms, that is, by chains of "if . . . then." Entailment is the key. As with the coded molecules of DNA, nothing is in the conclusions that is not in the premises. From all this we get an impression that thinking is constructing—building knowledge chains and structures step by step—to eventually cast a minimal idea into other *forms* that bring out its heretofore hidden potentialities.

But it is clear that many mental constructions, including those regarded as most creative in both the arts and sciences, occur, so far as we are able to observe them, in a single stroke. In fact, we want to call these "strokes of genius" or "moments of revelation." More soberly, we contrast this instantaneous, spontaneous production with deliberate, chain thinking and cast them into a dichotomy of intuition versus intellection.

But maybe the two processes differ only in their speed and visibility. If the chain that makes what is implicit explicit is buried or shortcut, we know only the conclusion, the product at the moment of manifestation. In other words, this highly touted distinction between inspiration and reason may be just another form of ignorance. Beethoven's notebooks indicate much revision and gradual construction, whereas Mozart seems often to have composed straight off, but the products were of the same sort and quality. Whether the composition be verbal, musical, mathematical, or physical, developing a theme or motif—which is nothing less than parlaying something given into something novel—should probably be acknowledged as thinking, without regard for how rapidly or overtly the psychological process occurs.

Suppose then, especially in view of the inconclusiveness of research on thinking, we treat thinking, for learning purposes, as mental building. This would allow us to talk in the same breath,

without prejudice, about construing a text and constructing a physical apparatus, since both require "making something out of" some givens. Comprehending and composing mean literally "taking together" and "placing together," which tells us that making sense of something is very close to making something. Thinking and making both consist of putting one thing against another. In *Man the Musician* (1973), volume 2 of *Sound and Symbol,* Victor Zuckerkandl argues, as part of his case for *homo musicus,* that mathematical and musical thinking are making, because they make their own materials, just, he says, as God's thoughts are His creations.

Again, the things themselves about which we think, resemble the thinking. That is, the material reality that math, say, seems to remove us from is actually endlessly and essentially rhythmic, like thought itself. Consider the cycles in individual behavior and in history that syncopate and counterpoint each other. Or the interplaying periodicities of heavenly bodies. At the subatomic level, all matter is vibrational, not particulate. All the phenomena of physics studied separately in school—sound, light, electricity, and the various kinds of human-made and natural radiation—fall along a single frequency spectrum. The most fundamental aspects of any material subject in society and nature are its rhythms.

Rhythm, like reason, is the great relator, the most common denominator, the ultimate medium of exchange. However different otherwise, languages and subjects share it, verbal and nonverbal exchange occurs through it, and art and life meet in it. If some universal force is to integrate learning, then we want a rhythmic curriculum.

Learning as Attunement

Let's shift focus from the rhythm of knowledge to the rhythm of the knower, who is vibrating like the rest of nature. Direct knowledge of things means knowledge unmediated by discourse or by culture in any other form. Its impact is not consecutive but simultaneous. The effect is saturation, as in the expression "to be imbued" with something.

We can get some idea of such knowing from children in the first two or three years of life, before language and other socialization have substantially structured their consciousness. Not having con-

ceptualized much of the world yet, and not yet very proficient at verbalizing, they rely on attunement to know what's up.

Tuning into other people and the environment works better the less distinct we feel from them. Being "open" or "receptive" really depends on the absence of boundaries, which inevitably become partial barriers. The small child does not distinguish much between self and world and indeed, until an ego structure forms to negotiate with the world, will have little of the sense of selfhood that older people are familar with. Inseparable from this ego structure arises a knowledge structure about the world and oneself that is necessarily partial but also somewhat obstinate. Preschool children learn fast because there's little to block their exchanging with the material and social environments. They get to know things by identifying with them and attuning to them.

Sometimes we say that people pick up knowledge by osmosis. This is a good metaphor, because osmosis depends on highly permeable membranes that permit fluids to pass easily in and out. Adults can sometimes learn nearly as rapidly as tots when in states and circumstances resembling those of infancy. Nothing is more important for future education than to understand what these may be. Identifying with other people and with nature certainly is a chief condition. When boundaries dissolve and defenses lower, attunement begins. How does this occur?

Well, we all begin life by identifying with the world and can regain this condition to the extent we can suspend our ego and the culture it is bound up with. This may happen at moments of extreme excitement or of unusual quietude. At both times we slip boundaries and are "transported." Where? "Beside" ourselves. But these are extremes, as in infancy. How about in daily life? Any time we focus intensely on some thing or activity, we approach this state. Hot motivation requires that the ego be willing to suspend itself somewhat for the sake of fulfilling its own will. This is how very determined adults can learn fast. They will submit to a tyrannical guru, forget what they thought they knew, quit defending themselves, identify more broadly than usual, or do anything else it takes to reach an intensely desired goal. They open up and get out of themselves. They become as a child.

If education enables people to identify broadly, minimize defensive egoism, and yet find things they want to do for intense personal reasons, this aids people enormously to develop or regain

attunement. For contrast, consider traditional schooling, where children stay on guard against both staff and classmates, rarely decide what they do, and actually learn to tune *out* in order to insulate the self from all the impertinent institutionalism. The same three *i*'s that best further other sorts of learning—individualization, interaction, and integration—will also create the ground conditions for attunement. Plenty of warm human relations, of diverse nonverbal experience, of opportunities to connect all around, and of practice in making decisions will set the stage for learning by attuning while serving all sorts of other purposes. But they set necessary, not sufficient conditions.

It's no good to romanticize infancy. Preschoolers learn fast, but they may learn some awful things that will haunt them the rest of their lives. Precisely because they are so open and undefensive, they get indiscriminately imprinted by whatever happens around them, often indelibly as well. They absorb stimuli deep in, with virtually no screening, and connect these with little benefit yet of a developed knowledge structure. They telepathize without knowing it, so that they can't tell their minds from those of people around them. They obey, and disobey, unspoken commands. They imitate others unconsciously and as if the behavior were their own. In their trancelike state they are undergoing the equivalent of hypnosis but without having consented and without even being aware there is such a thing.

To avoid these disadvantages, the learner needs control and consciousness, a measure of which comes with increasing maturity and the normal growth of selfhood. But beyond this, schooling can do an enormous amount to facilitate attunement that does not usually occur in our culture without special education. Once beyond infancy, much depends on the refinement of the person. Someone not sensitive to certain signals will of course be unaware of the information they are beaming. Radio and television signals are passing through our bodies all the time without our "reading" them, because we are not sensitized to their frequencies. But it is difficult to know just how much people can learn by attunement because the "normal" range seems considerably lower than what many individuals are capable of.

Besides receptivity, good attunement requires keen sensory and kinesthetic perception, fine discrimination of ideas and imagination, a subtilized sensibility, and a higher consciousness. Many things in

our society work against these, from bad eating habits and crude entertainment to gross values and heavy vibes. A refined person in this sense is not an easily hurt hothouse plant but a fine-tuned human organism capable of sending and receiving across the maximum frequency spectrum. Furthermore, because they are highly aware, such people can tune in and out of things at will.

We attune to what deeply interests us, to people or surroundings we spend much time with, to animals or materials we work or play with, to activities we observe or participate in. Typically, individuals are acute about some things and obtuse about other things. Any of these could be good or bad. Public education should not choose what students attune to but should create maximum access to other people, things, and environments. Influenced by plentiful interaction with others, individuals have to choose. But this education has to include practices in concentration and control of attunement that may sensitize everybody to everything. Nothing could be more apt here than making and hearing music, singing and dancing, which should be a daily part of school life.

The nervous system has to be quickened and sharpened and the body in general purified. What people eat, and how much, directly affect their sensitivity and receptivity. Foods vary in how toxic they are, how much they clog the cells, how assimilable they are, how long they linger in the body, and how much they affect glands. Waste removal is critical in purification and relates to the other key physical factor—activity. Some activities just build muscles, some circulate air and blood, some flush out the body, and some stimulate or balance glands. Because they secrete and regulate, glands affect many functions, including the electrochemical tuning of the body that in turn influences sensory, emotional, and psychic attunement. Physical education of the future would address not only health and skill but the capacity of the organism as an instrument of knowing.

The physical state is part of the overall state on which the capacity for direct knowledge depends. It interacts with the state of mind and consciousness. All fluctuate, partly according to focus, which is the key to attunement. Attention and concentration play paramount roles in learning of all sorts, including discursive. There's no question about it, sustaining focus makes things happen that don't otherwise—from logical culminations and intuitive leaps to breakthroughs in musical or athletic ability. When we dwell on or dwell in something exclusively for some time, we lose ourselves and

take on some of the nature of that object, activity, or setting. In mechanical harmonics, when one thing—a pendulum, say—starts to move in time with some rhythm already established nearby, that's called entrainment. The thing is carried along or away by the activity. Likewise we start to resonate with what we're engaged with. That is attunement. Through it we come to know the object of our focus.

To focus, one must beam on one thing and let the rest fall away. Highly motivated activities naturally involve just this, but today's urban environments distract and jangle attention. Schools can try to arrange settings for concentration and practice in focusing. The Montessori schools set aside time for individuals to become rapt in some task, and many teachers are showing their youngsters how to get quiet, relax their bodies, empty their minds, and concentrate inwardly on some chosen image or idea. Preschool children who spent fifteen to twenty percent of their time "staring," reported Burton White (1975), were rated later in school as the brightest, happiest, and most charming. This staring is a natural form of meditation that may be directed inward or outward. The famous Professor Louis Agassiz of Harvard made his biology students gaze fixedly at a fish, say, until they virtually developed X-ray vision and could eventually see many things they couldn't at first. Focus may be fixed on objects or ideas, or on nothing.

Regularly quieting both body and mind allows the ego to go off duty for a while and for a person to slow or suspend inner chatter and hence the customary self-concern and worldview. To become a good receiver, stop transmitting for a while. Long-range, this habit can carry over to the rest of one's routine. It fastens one's being so securely that going out of oneself is less threatening. At the same time, it reduces stimuli so one notices what was drowned out before, like a faint instrument when the rest of the orchestra suddenly cuts off. So it is that apparently withdrawing from the world brings us closer to it. The best education would teach how to shift and hold attention either inside or outside and eventually how to remerge with the world at will. In an essay in *Coming on Center,* "Writing, Inner Speech, and Meditation" (Moffett, 1988), I have written more about some of these processes of attunement.

Such means of achieving direct knowledge, or gnosis, have long been regarded as spiritual discipline. Through attunement, knower and known become like one. Spirituality is wholeness, the reinte-

grating of the pluralism of the world into the primal unity underlying its differences. To attune is to let go of some individual differences long enough to experience the outside as the inside—and the inside as the outside. It thus risks identity but only to the extent one is unsure of one's own integrity. Centering practices can build self-esteem by consolidating the sense of self in independence of environment. The same activities that help one "get it together" for oneself also help us experience other things and other people the way we experience ourselves. Learning to know directly, to attune, naturally develops spirituality also, without rites and sermons.

Two main views of knowledge have vied for predominance in education since antiquity. According to the empirical mode, knowledge derives from material experience ordered by reason, as typified by investigative inquiry. According to the gnostic mode, knowledge comes from making ourselves consonant with what we want to know, since we and the world are related as undertones and overtones. These two views derive from differing assumptions about the relation of human nature to nature at large. In this respect, epistemology becomes metaphysical.

Our highly individualized modern consciousness inclines toward the empirical because it feels cut off from nature and so assumes that nature has "secrets" that have to be "wrested" from it by pursuing even farther the course of objectification that originally separated mind from matter. This means piecing together reality bit by bit through experimentation and inductive/deductive reasoning. In the meditative view, people may learn by resonance, by going into themselves in order to tune into things outside. This way of knowing assumes an underlying unity across nature that includes correspondences between inner and outer, mind and matter. These permit attunements between human nature and the rest of nature. If everything is consubstantial, the All is knowable through direct and total revelation in the instantaneous way attributed to intuition or inspiration, whereas the experiential learning by sense and reason slowly reunifies the world through successive approximations.

But educators don't have to resolve this metaphysical issue. They can plan for both empirical and gnostic knowing. Whether we are building the world on our own authority or rebuilding the long lost One, we do not need at once to know. We know that knowledge comes

sometimes slow and partial, sometimes swift and whole. If we plan for youngsters to figure out the world, and at the same time to attune themselves to it, we can hardly go wrong. If nature is vibrant, and reason resonant, both modes can interplay in a single harmonic learning field.