

CHAPTER 1

CURRICULUM DESIGN

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Now let us consider the idea of *curriculum design*. As indicated by the definitions at the beginning of this book, the term “design” is used as a verb to designate a process (as in “designing a curriculum”), or as a noun to denote a particular plan resulting from a design process (as in “a curriculum design”). Never mind that a curriculum is not a garden or a bridge or a traffic pattern; our purpose in this chapter is to see how things play out when we apply the design practices of architects and engineers to the creation of new curricula. And, for the moment, let us put aside the question of precisely what a curriculum is (a matter to be taken up at the beginning of the next chapter), since the *process* of curriculum design can be explored without first having agreement on a precise definition of curriculum.

The purpose of this chapter is to explore ideas, not to provide detailed step-by-step instructions on how to create an actual curriculum design, let alone an actual curriculum. It is as though, by way of analogy, the chapter deals with how general design principles may seem to apply to designing any kind of buildings, but not to how to produce detailed engineering plans for use in constructing actual buildings. To make the argument easy to follow, the chapter parallels the Prologue section by section.

AN INTRODUCTORY EXAMPLE

This time, instead of the backyard garden of the Prologue, our desired end is an effective K-12 curriculum. Our approach need not be altogether orderly, but we would surely do these things:

- We would become gradually clearer on why we want a new curriculum. To have students—some students? all students?—learn more than they learn now? How much more? Learn different things? And which things? To respond to national standards or international comparisons? To raise SAT scores? How far? To increase attendance and the graduation rates? To have more graduates enter college? Certain colleges? To respond to criticism from teachers? Students? Parents? The community? State authorities? All such criticisms, or only some? Which? What if some of our intentions conflict with others?
- And what would get in the way of creating a new curriculum? Teacher, student, parental, or community resistance? Tradition? State laws? Lack of funds? Absence of good evidence for the benefits of change?
- As our goals and constraints become clear, we would identify some alternative design concepts to focus our thinking on curriculum possibilities. A design concept for a curriculum could be to organize instruction around inquiry at every grade level and in every subject, or focus strongly on community issues, or integrate the sciences and humanities, or emphasize the development of lifelong learning skills. On the chance of finding design concepts that may not have occurred to us in the beginning, we would study the curriculum literature, search the Internet, talk to school and university educators who have been involved in curriculum design, and look at curricula in other districts.
- We would narrow the possibilities down to a few appealing design ideas that would work within the design constraints we face, think over our desired goals, and choose an approach that would seem to be the best bet.
- Then we would develop that approach in enough detail to get started actually planning the curriculum. During this stage, trade-offs would have to be considered—a choice, for instance, between the desire to have students cover a large amount of material and to have them develop a deep and lasting understanding of what they study. Our design would describe the structure of the new curriculum, its content, and how it would be operated. In developing the final design, we would hope to call on expertise in curriculum design (books, journals, software, and consultants).
- As actual implementation of the curriculum design progresses, we would come up against unexpected difficulties, forcing us to modify the original design—or to choose an alternate design altogether.
- Even with the curriculum in place, the design challenge would not be over. Maybe the actual curriculum would not match the design very well because

mistakes were made in implementing the design. Or the curriculum would match the design quite closely, but we would not get the results we expected. In other words, we would discover or decide that modifications are needed, an eventuality we had anticipated and planned for.

This brief sketch obviously oversimplifies the process of curriculum design even as an ideal, and of course it does not pass muster as a description of what actually happens, if for no other reason than that total K-12 curriculum design is rarely undertaken. But perhaps it suffices to make our main point: the general principles of design used in other fields can apply as well to the design of curricula. On that premise, we now proceed to explore curriculum design in somewhat more detail.

ATTRIBUTES OF CURRICULUM DESIGN

If designing curricula is like designing any object, process, or system in important respects, it follows that it has these attributes:

Curriculum design is purposeful. It is not just to “have” a course of study. Its grand purpose is to improve student learning, but it may have other purposes as well. Whether the purposes are in harmony or in conflict, explicit or implied, immediate or long-range, political or technical, curriculum designers do well to be as clear as possible about what the real purposes are, so that they can respond accordingly.

Curriculum design is deliberate. To be effective, curriculum design must be a conscious planning effort. It is not casual, nor is it the sum total of lots of different changes being made in the curriculum over weeks, months, and years. It involves using an explicit process that identifies clearly what will be done, by whom, and when.

Curriculum design is creative. Curriculum design is not a neatly defined procedure that can be pursued in a rigorous series of steps. At every stage of curriculum design there are opportunities for innovative thinking, novel concepts, and invention to be introduced. Good curriculum design is at once systematic and creative—feet-on-the-ground and head-in-the-clouds.

Curriculum design operates on many levels. Design decisions at one level must be compatible with those at the other levels. A middle-school curriculum design that is

A Project 2061 Glossary for Curriculum Design

Curriculum: An actual sequence of instructional blocks operating in a school. The sequence may cover all grades and subjects (a K-12 curriculum) or some grades and subjects (a middle school science curriculum), and be intended for all students (a core curriculum) or only some students (a college-preparatory curriculum).

Curriculum Block: A major component of instruction—from six weeks to several years in duration—that receives separate recognition on student transcripts. Important features of blocks include prerequisites, alignment with benchmarks, and evidence of instruction credibility.

Curriculum Concept: An idea that expresses the character of a curriculum design at a succinct, abstract level. Such concepts—usually only from a few sentences to a few paragraphs in length, and perhaps addressing very few aspects of the design—help to focus the design work.

Curriculum Design: A proposed organization of particular instructional blocks over time, with instructions for how to navigate among them. Designs—usually described in a few pages—can be invented de novo, elaborated from a curriculum concept, or distilled from an operating curriculum.

Curriculum Specifications: A delineation of the goals and constraints to be taken into account in designing a curriculum.

incompatible with the elementary- and high-school designs will almost certainly result in a defective K-12 curriculum, no matter how good each part is on its own. By the same token, the middle-school curriculum itself cannot be effective as a whole unless the designs of its grades are in harmony.

Curriculum design requires compromises. The challenge is to come up with a curriculum that works well—perfection is not its aim. In developing a design that meets complex specifications, trade-offs inevitably have to be made among benefits, costs, constraints, and risks. No matter how systematic the planning or how inventive the thinking, curriculum designs always end up not being everything that everyone would want.

Curriculum designs can fail. There are many ways in which curriculum designs can fail to operate successfully. A design can fail because one or more of its components fail or because the components do not work well together. Or, the people who have to carry it out may reject the design because they misunderstand it or find it distasteful. In most cases, however, curriculum designs are neither wholly satisfactory nor abject failures. Indeed, a key element in curriculum design is to provide for continuous correction and improvement, both during the design process and afterward.

Curriculum design has stages. Curriculum design is a systematic way of going about planning instruction, even though it does not consist of some inflexible set of steps to be followed in strict order. Curriculum decisions made at one stage are not independent of decisions made at other stages, and so the curriculum-design process tends to be iterative, various stages being returned to for reconsideration and possible modification. But recognizing the different tasks and problems at each stage is important in making the process work. The stages, which are considered in turn in the rest of this chapter, are establishing curriculum-design specifications; conceptualizing a curriculum design; developing a curriculum design; and refining a curriculum design.

ESTABLISHING CURRICULUM-DESIGN SPECIFICATIONS

In the fine arts, some creative work can be purely expressive, whatever the artist feels like doing at the moment. Design, though it can be equally creative, is undertaken in a context of purposes—or goals—and constraints. (Even in the fine arts, paintings, songs, and novels usually are more or less designed, not free expressions.) Indeed, some accounts of

In simple situations, designs can be “optimized” to give the best possible outcome on some single variable. But this is a design luxury. In complex situations, it may not be possible to arrive at any design that does better than marginally satisfy all the specifications. The best possible design may not fit any of the specifications well, but attempt only to distribute advantages and shortcomings equitably among all of them.

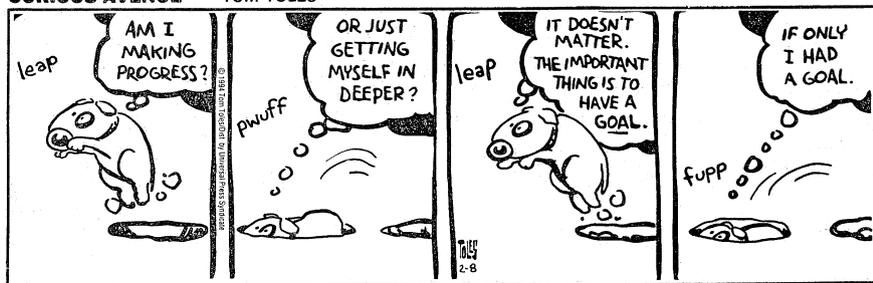
the design process begin with the design “problem”—a situation involving something that needs to be accomplished with limited means to accomplish it. Goals are the features of a design situation that we desire. If we are not sure what they are, we may not know whether we will be able to accomplish them or not. Constraints are features of the design situation that we cannot avoid. Some will be physical, some financial, some political or legal. If we try to ignore them, they will sooner or later assert themselves—the bridge will collapse, the client will decline to pay, picket lines will be set up, or the sheriff will arrive. Ignoring constraints in curriculum design may eventually have the result that the teacher union will go on strike, the community will replace the school board, or the state will take over the schools. The success of a curriculum-design process will depend heavily on how clearly its goals are laid out and its constraints are recognized.

Curriculum Goals

The purposes of elementary and secondary education are many. Schooling is expected to foster healthy, socially responsible behavior among young people on their way to adulthood. A modern school system is expected to prepare students for citizenship, for work, and for coping with everyday life, even as it fosters universal literacy and encourages the development of each student’s particular interests and talents, whether academic, artistic, athletic, or any other. Accordingly, a lot is expected of a curriculum. Moreover, schools have design considerations—custodial, medical, safety, economic—that are only marginally related to the curriculum as such.

For the curriculum design being considered in this book, the basic “problem” is to produce science-literate citizens within the limited time and resources that society is willing to provide for the purpose. Moreover, the scope of possible solutions is taken to be limited to what can be done in formal schooling.

CURIOUS AVENUE TOM TOLES



In describing a curriculum, whether existing or proposed, the first requirement is that its purposes—*what it is supposed to achieve*—be made clear. Although schooling in general has many purposes, the curriculum is the school district’s main instrument for promoting the learning of specified knowledge, skills, and attitudes. Curriculum goals

are thus essentially *learning goals*. Strictly speaking, goals are not part of a curriculum—the goals are the ends, while the curriculum is the means—and it is important that the two not be confused. A common example of confusing means with ends is treating “hands-on” activities as curriculum goals in their own right, rather than as one possible means to achieve well-specified learning goals.

To make headway in curriculum design, however, it is necessary to concentrate intensely on the issue of learning goals, identifying those that are credible and usable. To do this properly requires dealing with difficult questions involving what may be termed *investment* (what does it cost in time and other resources to come up with a coherent set of learning goals?); *rationale* (what is the basis for particular sets of goals?); *specificity* (how detailed do the goals have to be?); and *feasibility* (what will students be able to learn?). Wrestling with these questions is worth the time it takes because it will help everyone involved focus on fundamental issues at the very beginning of the effort and maybe even save time in the long run. This section elaborates briefly on the general consideration of the goals discussed in the Prologue, emphasizing some of the particular issues involved in identifying learning goals.

Investment. The process of getting from broad generalizations to grade-level specifics is enormously difficult and time-consuming—at least if it is to be carried out well. It took three years, the direct participation of hundreds of scientists and educators, and multiple levels of review by still other scientists and educators to produce *Science for All Americans*. It took another four years and even more individuals and institutions to transform those adult literacy goals into the grade-level learning goals presented in *Benchmarks for Science Literacy*. The National Academy of Sciences, which was able to draw on *Benchmarks*, took over three years to produce *National Science Education Standards* (which includes other recommendations as well as learning goals). Many states have also invested months and years in creating curriculum frameworks, often basing their work on the national-level formulations of specific learning goals (though with varying degrees of precision). A decade of experience has shown that the meticulous specification of valid learning goals is far different from and vastly more difficult than merely creating one more list of topics to be studied.

These observations are not meant to discourage school districts from specifying what they want a new curriculum to accomplish. Trying to design or redesign a curriculum without clarifying one’s goals is folly, for it leaves a district without a clear basis for making design decisions. The familiarity with goals that comes from clarifying each one of them is a significant advantage when the time comes to choose

FROM TYLER TO BENCHMARKS

The standard advice on curriculum development was formulated in *Basic Principles of Curriculum and Instruction*, a short 1950 book by University of Chicago professor Ralph W. Tyler. With engaging logic, Tyler asked four fundamental questions:

- What educational **purposes** should the school seek to attain?
- What educational **experiences** are likely to attain these purposes?
- How can these educational experiences be effectively **organized**?
- How can we **assess** whether these purposes are being attained?

The Project 2061 plans for redesigning the curriculum are fairly close to this classical formulation. According to Tyler, **purposes** should be derived from the needs and interests of *learners*, features of *contemporary life* (outside the school), and what *subject disciplines* have to offer (to students outside of specialties). This overly large set of possible purposes so derived would then be screened by *philosophy of education* and *psychology of learning*. Philosophy would settle questions such as what values are essential to a satisfying and effective life, whether there should be a different education for “different classes of society,” and whether efforts should be aimed at the general education of the citizen or at specific vocational preparation. Psychology would settle questions about whether something could be learned at all, at what age it might best be learned, how long it might take, what multiple purposes might be served by the same learning experiences, and how emphasizing relationships among purposes might lend greater coherence to learning.

Although some curriculum theorists since Tyler have doubted that goals are a good place to begin (or even that they are helpful), their objections seem to be based largely on the difficulty of the task.

The Project 2061 goal specifications in *Science for All Americans* and *Benchmarks for Science Literacy* allow curriculum planners to move directly to the even more formidable task of determining how to achieve these goals. Nonetheless, readers are advised to study what the benchmarks specifically say and what implications they have for materials, instruction, and assessment. Mechanical use of unstudied goals, however good they are, will be unlikely to produce good curriculum. *Designs for Science Literacy* focuses chiefly on the organization of the curriculum, assuming that appropriate educational purposes, experiences, and assessment are in place.



Project 2061 focuses on a basic core of knowledge and skill for all students. The project is convinced that the basic core so constructed will provide the best foundation for more students to study science even further.

curriculum materials or assessments. And local adaptation of particular goals is more successful when their intent is clear. Moreover, the sense of ownership that develops from the effort to define goals may have important motivational benefits in the hard work that will follow. Clarification, however, does not require starting from scratch.

The popular precept that “all stakeholders should have a hand in setting goals” sometimes is interpreted to mean that goals should actually be formulated locally. But in truth, most school districts simply lack the time and financial resources to do a credible job of creating goals on their own, whereas national groups—and to a lesser degree, state groups—have both. Limited local resources are better employed in modifying already credible sets of goals than in trying to do the work all over again. Moreover, given the mobility of today’s U.S. population, it is desirable that local education meets at least basic standards that prepare youth for success anywhere, a scope not ensured by an intense focus on local concerns.

School-district curriculum designers should therefore draw heavily on the work done by national and state groups, and even consider adopting such recommendations in their entirety. The design team should study the recommendations of those groups carefully, making sure they understand the recommendations and the premises underlying them. Then the team can decide whether to adopt them as they are, adopt them with modifications, or do the job themselves. But they should keep in mind that the credibility of a set of goals rests in some large measure on the perceived competence of those who formulated them and on the care that went into their formulation.

Rationale. Whether goals are created locally or drawn from external sources, their credibility depends partly on the rationale offered for the entire set of goals. For example, the rationale used in arriving at the learning goals recommended in *Science for All Americans* was that meeting those goals would benefit graduates by:

- Improving their long-term employment prospects, along with the quality of the nation’s workforce, and providing a base for some students to go on to specialize in science, mathematics, or technology or in related fields.
- Assisting them in making personal, social, and political decisions.
- Acquainting them with ideas that are so significant in the history of ideas or so pervasive in our culture as to be necessary for understanding that history and culture.
- Enabling them to ponder the enduring questions of human existence, such as life and death, perception and reality, individual good versus the collective welfare, certainty and doubt.

- Enhancing the experiences of their student years, a time in life that is important in its own right.

Of course, that is not the only possible rationale for the selection of learning goals. Often, only economic or civic purposes are emphasized. And sometimes educators include such purposes as helping students to score well on crucial examinations, secure employment, or qualify for admission to college; fostering general study habits that have lifelong value; or producing graduates with the knowledge and skills that educated adults have had in the past. Some goals may focus not on long-term ends but on short-term means such as lowering the dropout rate or improving the image of the community. Whatever there is to be said for each of these, the only point here is that the rationale for curriculum learning goals ought to consist of a statement of purposes to be served.

Establishing a clear rationale fosters a more thoughtful process of goal selection than arguing each proposed goal *ad hoc*. First, it requires a discussion of how, in principle, goals will be decided. Second, it limits the kinds of arguments that can be made in behalf of a particular goal. Even so, there is not a strict deductive logic linking a proposed goal to one or more rationale statements. Rather, requiring that justification be referenced to an explicit rationale promotes healthful debate by requiring curriculum designers to defend a claim for adopting a particular goal by completing “Everyone should learn this because...” using certain kinds of arguments and not others. A familiar argument that would not pass muster according to the Project 2061 rationale is “Because that is what I had when I was in school and I loved (or hated) it.”

Specificity. Expressing curriculum goals in terms of what is to be learned turns out not to be as simple as one might expect. Leaving aside the matter of how to go about deciding on curriculum goals, there is the question of what kind of language to use in characterizing the knowledge and skills that are intended to be acquired, and there is also the question of how specific to be in stating those goals. The greater the grade span of the curriculum, the more difficult it becomes to answer these questions, since the language and specificity appropriate to one level may not be suitable for another. Learning goals can be expressed at many different levels, ranging from very general propositions to very specific ones. The Project 2061 experience in specifying goals provides an example:

The desire for *science literacy for all citizens* led to the general goal that *all students* should be well educated in science, mathematics, and technology by the time they leave their common schooling. This in turn led to agreement on *five criteria* for identifying specific learning goals in science, mathematics, and technology:

utility, social responsibility, intrinsic value of knowledge, philosophical value, and childhood enrichment. Based on these criteria, *Science for All Americans* recommends 65 major learning goals to be reached by all students by the time they graduate from high school. Finally, several hundred specifications, listed in *Benchmarks for Science Literacy*, describe what students should know and be able to do in science, mathematics, and technology by the end of grades 2, 5, 8, and 12.

How far down the specificity ladder to go in framing goals depends in part on how easily a working consensus can be reached among all of those responsible for setting them. Usually, agreement is relatively easy on very general goals and becomes harder as the goals become more specific, if for no reason other than their greater number and their greater demand on technical knowledge. The process should start as general as is necessary and should persistently work toward consensus on sets of specific goals.

Examples of how learning goals have been formulated are to be found in the various national education-standards reports published in recent years. The only explicit discussion of the *language of curriculum goals* in any of them, however, is to be found in *Benchmarks for Science Literacy*. (See sections Characterizing Knowledge and Grain Size from CHAPTER 14: Issues and Language of that publication.) The two-page diagram that follows shows a hierarchy of science literacy goals selected from *Science for All Americans* and *Benchmarks*.

Apart from questions of what level of specificity of learning goals is most useful for purposes of curriculum design, there are questions of what format to use to specify learning goals. A common approach is simply to list headings for topic areas—as general as “chemistry” or as specific as “pH,” with little clue as to what would actually be studied and learned under them. A more helpful approach is to express what is to be learned in statements of the knowledge and skills to be acquired by students—*Benchmarks for Science Literacy* and *National Science Education Standards (NSES)* being examples in science education. Another helpful approach is to express what is to be learned as descriptions of observable behaviors expected of students—the approach taken, for example, in the *National Standards for Arts Education*. Both statements and behavior formats have strengths and weaknesses that curriculum designers should become familiar with in deciding how best to articulate the learning goals that will be the focus of their work.

A still more detailed approach is to prescribe the exact assessment tasks and criteria for judging them (in a narrow sense, the exact examination questions and scoring scheme). An obvious weakness in adopting such an approach is that those specific tasks alone might determine the curriculum, neglecting students’ capacity to apply their knowledge and skill in new contexts.

“*Benchmarks* was faced with a more difficult language problem in trying to convey accurately what children in the lower grades should learn. It would not do just to match the children’s language exactly—*Benchmarks* is for educators, not students—yet to use the adult technical language of SFAA could encourage teaching it prematurely to children. The solution was to try to say in plain English what the quality of the learning should be and use technical terms only when it was time to make them part of a student’s permanent vocabulary.”
—*Benchmarks for Science Literacy*, p. 312

See the Bibliography at the end of this book for a list of all of the K-12 standards reports.

CURRENT ARGUMENTS ABOUT GOALS FOR LEARNING

Most everyone concerned with curriculum believes that students learn too little science. (Some educators would claim that students know even less than we think they do.) One approach to solving the problem is to set expectations for student learning higher and higher, in the hope that they will inspire or coerce teachers and students toward higher achievement. Often, this high-expectations approach not only applies to eventual achievement, but also involves pushing expectations to lower and lower grade levels. (For example, third graders may be assigned to study atoms, which is three years before the age when, according to extensive research on learning, children are first able to understand anything important about atoms.)

A different response to lack of student learning is to reduce the shallowness and confusion of an already unlearnably overstuffed curriculum, to make time for better learning of the most important facts, principles, and applications. To the higher-expectations proponents, this approach is “watering down” or “dumbing down” the curriculum. To the better-understanding advocates, the higher-expectations advocates are “elitists” who care mostly about preparing future scientists rather than making sure that all students achieve basic science literacy.

Although often overshadowed by partisan philosophical convictions, the debate requires some underlying facts. What are students currently learning in science? What could they learn under the best conditions? To what extent do expectations that are over students’ heads motivate them to learn more than they would otherwise? To what extent will unreachably high demands breed confusion, withdrawal, and learning less than before?

Better knowledge about these issues would help to locate the best trade-off between quantity and quality, to maximize student motivation and minimize confusion. It would be helpful if advocates of both approaches could cooperate on seeking empirical answers to these questions.

ORGANIZATION OF SCIENCE FOR ALL AMERICANS AND BENCHMARKS FOR SCIENCE LITERACY

Within Domains of Science, Mathematics, and Technology:

The learning goals in *Science for All Americans* and *Benchmarks for Science Literacy* share the same organizational structure, beginning with the three broad domains of science, mathematics, and technology. Within these domains, learning goals are distributed among 12 chapters, 65 sections within chapters, 250 topics within sections, and finally among more than 800 detailed benchmark statements within topics.

Chapter 1: The Nature of Science

- The Scientific World View
- Scientific Inquiry
- The Scientific Enterprise

Chapter 2: The Nature of Mathematics

- Patterns and Relationships
- Mathematics, Science, and Technology
- Mathematical Inquiry

Chapter 3: The Nature of Technology

- Technology and Science
- Design and Systems
- Issues in Technology

Chapter 4: The Physical Setting

- The Universe
- The Earth
- Processes That Shape the Earth
- Structure of Matter
- Energy Transformations
- Motion
- Forces of Nature

Chapter 5: The Living Environment

- Diversity of Life
- Heredity
- Cells
- Interdependence of Life
- Flow of Matter and Energy
- Evolution of Life

Chapter 6: The Human Organism

- Human Identity
- Human Development
- Basic Functions
- Learning
- Physical Health
- Mental Health

Chapter 7: Human Society

- Cultural Effects on Behavior
- Group Behavior
- Social Change
- Social Trade-Offs
- Political and Economic Systems
- Social Conflict
- Global Interdependence

Chapter 8: The Designed World

- Agriculture
- Materials and Manufacturing
- Energy Sources and Use
- Communication
- Information Processing
- Health Technology

Chapter 9: The Mathematical World

- Numbers
- Symbolic Relationships
- Shapes
- Uncertainty**
- Reasoning

Chapter 10: Historical Perspectives

- Displacing the Earth from the Center of the Universe
- Uniting the Heavens and Earth
- Relating Matter & Energy and Time & Space
- Extending Time
- Moving the Continents
- Understanding Fire
- Splitting the Atom
- Explaining the Diversity of Life
- Discovering Germs
- Harnessing Power

Chapter 11: Common Themes

- Systems
- Models
- Constancy and Change
- Scale

Chapter 12: Habits of Mind

- Values and Attitudes
- Computation and Estimation
- Manipulation and Observation
- Communication Skills
- Critical-Response Skills

**TOPIC/SEQUENCE
WITHIN A SECTION:**

sources of uncertainty
 probability
 estimating probability from data
 or theory
 counts versus proportions
 plots and alternative averages
 importance of variation and
 around average
 comparisons of proportions
 correlation versus causation
 learning about a whole from
 a part
 common sources of bias
 importance of sample size

BENCHMARKS:

K-2
 Often a person can find out
 about a group of things by
 studying just a few of them.

3-5
 A small part of something may
 be special in some way and not
 give an accurate picture of the
 whole. How much a portion of
 something can help to estimate
 what the whole is like depends
 on how the portion is chosen.

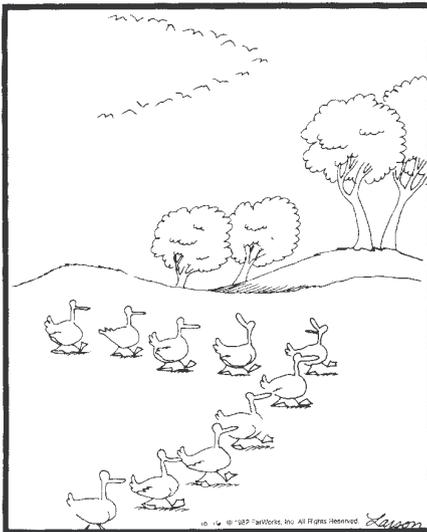
6-8
 The larger a well-chosen sample
 is, the more accurately it is likely
 to represent the whole. But
 there are many ways of choosing
 a sample that can make it
 unrepresentative of the whole.

9-12
 For a well-chosen sample, the
 size of the sample is much more
 important than the size of the
 population. To avoid intentional
 or unintentional bias, samples
 are usually selected by some
 random system.

Chapter 14 of *Benchmarks for Science Literacy* describes some of the issues related to language and “grain size” used to specify learning goals.

THE FAR SIDE

By GARY LARSON



“Say... Look what
THEY’RE doing.”

Still another approach is to conceive goals as what or how students should study—such as using certain books or works of art, or by employing a “discovery” method of instruction—rather than what students should end up knowing and being able to do. But whatever merits those propositions may have for instruction, they fall outside *Designs’* notion of goals for learning—that is, for what students will eventually know and be able to do.

Feasibility. No matter what resource, rationale, or format is used to solicit suggestions for curriculum goals, it is unlikely that all the goals suggested should be adopted. Almost certainly, there will be too many goals for students to achieve, especially if the main purpose is to design a basic core to be achieved by all students. Priorities must be set by considering what is feasible in the time available for teaching. There is little to be gained, and much to be lost, by expecting more of students than they can possibly learn. A few may be stretched to greater learning, but more will likely just give up or learn to complete assignments mechanically without understanding (or even expecting to understand). But the feasibility line can hardly be set just at levels known to be safely low, for expecting too little will inevitably result in too little learning.

On what basis can learning goals be identified that make sense developmentally as well as conceptually? Teachers and cognitive researchers are the two main sources of pertinent knowledge, as discussed in *Benchmarks for Science Literacy*, Chapter 15: The Research Base:

The presence of a topic at a grade level in current textbooks or curriculum guides is not reliable evidence that it can be learned meaningfully at that grade. For example, atoms and molecules sometimes appear in a 4th-grade science reader. Yet extensive research on how children learn about these ideas suggests postponement until at least 6th grade and perhaps until 8th grade for most students. [p. 327]

The single most important source of knowledge on student learning comes from thoughtful teachers. They have firsthand experience in helping students acquire science, mathematics, and technology knowledge and skills. Their input is limited, however, by the realities of the usual teaching situation. Teachers have little time to conduct careful assessments of student learning, lack instruments for assessing richly connected learning and higher-order thinking skills, and rarely have opportunities to compare their experiences with others who teach the same concepts and skills. [p. 327]

Researchers have the advantage of being able to work out a careful design, having time and other resources (including special training in research methods) that teachers seldom have, and undergoing systematic peer review... But research, too, has its limitations. [p. 328].

Evidence on learning from both teacher experience and research ought to be interpreted cautiously because it necessarily refers to today's students taught in today's schools by today's teachers. There are so many variables operating in the learning process—teacher and parent expectations, the learning environment, the methods and materials used, the previous knowledge and experience of individual learners, and more—that the failure of students to learn something currently leaves open the question of whether they could have done so if they had had ideal learning conditions from the beginning. [p. 329]

This account suggests that goal-setting groups should draw on the experience of teachers and the findings of research for guidance without expecting definitive answers. It also makes clear why defining goals is not something that can be done casually or quickly, and why it makes sense to depend on the work of those who have the time and resources to bring experienced teachers and knowledgeable researchers together with content specialists to examine the possibilities carefully.

Curriculum Constraints

The other side of setting curriculum-design specifications is identifying the constraints placed on what the design can be like. There are always constraints on design. They may take the form of what will not be permitted and what conditions must be taken into account. As with goals, constraints need to be made explicit if they are to influence curriculum design.

A major impediment to the attainment of curriculum goals is the lack of sufficient time for instruction—hours per day, days per year. In the history of modern education, curricula have been expected to serve more and more goals with few ever being eliminated. An honest acknowledgment of this limitation leads to a conflict among goals: Some goals need to be given up if others are to be met. There is a very real danger that when curriculum committees come up with a delineation of K-12 learning goals, whether their own or adopted, they will fail to purge previous goals that on examination they might find to have lower priority—acting, in other words, as though the time constraint were not real.

Along with time, public discomfort with certain topics (notably human reproduction and evolution) can be a barrier that must be dealt with in curriculum design. Some others are state policies, state and federal legislation, court orders, cost, faculty unpreparedness, lack of suitable instructional materials, standardized tests inadequately aligned to learning goals, college admission requirements, union contracts, and long-standing traditions. And above all, there is the limitation of not knowing enough about student learning—what students can and cannot learn under various circumstances.

What students should know about design constraints at each grade range:

K-2

People may not be able to actually make or do everything that they can design.

3-5

There is no perfect design. Designs that are best in one respect (safety or ease of use, for example) may be inferior in other ways (cost or appearance). Usually some features must be sacrificed to get others.

6-8

Design usually requires taking constraints into account. Some constraints, such as gravity or the properties of the materials to be used, are unavoidable. Other constraints, including economic, political, social, ethical, and aesthetic ones, limit choices.

9-12

In designing a device or process, thought should be given to how it will be manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it. The costs associated with these functions may introduce yet more constraints on the design.

—*Benchmarks for Science Literacy*,
pp. 49-52

A rush to accommodate perceived barriers by lowering one's sights should be resisted, however. After all, except for established physical laws, constraints are not necessarily forever. Laws can be changed, budgets raised, traditions recast over time. Curriculum designers should neither ignore constraints nor assume they are insurmountable, but they should try to identify them carefully.

As constraint issues come up at any stage in the design process, it is important to find out what latitude there may be for dealing with them. For example, university admission practices can be looked upon as an impediment to changing the college-preparatory component of the curriculum, for to make major changes may place at risk high-school graduates seeking university admission. But many universities are willing to consider modifying their admission criteria to accommodate school districts, or at least to collaborate with them in systematically trying out proposed changes and introducing them over time if all goes well. Indeed, claimed barriers to curriculum change may turn out to be more an excuse for inaction than a reality. Identifying constraints specifically—as in “We want X but are constrained by Y”—can help to focus a design argument, as in “Do we give up on X or try to eliminate Y?”

An especially frustrating kind of constraint is one that is locked in multiple ways into a system so no one part can change unless all the other parts change. Such a constraint is sometimes called a QWERTY effect after the first six letters on a standard keyboard, which was designed on a theory of typing that is now outmoded but still almost impossible to change because of the investment in equipment and training based on it.

Another example is the English measurement system, which some experts consider to be too woven into U.S. manufacturing to allow us to change to the metric system used almost everywhere else in the world.

Another mechanism for dealing with constraints is to build into the design a process for ameliorating them after the designed curriculum has been implemented. If, for instance, a school district lacks the technological capabilities called for by a proposed design, then instead of abandoning the design entirely, it may make sense to include a plan for technological modernization as part of the design, with an understanding that the new curriculum will be implemented in stages as the school district's technological capacity grows.

In short, as design proceeds, some adjustment of learning goals may become necessary to accommodate constraints that cannot be gotten around, just as some constraints can be modified. Clarifying the specifications for both goals and constraints throughout the entire design process raises the likelihood that the ends and means of the final design will be in accord.

CONCEPTUALIZING A CURRICULUM DESIGN

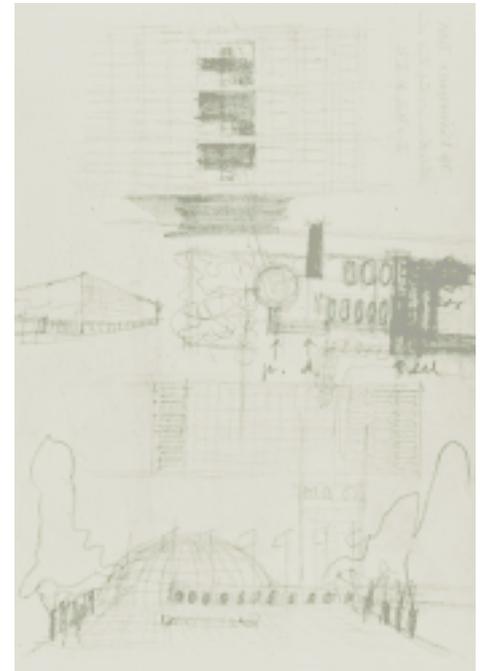
Some overarching idea about the curriculum is a starting place for the creation of a design concept. It may be impressionistic rather than definitive, but no less valuable for that. It provides a point of reference as alternative designs are debated and negotiated. The possibilities are endless, but a curriculum concept commonly includes the instructional contexts to be emphasized, the teaching methods to be used, and the resources to be exploited.

Design concepts can be expressed in a variety of ways—lists and other verbal descriptors, sketches, flow charts and other diagrams, physical models, or accounts of attractive precedents. In the case of a curriculum design, we need at least a brief statement that captures the character of what the new curriculum will be like—or at least articulates separately those few aspects that are deemed to be central.

As we saw in the Prologue, the United Nations governing board informed the architects of the United Nations headquarters in New York City that the new facility should “proclaim the dignity and significance of the infant organization, yet serve as a practical ‘workshop for peace,’ be international in spirit but still live in harmony with its surroundings, and point to the future rather than honor the past.” Such an overarching idea can serve as an inspirational design concept. It provides a point of reference as alternative design possibilities are debated. Similarly, in curriculum design, it makes sense to formulate an overarching idea or a small set of ideas. One way to think about such a statement is to imagine offering a brief answer to this question: What is the curriculum intended to be like?

Below are some examples of possible concepts, not necessarily mutually exclusive, for curricula. Although they promote a variety of goals, any one (or combination) of them would still have to aim also at achieving the agreed-upon set of specific learning goals. These examples of curriculum concepts are not offered as a complete set of categories, but only as a few interesting possibilities that could stand alone or be combined with one another.

- A **classics curriculum** that, in early grades, concentrates on preparing students to study in later grades the great writings, master paintings, musical compositions, grand structures, and scientific discoveries of the ages with increasing understanding and delight.
- A **community-centered curriculum** in which, at every grade level, students explore traditional subjects in relation to community needs and problems, with what constitutes “community” expanding over the years from a neighborhood to a global frame of reference.
- A **high-tech curriculum** that, from the first year on, exploits the power of state-of-the-art information and communications technologies so that all students can become proficient in finding, gathering, organizing, analyzing, and communicating information, which, in effect, would put them in a virtual classroom of worldwide learning.
- A **science and technology applications curriculum** in which all subjects are studied in the context of agriculture, materials and manufacturing, energy sources and use, information processing and communication, health, transportation, and other such general categories of human endeavor.



Architects considered 86 different design concepts for the United Nations Headquarters.

The United Nations Headquarters today.



CURRICULUM CONCEPTS

*After publication of Science for All Americans in 1989, teams of teachers, administrators, and curriculum specialists at Project 2061's six School-District Centers began work on unique curriculum concepts that would meet their own local requirements as well as national science literacy goals. They were encouraged to be as imaginative as possible, creating models of what a K-12 curriculum **could** look like. Their efforts resulted in some very different curriculum concepts. The teams have characterized their work in the following ways:*

San Antonio Center

This concept is well suited to urban or suburban school districts serving large numbers of students from ethnic and racial minorities. The goal of the concept is to provide all students with school-based experiences organized around the content described in *Science for All Americans* Chapter 8: The Designed World. Students will learn about key aspects of technology in the areas of agriculture, materials and manufacturing, energy, health technology, and communication/information processing. Blocks begin with interesting problems from these content areas and provide at least 16 opportunities for students to participate in designing a solution and/or creating an authentic product. Rather than being tied to specific grades, these opportunities will be designed for four different levels of content complexity and, within those, four different ranges of cognitive abilities.

In pursuing these goals, students will cycle through district learning centers that focus on different technological themes—attending each three times in the elementary-school, twice in the middle-school, and twice in the high-school years. By the junior year of high school, students may choose to continue their progress or begin to work on dual-credit Advanced Placement courses as they begin to shape their careers.

San Diego Center

This concept draws on the city's rich natural and public resources and the economic, cultural, and linguistic diversity of its communities. To provide equitable

access to all of the assets available throughout the district, the concept establishes eight regional Resource Centers where students from every community come together to learn. Each Center has a unique theme and focus, drawing on its own regional qualities and resources. Students visit each of the Centers at least once during each grade range.

The curriculum is assembled from a variety of curriculum blocks that have been embedded in the context of one of the Resource Centers. Blocks begin with questions about the world and how it works, and students use evidence to develop and/or evaluate scientific explanations. Through the study of various historical episodes, students learn more about the development of scientific knowledge from tentative hypotheses to rigorously tested theories.

Blocks for each grade range emphasize different, progressive categories of skills and ideas: exploration and discovery for K-2, concept development and research skills for 3-5, relating learning to personal and social issues for 6-8, and expanding perspectives to more global issues in 9-12. Because students spend extended periods of time (from days to weeks) at each of the Resource Centers, it is essential for blocks to integrate or connect with learning goals from the other disciplines. This concept also requires blocks to provide students with opportunities to explore a variety of career options and to meet some career requirements through applied learning experiences.

Philadelphia Center

Designed for a large urban school district with a majority of its students considered to be at the poverty level, this concept organizes learning goals into four major contexts—The Physical Setting, The Living Environment, The Human Organism, and The Designed World—based on *Science for All Americans*. Key characteristics of the concept also serve to describe criteria used to select curriculum blocks. For example, all blocks must reflect the spirit of inquiry, with several blocks at each grade range specifically addressing how scientists work through activities that emphasize problem solving, gathering/analyzing/interpreting data as evidence, controlling for bias, etc.

At each grade range, students explore a different approach to learning: *themes*

are emphasized at the elementary level, *issues* at the middle grades, and *case studies* at the high school level. Blocks featuring career-related experiences make up an increasingly greater proportion of the curriculum as students progress from elementary to middle to high school.

San Francisco Center

To respond to the compelling student question, “Why do we have to learn what you are teaching us?” this concept organizes the curriculum around purposeful and contextual learning experiences that are meaningful *from a student’s perspective*. All students engage in challenges where they investigate and respond to environmental and social issues, make decisions and solve problems of local and global concern, design and create products and performances, and inquire into “How do we know what we know?” Although challenges can be discipline-based, most challenge-based learning experiences maximize opportunities for students to make connections across disciplines.

To help students learn to think in a “systemic” way, the concept identifies four basic organizing systems—the individual, society, the natural living environment, or the physical universe—that can be used to create challenges that are appropriate to the student’s developmental level. Schoolwide challenge-based learning experiences make up only part of the school year, but this pedagogical approach permeates the teaching and learning throughout the educational program.

McFarland, Wisconsin Center

This concept is developed around the assumption that there are at least five behaviors that are inherently meaningful to human beings: stewardship, creativity, wonder, appreciation for the continuum of the human experience, and perseverance. These qualities are woven throughout the 52 projects that comprise the K-12 curriculum.

The curriculum blocks will be cross-disciplinary, open-ended units of instruction called *vistas*. They will be structured around nine thematic concepts that are based on continuing human concerns: food, water, energy, living organisms, shel-

ter/architecture, exploration, play, recreation, earth/sky, and communication. Each vista is designed to last at least nine weeks and includes multi-age bands of students who work together, learning through inquiry-based activities. Children will stay with the same teams of teachers for each band, allowing a community of learners to develop and grow together. When all 52 vistas are completed, a child will have encountered each benchmark at least twice.

Specific activities in the vistas change depending upon the readiness and abilities of the learners in a particular group. The concept includes a common core of learning for all students, along with time for individuals to follow their own special interests.

Georgia Center

The Georgia concept reflects the unique demands that rural communities (like the three rural counties that comprise the Center) make on schools and their resources. Because of the lack of other local facilities, the rural school is often at the heart of the community's cultural, social, and political activities. Rural students also bring different kinds of knowledge and experiences to school that are unlike those of students in an urban or suburban setting. For example, many children raised on farms come to school already having experienced a "living lab" at home. Even those not on farms often have more space within which to roam and experience nature firsthand. To reflect these unique characteristics, the Georgia concept is designed to help students learn benchmark ideas through "local" topics, including Raising Animals, Timelines, Weather Station, School Garden, Traffic, Where Do I Live?, Communications, Diversity and Independence, Energy, Environment and Human Presence, Evolution, Forces, Human Society and Me, Matter, Part/Whole, Scale, Waves, and Weather and Atmosphere. Many more such learning sequences will be needed to account for all the learning goals outlined in *Science for All Americans*.

- A **hands-on curriculum** in which instruction is largely organized around individual and group projects that favor active involvement over passive learning—in science, actual investigations over textbook study; in art, studio work over slide lectures on art history; in social studies, preparing reports on actual community problems; and so forth.
- A **language-immersion curriculum** in which a standard liberal-arts curriculum is invested with the development of language competence that facilitates the participation of Americans in global business and in cultural and scientific affairs.
- A **learning-to-learn curriculum** in which, in every subject and at every grade level, learning techniques are emphasized even more than the acquisition of given knowledge, guided independent study is featured as a way to develop these techniques through practice, and graduation is based on the student's showing competence as a self-learner.
- An **individualized curriculum** in which, in the upper grades, each student fashions—from a rich array of diverse offerings—a personal program of studies in collaboration with parents and guidance counselors, and in which graduation is predicated on the student's completing that program and passing examinations in prescribed subjects.
- A **work-study curriculum** in which academic studies are leavened with supervised real-work assignments in school (teaching, cafeteria, gardening, building maintenance, clerical, etc.), or in the community as volunteers (in nursing homes, parks, libraries, university and industrial laboratories, etc.), so that students develop good work skills and a commitment to community service, in addition to receiving a basic education.
- A **"vistas" curriculum** in which instruction is organized into a relatively few, interdisciplinary, cross-grade settings—such as a farming plot, a forest site, or community service operation—in which students participate several times, at different levels of sophistication, over their K-12 school careers.
- An **inquiry curriculum** in which, at every opportunity, study is motivated and organized by students' own questions and efforts to find answers themselves.
- An **environmental curriculum** that uses the description and operation of the physical and biological environment—and the social issues associated with them—as a focus for learning all subjects at every grade level.

In these few examples, each curriculum-design concept features only one or two aspects of a curriculum. Of course, a complete final design has to incorporate all aspects of the curriculum as a system, but the drive to create and promote a new curriculum commonly comes from an inspiring emphasis on just one or two of its

dimensions. In any case, after considering several possible curriculum concepts—there are always alternatives—one must be selected for development.

Judging from the language found in the education literature, the need for general characterizations is widely recognized. One trouble with such shorthand designators is that they are often no more than popular slogans of the day and only superficially characterize curricula. It may be hard to distinguish a curriculum claiming the banner of “hands-on,” “problem-solving,” or “back to basics,” from one that does not. Something more than a label is needed.

Still, it is not particularly helpful to have a long treatise on one’s philosophy of education, particularly since such statements tend to encompass political and instructional issues as well as curriculum, and often have a tenuous connection to the actual curriculum design. What stands to be most useful as a design concept is no more than a paragraph or two—more than a slogan, less than an essay—setting out the main ideas, themes, or features that help to make sense out of what might otherwise appear to be a hodgepodge, a curriculum without character or personality.

DEVELOPING A CURRICULUM DESIGN

Once progress has been made toward setting curriculum goals, identifying design constraints, and selecting a design concept, the main task of developing a full-fledged design can proceed. Curriculum design calls for making decisions on what the content and structure of a curriculum will be. Because the task is a complicated one, it is well for the school district’s curriculum-design team to consider what strategies it can use to facilitate the process.

Curriculum-Design Strategies

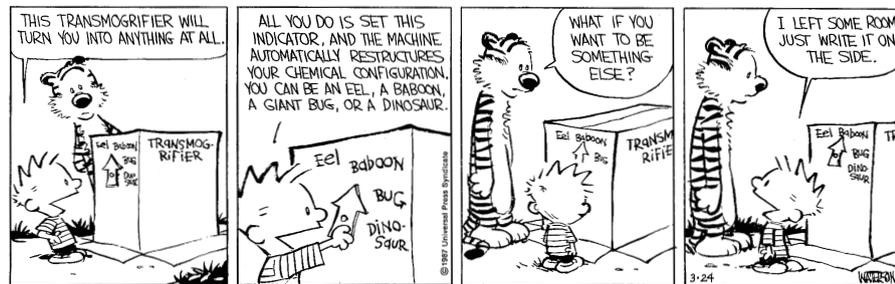
Developing a K-12 curriculum design is difficult because a curriculum is complex and because the tools available for creating one are few. Three basic strategies that can help include copying or modifying an existing design, compartmentalizing the design challenge by grade range or subject area to make design development manageable, and testing aspects of the emerging design in the development stage. Any combination of these strategies can be used.

Copying or modifying an existing design. To design a curriculum from scratch is possible, but difficult. Invention is hard and usually not necessary. Instead, it makes sense

for a curriculum-design team to look for an existing curriculum design that could be used to meet many, if not all, of the goal and constraint specifications. If the search is successful, the question then becomes whether to copy it as is or to modify some of its features. The problem with implementing this strategy is that although there are plenty of K-12 curricula in operation, there are virtually no adequate descriptions of them that can serve as designs to follow. (Prose about curriculum tends to be rhetorical rather than operational.) Chapter 4: Curriculum Blocks suggests the possibility of curriculum “models”—more than just design concepts, but much less detailed than complete designs—that would eventually be available to guide local design.

Calvin and Hobbes

by Bill Watterson



In the absence of adequate descriptions of curricula, an actual, operating K-12 curriculum can be studied to develop such a description. Using this approach, the curriculum-design team identifies another district’s curriculum that seems to be something like what it has in mind. The team studies that other district’s curriculum and student performance and perhaps visits its schools to interview teachers, administrators, board members, students, parents, and community leaders. If its own district is reasonably similar to the other district being studied, the team may decide to adopt the entire other curriculum or some of its properties. If, as a consequence of a series of such investigations, features are adopted from several different districts, the team will then need to reconcile them with one another. This will be a time-consuming activity but no different in principle from designing a new school building instead of a new curriculum. In fact, however, few districts are likely to undertake such an expensive and problematical effort.

Compartmentalizing the design challenge. A K-12 curriculum is a complex system. But such complexity can be dealt with by focusing on only those aspects of the curriculum that have to be designed afresh and by breaking the task into more manageable parts

and dividing the work among different subgroups of the design team. The obvious question is how best to compartmentalize the effort. It may not matter much if later steps are built into the process to ensure that the earlier parts get put back together in a cogent whole. A danger in dividing the design effort by *grade range* is that the resulting curriculum design will not be coordinated well between grade ranges. If the design work is divided by *subject matter*, the resulting design may lack intellectual coherence. Or if the work is divided by categories of students, the design may produce social conflicts. And so on—no one way of dividing the design effort is entirely satisfactory.

One possibility for safeguarding overall curriculum coherence is to have a cascading committee structure for the design team. Suppose, for instance, that two committees are formed in each *school*: (1) a cross-subjects committee that pays attention to how subjects relate in each grade in that school, and (2) a cross-grades committee that pays attention to how each subject is developed from one grade to the next. And then there would be *districtwide* cross-subjects and cross-grades committees with representation from the school committees. And, above that, there would be a single central committee made of representatives of the districtwide committees. And finally, representatives of *that* committee would serve on a board-appointed, community-wide curriculum-design advisory committee.

Such a formidable committee structure may sound oppressive in the telling, but it does have the virtue of involving many teachers in the process and of forcing the need for coherence to the forefront. However, it would be a great help to be able to begin the effort with a set of specific learning goals already arranged for conceptual coherence over K-12, and to have available curriculum blocks with known internal coherence (as discussed in Chapter 4: Curriculum Blocks). It should also prove helpful to have computer software that could keep track of the cumulative characteristics of curriculum blocks as they are progressively assembled into an entire curriculum.

Testing in the development stage. No matter how many committees are involved, how thorough the analysis that takes place, and how persuasive the arguments that are made, things can go wrong. Good design practice calls for testing elements of an emerging design even as design development is under way. Curriculum features can be tested in single schools, in single grades, in single classrooms, or even with subgroups of students within classrooms. And combinations of these tests are possible, such as subgroups of students in single classrooms in each of several schools. Not every aspect of a curriculum can be tested on a limited scale, since much of a curriculum depends upon interactions among its component parts. But some ideas and propositions do

A companion Project 2061 tool *Designs on Disk*, enlarges on many ideas in this book.

THE FAR SIDE By GARY LARSON



Early experiments in transportation

lend themselves to testing, and a search of the literature sometimes reveals that some have already been put to a more or less rigorous test.

Curriculum-Design Decisions

In all design work, several concepts are employed in making decisions. As outlined in the Prologue, these are benefits and costs, risk, and trade-offs. Here they are examined from the perspective of curriculum design.

Benefits and costs. When goals are settled on early in the design process, the benefits expected from a new curriculum remain fairly stable. Costs do not. Every component of a K-12 curriculum has costs associated with it. Teachers, instructional materials, facilities, and support staff cost money; instruction takes time. Costs, however, are not unambiguously tied to benefits. Some curriculum components cost more than others. Inquiry-based science, for instance, costs more than textbook-based science, but how much more? What learning accrues from the former that is missing in the latter and vice versa? Is the benefit—added learning—worth the added cost? And to whom?

Decisions about spending on facilities and resources often derive more from speculation and fashion than from good evidence of effect on student learning. Money is a severely limited resource in most school districts, but an even more critical cost factor is time. Like money, time invested in one component of a curriculum is time not available for other components. However, there is a nearly absolute ceiling on time available for teaching and learning: currently about 1,000 hours a year for 13 years. Student time is finite; so is teacher time and so is time in the school class schedule. Hence, the argument for inclusion of any proposed component must be that its learning benefits justify the time it will take. Could more important things be learned in the same time? Can the same learning be gained in less time? Time and dollar costs provide estimates of effectiveness when weighed in relation to expected learning outcomes.

Political costs cannot be avoided, since most important curriculum decisions are viewed differently by different individuals and groups. Unanimity is hard to come by in education. Teaching methods, grouping practices, course requirements, promotion and graduation requirements, etc., almost always attract both support and opposition. In meeting the design challenge realistically, it is not possible to avoid all social costs, but it is essential to avoid having all of the curriculum decisions favor certain individuals and groups over others.

Risk. The notion of risk may be obvious enough in the case of industrial products,

but in education we are not used to thinking in terms of risk except, perhaps, the risk that something will not have the benefits claimed for it. In fact, though, any curriculum design does have risk associated with it. For one thing, there may be undesirable, even unanticipated, side effects. For instance, introducing abstract topics early in the curriculum may increase the risk of many children failing to learn the material, losing self-confidence, and staying away from the subject in later years. Also, small-group instruction may help some students with certain learning styles to improve their understanding but impede other students. And courses that require a lot of homework may penalize students who come from disadvantaged home situations.

Another risk commonly connected with curriculum change is whether the change will pay off with higher scores on standard examinations—or will instead lower scores by attending to goals different from those reflected on the tests. And there is the “transcript risk”: four years of, say, “integrated science” in high school may not pass muster in some college admission offices without the requisite labels “chemistry,” “physics,” and “advanced biology.”

Risk cannot be avoided. Good design practice calls for making an effort to ascertain what risk is associated with various curriculum propositions. This approach reduces—but does not eliminate—the chance that unanticipated, unwanted side effects will occur, and it alerts curriculum-design teams to look for ways to reduce the identified risks. Consistent with the notions of “overdesign” and “redundancy” mentioned in the Prologue, for example, instructional systems can provide safety nets for students who do not succeed within the allotted time and instructional resources. At the very least, risk analysis alerts educators and parents that particular dangers are associated with the proposed curriculum.

Trade-offs. Curriculum could be designed more confidently if benefits, costs, and risk could all be quantified. For example, if all benefits could be expressed in a common measure (say, the average number of new ideas learned per student) and all costs could be estimated in terms of a common measure (say, dollars or curriculum-hours), then it would be possible in principle to maximize the ratio of benefits to costs and risks. But there are no such common measures. How can the benefit of better student self-esteem be compared to the benefit of better multiplication? What dollar cost can be assigned to teachers having more time for teaching and less time for their personal lives? Still, at the least, it is useful to list benefits and costs and estimate gross differences in priorities among them as a basis for making plausible trade-offs.

The trade-off concept acknowledges that there are no perfect solutions. There are only solutions that, compared to one another, bring different benefits, different costs, different

risks. Thus A and B may appear to deliver about the same benefits, but B costs less and A is safer—so the decision will hinge on making a trade-off between low cost and low risk. Or, C may result in more learning on average than D, but be less effective for students in need of special help and for those with unusual talent. There the trade-off is between student populations, and whichever way the decision goes, the designers are on notice that some action will be needed to compensate the group placed at relative disadvantage.

Benefit-cost-risk analysis is not widely used in making curriculum decisions, at least not explicitly so. Most propositions put forth to modify existing curricula try to make a case for the absolute value of the proposed change: this or that course is needed to accomplish this or that purpose, or increasing the time allotted to this or that subject is inherently good. Sometimes a comparative case is made: it is better to introduce such and such in the 4th grade than the 5th, or all students now taking general mathematics should take algebra.

Such propositions are not sufficiently tough-minded. Effective trade-offs can be made only when questions such as the following have been answered: What learning benefits that would be missed otherwise will accrue to students? Which students? What evidence is there for that claim? What will those benefits cost? Are the benefits worth the cost? Can the same benefits, or nearly the same benefits, be acquired more cheaply? What risks are there associated with the proposed action? Who might gain and who might lose? These kinds of general questions, and others that pertain to local circumstances, should at least be entertained. Though there is no adequate calculus for balancing them, thinking about them can at least reduce unpleasant surprises—and may reveal unexpected opportunities.

REFINING A DESIGNED CURRICULUM

A curriculum rarely works as well as its design would lead us to expect, and some need for tuning is inevitable. With luck, some of the needs for tuning will be identified during the final stages of design. Inevitably, some will show up only when the design is fully implemented. And, beyond components not working quite as planned, every design is likely to have unexpected side effects. Even if the curriculum works well enough for awhile, eventually some things are likely to go wrong and need fixing. And in time, no matter how smoothly the curriculum is functioning, its design will become obsolete. New knowledge, new methods, new technologies, and new circumstances will open up new possibilities. So a design should include provisions for monitoring the implementation of the curriculum and its effects.

Aspects of a curriculum design for which systematic monitoring is desirable emerge from the premise that (1) the actual curriculum matches the design, (2) the students subject

to the curriculum are actually acquiring the learning the curriculum has been designed to effect, and (3) the learning, once acquired by students, is having the benefits attributed to it. It is also necessary, of course, to monitor whether the various costs are within tolerable bounds—but that is an aspect of change that schools are already able and eager to perform.

Curriculum Congruence with Design

To make judgments about a curriculum *design*, a school district needs to know the degree to which the *actual* curriculum is a reasonable rendition of that design. We cannot make valid judgments about a given aircraft design if the manufacturer deviated from the design in significant ways—and such deviations are much more likely to occur in the “manufacturing” of a curriculum than an aircraft. This suggests that periodically, particularly in the early years, a new or revised curriculum be checked for its match to the intended design. This can be done in two complementary steps, internal and external.

Internal. Committees composed of teachers, administrators, students, and interested citizens, including some members of the design team itself, should be established to monitor assigned aspects of the implementation process. For example, data can be collected on the time allotted to instructional blocks, on the patterns of enrollment in them, and on the comprehensiveness of specific learning goals ostensibly targeted by them. A cross-grades, cross-subjects oversight group can study the committee’s findings and prepare a report for the board of education. Such a study should be made annually until there is confidence that the curriculum matches the design—either because the implementation has been faithful or because the design has been modified to match practice. Afterward, internal studies should be conducted on a specified schedule, say every three or four years.

External. All institutions need input from external perspectives. School systems are complex institutions whose parts, including the curriculum, ought to undergo periodic examination by outside experts. The tradition of “visiting committees,” common in college and secondary education, is increasingly common among grade schools as a way to obtain impartial but authoritative opinions on how well a curriculum matches the adopted curriculum design. This policy, if budgeted for on something like a four-year cycle, is well within the means of most school districts, and it acknowledges that all technological systems require feedback and control to operate as intended.

Both of these methods for checking the congruence between an implemented curriculum and its design depend on having an explicit description of the curriculum

design. Such a description makes it possible for reviewers to know what to pay attention to and helps them avoid going off on low-priority tangents.

Learning Results

Assuming the curriculum has been correctly implemented and is being well operated, questions remain: Are students learning what the curriculum design intended they would? Are they learning some things but not others? Are all categories of students learning what is intended, or only some of them doing that? Is adequate learning occurring at every grade level? In every classroom?

To answer such fundamental questions requires detailed prescriptions for what is to be learned. In the domain of science, mathematics, and technology education, *Benchmarks for Science Literacy* provides a basis for estimating student learning for specific levels—at the 2nd-, 5th-, and 8th-grade levels. *National Science Education Standards* can also be used for that purpose in science, as can the National Council of Teachers of Mathematics' *Curriculum and Evaluation Standards for School Mathematics* in mathematics, and similar standards for technology education.

Whatever benchmarks or learning standards are used, the point is for agreement to have been reached, *before* a new curriculum is instituted, on how to measure learning and where the checkpoints will be. Learning measures should be derived from—or at least be demonstrated to match—the learning goals set at the beginning of the design process, and the checkpoints should be keyed to the grade-range decisions made in the early part of the design effort. Since the purpose is to estimate the effectiveness of the curriculum design, not judge individual students, the evaluation can be spread over time. A three- or four-year cycle, examining different subject domains in different years, and sound sampling of both goals and students, will reduce the investment of time and money necessary to conduct the studies.

The results of such studies constitute performance profiles to hold up to the pre-selected benchmarks so that decisions can be made about modifying the curriculum design. Where discrepancies are found, the question will arise as to whether the curriculum design is at fault in some general way or whether one of its components is internally inadequate for its designated role. For example, inadequate learning of concepts about biological systems detected at the 8th-grade checkpoint after a substantial biology course in 7th grade may mean that there should not be any such course that early, or only that the particular instruction materials or teacher preparation for that course weren't good enough. The purpose of periodic studies is to raise just such design questions.

Long-Term Consequences

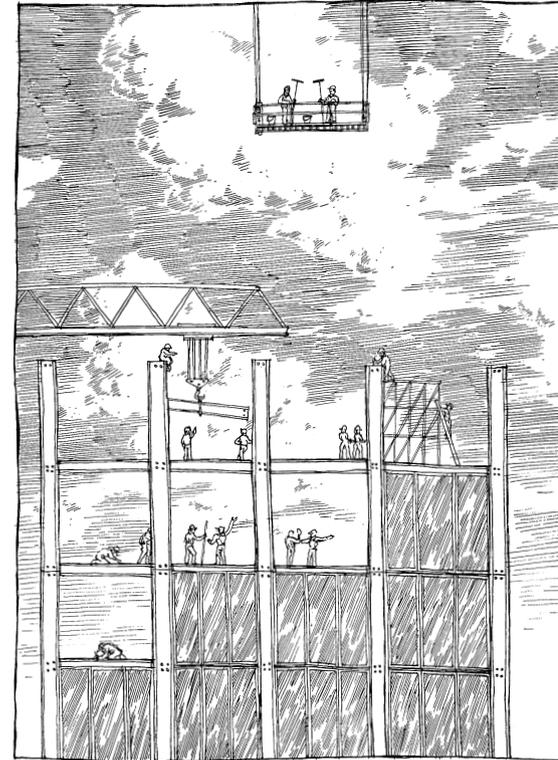
Meeting specific learning goals is the first test of a curriculum, but it is only a near-term measure. For most things, curricula no less than bridges and buildings, it is the long term that counts. Does the learning serve the learners well? To some degree that can be determined from benchmark testing: If students meet the 8th-grade benchmarks, does that appear to put them in a position to do well in high school? But eventually the horizon of interest must extend beyond the school years, for the main purpose of schooling is to prepare young people for an interesting and productive adulthood.

It is not realistically possible for a school district to mount the kind of longitudinal studies that give precise information on the effects of its curriculum. Perhaps, as research on teaching and learning advances, better short-term indicators may be found for long-term effects. But even so, there are simply too many variables at work to isolate a few and hold others constant as the most credible scientific study of effects requires. There are statistical techniques for studying multiple-outcome variables and adjusting for differences in inputs, but sophisticated multivariate studies are very costly.

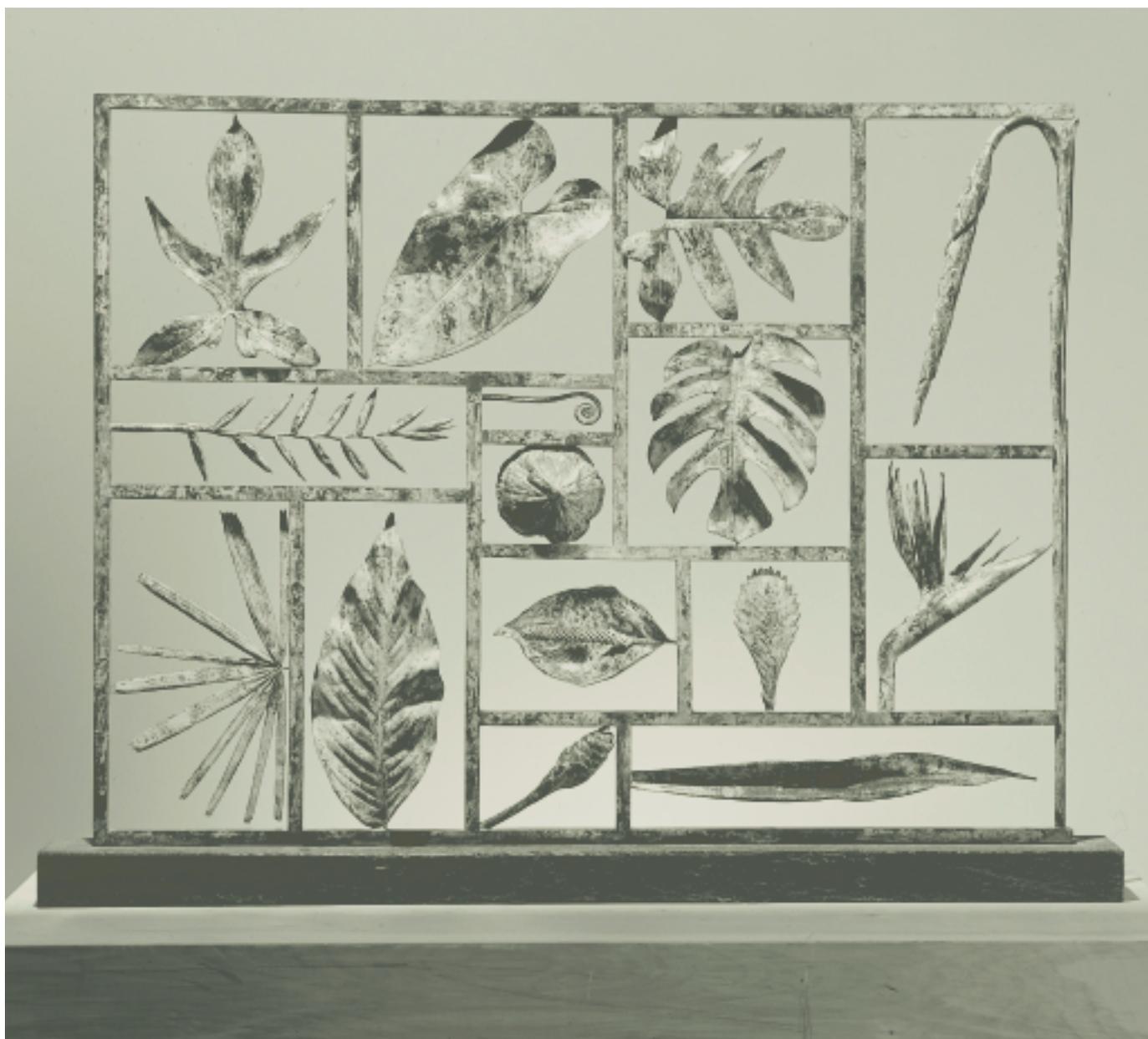
Networks of schools may be able to pool resources for such studies. It is more practical, however, to carry out opinion surveys of graduates periodically. Survey questions for graduates (as they encounter life, jobs, or further schooling) could cut across the entire spectrum of school experience, including some pertaining to the curriculum. If done sufficiently early after graduation, this feedback should be of use in considering what adjustments in the curriculum may be needed.

LOOKING AHEAD

In this chapter, the general ideas about design derived in the Prologue have been applied to curriculum design. The propositions necessarily have been general, with little on the actual process of creating a curriculum design. Yet to be considered are how goals should be adopted, how constraints should be identified and dealt with, how choices should be made among alternative curriculum concepts, what properties of a curriculum need to be considered, what trade-offs should be made, and the like. But recall that the purpose of the chapter is to lay out the idea of curriculum design and not to serve as a blueprint for action. Further, the intent so far has been to provoke discussion among teachers and others on just how to respond to the question: What is involved in designing an entire K-12 curriculum? Chapter 3 considers the dimensions of the curriculum, focusing on those that are most important to the design process.



"Planning Ahead"



Rhonda Roland Shearer, *Geometric Proportions in Nature, Study No. 1*, 1987

CHAPTER 2

CURRICULUM SPECIFICATIONS

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Although the general principles of design may apply widely, as has been argued, they have to be shaped to respond to the kind of thing to be designed, whether a ballet, a housing development, or any other object, event, or system. How can we best characterize the essential features of the K-12 curriculum? In answering, the chapter starts with a more or less standard definition of curriculum and recasts it in more structural terms. Curriculum structure, content, and operation are discussed, and a case is made along the way for developing and using curriculum graphics to facilitate thinking about those salient aspects of curriculum design.

WHAT IS A CURRICULUM?

Judging by how people talk about it, “curriculum” may be thought of as anything from what is written down in official district documents to what actually goes on in classrooms day to day. To complicate matters, curricula are often spoken of in terms of one or another of their special features (such as liberal arts, Great Books, language-immersion, activity-based, assessment-based, and—these days—standards-based curricula), in terms of students tracks (giving us college-preparatory, vocational, and “general” curricula), in terms of subject matter (the reading, mathematics, and Spanish curricula, for instance), and much else.

In books on K-12 “curriculum,” a curriculum is usually treated as a collection of courses, where a “course” is an educational unit usually at the high-school or middle-school level, consisting of a series of instruction periods (such as lectures, discussions, and laboratory sessions) dealing with a particular subject. “Courses” are usually a year or a semester long, but quarter or trimester courses and courses spanning several years are becoming more common. In earlier grades, curriculum is more typically described

curriculum

1. the whole body of courses offered by an educational institution or one of its branches.
2. any particular body of courses set for various majors.
3. all planned school activities including courses of study, organized play, athletics, dramatics, clubs, and home-room program.

— *Webster's Third New International Dictionary*

Since all of us have extensive experience as students in school, we all have a strong sense of what makes up a school curriculum...academic subjects, which are cut off from practical everyday knowledge, taught in relative isolation from one another, stratified by ability, sequenced by age, grounded in textbooks, and delivered in a teacher-centered classroom....This shared cultural understanding of the school curriculum exerts a profoundly conservative influence, by blocking program innovations even if they enhance learning and by providing legitimacy for programs that fit the traditional model even if they deter learning.

— D. F. Labaree, “The Chronic Failure of Curriculum Reform” (1999)

in terms of “subjects.” Courses and subjects are themselves often subdivided into “units,” which run from only a few days to a few weeks. For purposes of designing an entire K-12 curriculum, the component parts should be quite large—more like a course in extent than like a teaching unit. This idea is described further in CHAPTER 3: DESIGN BY ASSEMBLY and CHAPTER 4: CURRICULUM BLOCKS.

Dictionary definitions of curriculum are usually compatible with the “scope” part of “scope and sequence,” a phrase commonly used in education to mean that a description of a curriculum must say what the curriculum is made up of and how it is arranged. More specifically, a curriculum is always an assembly of instructional components distributed over time, never a single component in isolation. A chemistry course, for instance, is not a curriculum, though it may be an element of, say, a high-school college-preparatory curriculum or of a university premedical curriculum. And the collection of components forming a curriculum is a configured set of studies, not a haphazard collection—some things come before other things, some serve one purpose, others another, some are intended for all students, others for only some students, and so on.

Since a curriculum always has boundaries, a description of one should make clear what educational territory it encompasses. The boundaries of a curriculum can be identified according to grade range (an undergraduate curriculum, a K-12 curriculum, a middle-school curriculum), content domain (science, music, language arts), and student population (a core curriculum, a vocational curriculum, a college-preparatory curriculum, a bilingual curriculum, a prelaw curriculum). A “Project 2061 curriculum,” could be said to be any assembly of K-12 science, mathematics, and technology instructional components designed to enable all students to achieve science literacy as defined in *Science for All Americans*.

The design of curriculum within its prescribed boundaries involves a variety of aspects that we consider in this chapter under the headings of structure, content, and operation. Obviously there is likely to be interaction among the categories—decisions about structure have to take some account of the demands of content and the limitations of operation and vice versa—though such interactions are not dealt with explicitly here.

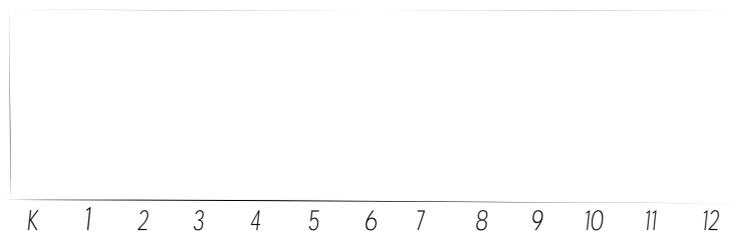
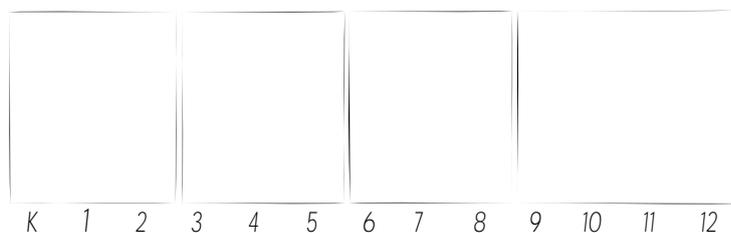
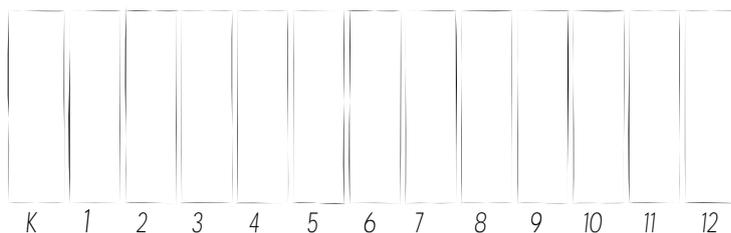
CURRICULUM STRUCTURE

Whereas architecture deals with the configuration of space, curriculum deals with the configuration of time. Minutes and years are for curriculum design what inches and miles are for architectural design. In a sense, there are two time dimensions to a curriculum: clock time and calendar time. Clock time is the number of minutes allotted

to instruction each day, typically portioned into distinct periods for different subjects or courses. Calendar time is the duration in weeks and months (or quarters or semesters). Together, these two temporal dimensions of school determine a total amount of instruction time that can be considered a “curriculum space” to be filled.

To start, it is extremely important to settle on the overall dimensions of a curriculum, since it is often useful to partition the whole into components for planning purposes. Whether the K-12 curriculum should be designed as a whole or divided into parts depends on the stage of design. Consider three possibilities shown in the diagrams below. In each, the horizontal dimension represents the 13-year calendar span of the school curriculum and the vertical dimension implies the daily instruction time available.

The bottom diagram here provides the comprehensive K-12 perspective needed to achieve a totally coherent curriculum, but is too large for most practical planning. Yet,



The Project 2061 publication *Atlas of Science Literacy* is an important tool for relating parts of a curriculum to the whole. It maps how student understanding of key ideas would grow and make connections over the entire K-12 span.

curriculum designers must have a way to refer back from the parts they are working on to the whole—which is why having a clearly stated K-12 curriculum concept is important. At the other extreme, the top diagram (on the previous page) indicates that planning can be done separately grade by grade. The trouble with this, of course, is that it is almost certain to lead to a fragmented K-12 curriculum. A reasonable middle ground is to plan within several grade ranges, as depicted in the center diagram. The center configuration has several advantages for planning:

- A span of three or four years seems manageable.
- The sections can be assembled to give a picture of the entire K-12 span.
- The properties of single grades can be inferred from the three- or four-grade spans.
- The four ranges approximate developmental stages—early childhood, late childhood, early adolescence, and adolescence (or the early elementary, upper elementary, middle-, and high-school grades).

Still another reason for using such curriculum spans is that benchmarks and content standards are arrayed in that way. While *Benchmarks for Science Literacy* uses the four divisions displayed above, *National Science Education Standards* (and also the standards in some other school subjects) use three ranges—K-4, 5-8, and 9-12. Although *Designs for Science Literacy* uses the four-part set of boundaries, the ideas presented are equally applicable to planning in three (or five) grade ranges.

Once agreement has been reached on the grade ranges for planning, one can turn to general structural features within them that are fundamental in some sense, but do not yet deal with subject-matter content. The parallel in our garden example in the Prologue was in deciding how much of the garden area to reserve for flowers, vegetables, and trees without getting into the details of which particular flowers, vegetables, and trees.

What then can be considered structural in curriculum design? We propose three main structural properties—without any claim that there are not other possibilities—that raise basic questions about the nature of the curriculum being designed: What balance is sought across the curriculum between core studies and elective ones? How much variation in time blocks is acceptable? What instructional formats should be included?

Core and Electives

A key structural feature of a curriculum is the distribution between core studies and electives. “Elective,” it is important to note, does not necessarily mean only studies that go beyond basic literacy. Core components of a curriculum are those in which all students participate, not necessarily the venue in which they achieve all of the com-

mon learning goals. A well-designed set of electives could provide for different students to achieve some of the same learning goals in different contexts. The basic literacy goals concerning force and motion, for example, might be achieved by some students in a transportation elective, by other students in an environmental elective, and by still other students in an astronomy elective.

The distribution of core and elective curriculum components can be represented graphically. But it may be difficult in practice to decide what in the curriculum is actually core and what is not core. It is clear enough what is core when all students must take the same course at the same pace and with the same requirements for success; it is a little less clear when all students must take the same course, say 10th-grade biology, but are grouped in such a way that different students have different versions of it; it is less clear still in cases in which students are required only to take the same subject, say “mathematics,” but under that title may have very different courses—perhaps algebra or business math. But such differences are a part of what is involved in structural analysis—analyzing how common the core really is will likely promote serious discussion of some fundamental issues.

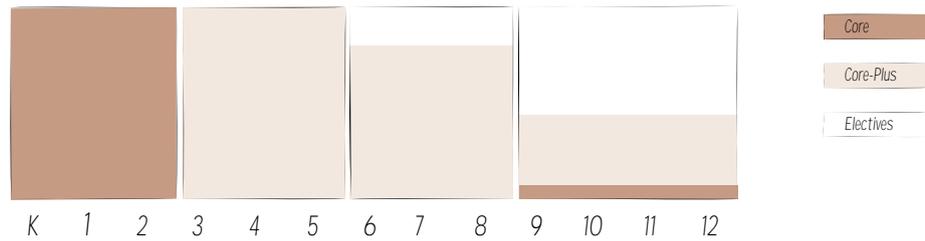
There are curricula in which all students take exactly the same program of studies (not altogether rare in private schools and the lower grades of public school systems); and there are curricula in which each student chooses a unique path, with no common core (more difficult to find in practice). But the great majority of curricula have various proportions of studies that are core and noncore electives.

Suppose that after a committee charged with designing a curriculum has reached a working consensus on the general character of the curriculum being designed, subcommittees for each of the four grade ranges work out plans. Let us say they decide as follows:

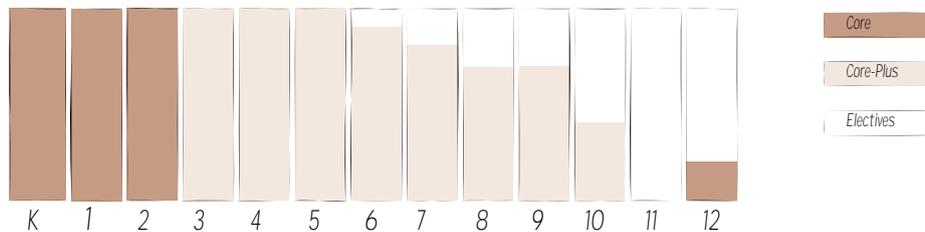
- Grade range K-2 will be all core, meaning all students have the same program of studies.
- Grade range 3-5 will be all core, but there will be options for students to pursue the topics at a more advanced level, though at pretty much the same time and location—call it “core-plus.”
- Grade range 6-8 will also be core-plus but in addition it will reserve about 20 percent of the span for alternative electives scheduled separately, gradually increasing them each year.
- Grade range 9-12 will reserve about half of the first two years for core-plus (with more in 9th grade) and after that all electives except for a single capstone course required of all seniors.

In different situations, a group of people designing curriculum might be called a design team, committee, study group, or still other combinations of such terms. In this book those terms are used more or less interchangeably, as seems convenient. In different situations also, curriculum design might be undertaken by a set of schools within or between districts, rather than by a school district per se.

Graphically, the results of the subcommittee deliberations may be rendered as



A grade-by-grade arrangement to achieve such proportions might look like this:



Schedule Variation

As things stand now in most curricula, the components are nearly uniform in time structure: they are either a semester or a year long, and all periods in the day have the same number of minutes. Presumably the period of approximately 45 minutes was settled on as a good compromise among various considerations—including the attention span of students and the number of subjects that have to share the time. The considerable advantage of uniform divisions of school time is that they can be neatly and reliably coordinated—their beginning and ending times are synchronized and are the same every day, so students can easily enroll in a variety of different subject combinations. Transitions from one to the next can also be uniform and minimal, simplifying the task of keeping track of where students are. Students can mix and match subjects.

Some educators argue, however, that not all content fits a given time container equally well. The U.S. Department of Education report *Prisoners of Time*, which claims that the greatest barrier to curriculum reform is the misuse of time, particularly faults the uniformity and rigidity of instructional time blocks. The report notes that, especially in the upper grades, all school subjects are almost always either a year or a semester long, meet every day of the week, and are allotted the same number of minutes per meeting.

Prisoners of Time: Report of the National Education Commission on Time and Learning, 1994.

In any case, in current practice it is seldom the intrinsic demands of a subject that determine the size and shape of its time dimensions, but the other way around—the time dimensions are set and each subject must do the best it can to fit the time available. Think what it would be like if all containers in a grocery store were required to be the same size and shape, and every product—bread, eggs, milk, watermelons—had to be made to fit them, no matter what. The containers would stack nicely, but would require a considerably awkward fit for some contents.

Laboratory experiments and design projects are prominent activities that require set-up (and take-down) time and so would obviously benefit from longer—and fewer—divisions of time. In “block scheduling,” some periods are given double length or more, allowing greater flexibility within each period. In an extreme version, a single period could fill a whole school day—or even a week. Such blocking raises significant issues in deployment of staff. If extended periods were devoted to single subjects, teachers would have to plan for longer (but intermittent) activities. If extended periods were shared between different subjects, as in various brands of integration, staff would have to plan more cooperatively. The structural question here, then, is how much variation will be permitted in the time subdivisions of a curriculum.

This is not to argue for either uniform or variable curriculum configurations, nor is it to suggest that curriculum designers should make the spaces first and then fill them up with content. Rather, it is to focus attention on the need in curriculum design to decide on what time constraints will have to be met—how much variation will be permitted.

This may, of course, differ by grade level. Consider a case in which grade-range design subcommittees end up proposing the following:

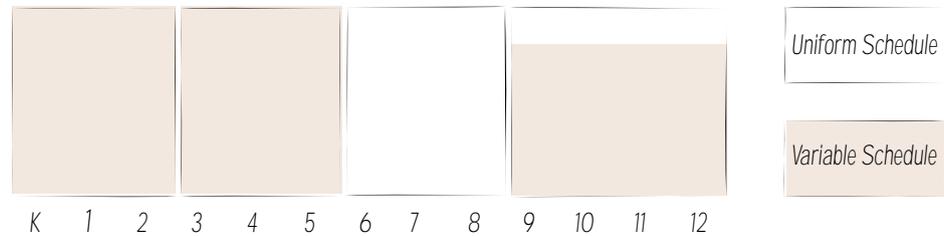
- Grade ranges K-2 and 3-5 both decide that individual teachers will be permitted to devote different amounts of time to different subjects within prescribed limits. If, for example, 20 minutes per day of science were required on average, which would amount to 60 hours in a school year, that time could be scheduled for 20 minutes every day, or an hour twice a week, two hours once a week, a half-day every other week, or, in an extreme example, all day for two solid weeks once a year.
- Grade range 6-8 opts for uniformity, with all classes meeting for one period every day for a semester or a year, thus keeping everyone’s schedule simple and facilitating changing classrooms for special subjects.
- Grade range 9-12 calls for all courses to be a semester or a year long, but different subjects can meet for three or five periods a week (or, in the case of laboratory, studio, and shop courses, for seven periods a week). The number of periods

Additional discussions of schedules appear in:

- Chapter 3 in the Candidate Blocks and Configuring Blocks sections
- Chapter 4 in the Time Frame subsection
- Chapter 6 in the Alternative Time Patterns section

a day for each course can also vary. However, an integrative core course required of all students is required to meet one period each day for the entire four years.

This arrangement may be represented graphically as



In Chapter 3, more detailed attention is given to a variation in actual partition of school time into courses and units.

Instructional Format

A K-12 curriculum as traditionally viewed is composed of “subjects” in the lower grades and “courses” in the upper grades. Instruction strategy changes somewhat with grade level, but by and large it is built on cycles of homework, recitation and class discussion, lectures (sometimes disguised as class discussion), hands-on activities (such as demonstrations, laboratory experiments, short projects, and field trips), occasional independent study and seminars, and eventually quizzes and tests.

For some kinds of learning tasks and in some circumstances, the traditional organization of instruction can be effective, especially when there is a well-defined body of easily understood content. Traditional instruction in the form of subjects and courses has a long history and, as materials and technology have been improved over the years, such instruction has arguably become more successful—at least in the hands of properly prepared and supported teachers. As teachers become aware of how superficially students can learn some ideas and of how persistent students’ misconceptions can be, and as they become more adept at applying cognitive principles of teaching and learning to their instruction, the “traditional” lecture-discussion or lecture-discussion-laboratory formats may be used more effectively for benefiting a wide range of students. Innovations within traditional formats, such as cooperative groups, self-paced study, and computer-based instruction, have offered additional possibilities for increased instructional effectiveness. Even so, there is reason to

doubt that the traditional format is satisfactory for many kinds of learning, no matter how well used.

A variety of other formats exist that may be better for certain purposes, such as for developing students' ability to participate effectively in group discussions or for learning on their own. For example, in addition to traditional courses in typical daily time frames, a curriculum can include stand-alone *seminars* that meet once or twice a week, stand-alone *independent study* that occupies all of a month or longer, and stand-alone *projects* that stretch over semesters or years—not as minor parts of courses, but as free-standing major components of the K-12 curriculum that have their own entries in student transcripts. Below is a brief look at these three formats. Educational research has not produced consistent evidence that any of them materially improves student learning, but they still appear to hold promise and are likely to play roles in instructional development in the future.

Seminars. To explore a small number of ideas from multiple perspectives, there is much to be said for using a seminar format. A Socratic seminar is not simply a discussion among 10 to 15 people, but a method for sharing in the examination of readings other than a textbook. Seminar texts include news or magazine articles, novels, plays, essays, biographies, speeches, research reports, or epic poems and can be in science, engineering, medicine, literature, politics, philosophy, or any other field. Seminars are led by someone who understands the format and has some background in the content. Expertise in the exact subject itself may not be required, especially given the temptation for subject-matter experts to intervene in the process to make sure that the participants correctly understand the content, rather than to guide the conversation purposefully. Some of the best seminar leaders may not yet be familiar with the given topic but provide a model for how to ask questions and consider alternative perspectives. With training in leading seminars, many people other than teachers can serve admirably; among them are parents and other community members, retired teachers and principals, and even students at higher grade levels who can be trained to do a good job of leading seminars for students in lower grades.

Seminars vary greatly in their time demands. Generally, they should meet only once or twice a week, giving participants time to study the source materials and prepare for the next meeting, but they can last anywhere from a few weeks to a semester. Seminars are sometimes part of a regular course led by the regular teacher, but a seminar's effectiveness in this setting may be reduced by the role the teacher is tempted to take as a content expert.

SHARING GOALS WITH STUDENTS

Presumably all instruction has specified goals, but the goals may not be clearly shared with the students. For example, in a project to design a catapult, the students' purpose is to build a winning catapult, whereas the teacher's intent is for them to learn about constraints and trade-offs in design.

Tests can give students a pragmatic indication of what the goals at least *were*. To the extent that students are advised on the nature of the assessment tasks—and how they will be scored—they may know the goals early enough to work deliberately toward them. (Hence the ubiquitous student query, “Will that be on the test?”) But assessments themselves are not always well suited to the underlying goals of instruction.

Independent study. As adults, we are pretty much on our own to learn what we need or want to know when we want to know it. We may do so by taking courses, reading, listening to lectures or tapes of lectures, using computer programs, asking experts, and so forth. In all these cases, we guide our own instruction. It is puzzling, therefore, that much of K-12 schooling (and undergraduate education, for that matter) provides little opportunity for students to learn and practice how to be independent learners. Students in school are told by teachers just what to study on a daily basis, what pages to read from a specified textbook (that in turn signals them in boldface type and glossaries which words to memorize), what experiments or other activities to carry out, and which end-of-chapter problems to do.

Development of independent learning skills can be fostered by explicit curriculum provisions for doing so, such as courses that include major independent-study components, and stand-alone blocks of time for independent study that are not part of a traditional course. One form of independent study is *goal-specified assignments*. Students are told what knowledge or skills they are expected to learn, what resources are available to them, and what the deadline is for accomplishing the learning. (See the nearby box about sharing goals with students more generally.)

Students should not, however, be sent off entirely on their own. Research has long shown that, for independent study to work, students need monitoring and coaching on how to proceed and on what is to be learned. Successful completion of the independent study assignment requires that the student submit a report or takes an examination (written, oral, or performance). As with seminars, independent study assignments are sometimes embedded in traditional subject and course formats. A possible advantage of having stand-alone independent study may be that teachers who are particularly good at coaching such study could specialize in it.

Projects. A distinctive form of independent study is a project to be carried out by a single student or by a small team of students. Projects can be of any duration (though a deadline should probably always be set), and can have an inquiry or action orientation. A project can stand alone as a curriculum entity or may be part of a course, but in either case it should be overseen by a person acting as a coach rather than as a traditional teacher.

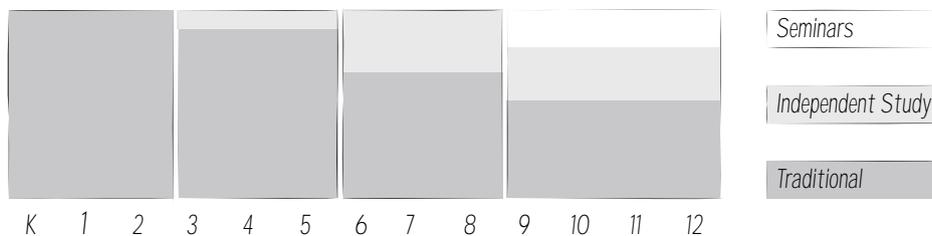
A particularly promising kind of project provides an opportunity for students to teach each other. Before being permitted to carry out the task, the would-be peer teachers should demonstrate their own competence in the material to be taught and must have their teaching plan approved by the project adviser and by the teacher of the target students.

In short, courses typically follow a textbook and are operated by teachers; seminars are based on readings and other non-textbook materials and are operated by seminar leaders who need not be regular teachers; and independent study takes the form of goal-specified assignments or projects, which are overseen by project advisers and coaches.

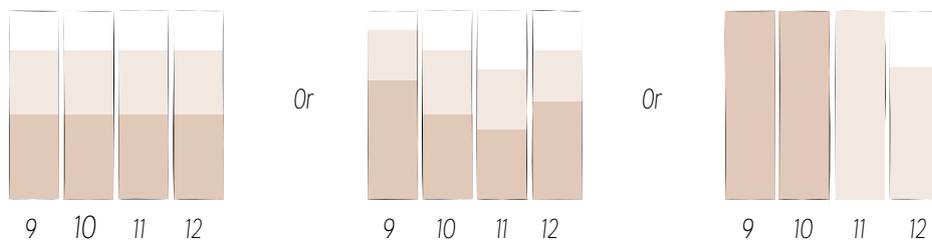
Thus, another structural property of the curriculum that can be depicted graphically is the proportion of instruction to be allotted to different formats. Suppose, after arguing the merits and drawbacks of these instructional formats in the light of the overall learning goals set for the new curriculum, our grade-range subcommittees decided the following:

- Grade range K-2 will be entirely traditional, with separate periods of time for mathematics, science, etc.
- Grade range 3-5 will introduce the equivalent of about three periods a week to independent study; the rest of the curriculum will be traditional in format.
- Grade range 6-8 will be composed of about two-thirds traditional instruction; the rest will be independent study, including peer-teaching projects.
- Grade range 9-12 will divide the curriculum into 50 percent traditional, 30 percent independent study, and 20 percent seminars.

In graphic form:



These proportions could, of course, be realized by a variety of grade patterns. For example, the high-school format could be met, as these diagrams suggest, by treating each year the same, by changing the proportions each year, or by concentrating the seminars and independent study in the last two years:



CURRICULUM CONTENT

In a neat design process, agreement would be reached on the general features of a curriculum before considering how content will be organized within those limits. In most practical situations, however, some back and forth between general features and particular organization is highly likely. Just as in our garden example, where we may have to decide which particular trees and shrubs to plant in the area reserved for them and how they would be placed, so curriculum designers have to decide upon the composition and arrangement of subject matter over time. Decisions also have to be made with regard to which principles for organizing subject matter are preferred—at one extreme organizing content by disciplines, at the other extreme by completely integrated studies, or by some mix of discipline-based and more-or-less integrated studies.

Content Distribution

To curriculum designers, the large-scale layout of subjects is of more interest than the details of what topics are to be treated in what fashion. Such a layout is analogous to beginning the design of a hospital by indicating roughly where the various facilities, wards, private rooms, emergency rooms, laboratories, and business offices are to be located, without specifying precisely how many of each there will be or how they will be equipped. A garden designer could begin by describing the general location of perennials, annuals, shrubs, fruit trees, and vegetables without indicating exactly which particular varieties there will be in each location. As more detail is added to the design, the character and purpose of the hospital or garden become evident.

The content of a curriculum can be dealt with on different levels of specificity. At the most general level, the issue is the relative attention paid to the major domains: arts and humanities; science, mathematics, and technology; and other common studies (vocational, physical education, health, and business). Suppose that with regard to those three categories (in that order):

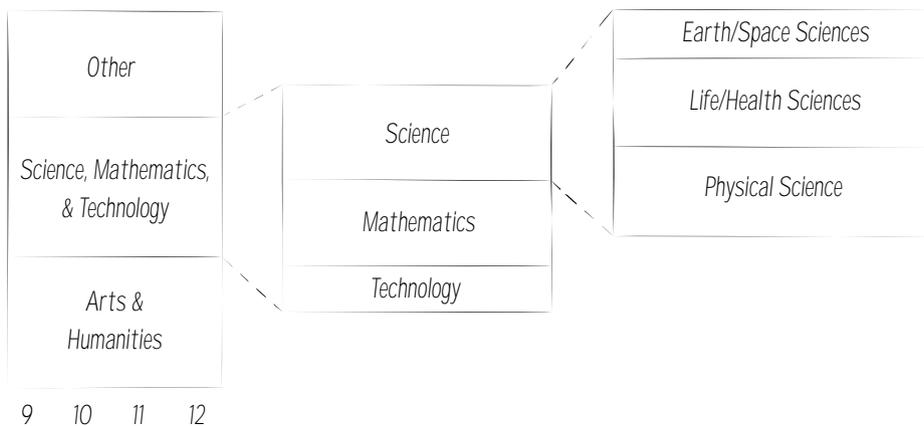
- Grade ranges K-2 and 3-5 decide to divide the curriculum into 50 percent arts and humanities (emphasizing reading); 40 percent science, mathematics, and technology (emphasizing arithmetic); and 10 percent other (health and exercise).
- Grade range 6-8 opts for 40 percent-40 percent-20 percent, thereby increasing the attention given to health and physical education.
- Grade range 9-12 agrees to increase the “other” category to 30 percent by including vocational and other noncore subjects.

This could be represented graphically as

<i>Other</i>			<i>Other</i>			<i>Other</i>			<i>Other</i>			
Science, Mathematics, & Technology			Science, Mathematics, & Technology			Science, Mathematics, & Technology			Science, Mathematics, & Technology			
Arts & Humanities			Arts & Humanities			Arts & Humanities			Arts & Humanities			
K	1	2	3	4	5	6	7	8	9	10	11	12

From such a broad demarcation, the content distribution can be decided in progressively greater detail. Each of the three major domains given above can be examined in further levels of specification. Examples of successive levels of detail for the preceding example of 9-12 curriculum are portrayed below.

Going from left to right, the first level shows how a 9-12 curriculum may configure time generally; the second how the science, mathematics, and technology portion may divide time among science, mathematics, and technology; and the third shows how the science part may allocate time among broad science domains. These diagrams indicate how time will be apportioned among various content categories but not how the content will be organized conceptually or in what sequence it will appear.



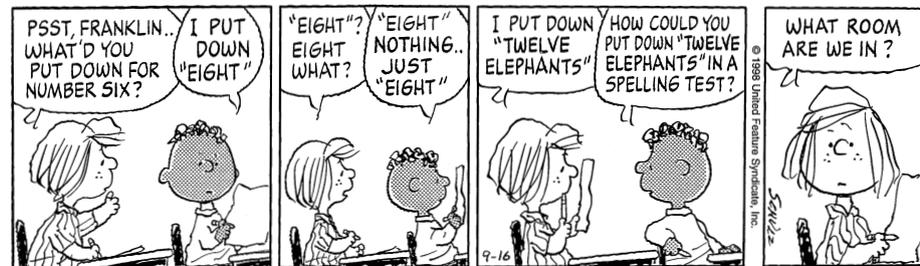
Content Organization

From the smallest teaching unit to a multiple-year sequence of courses, content is expected to be more than a jumble of topics. Lesson plans, course outlines, and curricula are each expected to be made up of content that conceptually forms a coherent whole. The coherence of an entire curriculum requires, of course, that the parts of which it is built have their own internal coherence. But even if each of the components of a curriculum is *internally* coherent, the curriculum as a whole may not be. In other words, curriculum coherence means that, at any level of content organization, the parts have to make sense in view of the whole and vice versa.

Although several different styles of coherence are possible, traditionally coherence is assumed to be provided by the internal organization of the separate disciplines or fields, usually as they appear in the respective introductory textbooks used in college survey courses and imitated in high-school courses. Disciplines, however, are not fixed. They evolve, although not smoothly or in an altogether predictable direction, and they occasionally undergo radical change. They overlap and intermingle—and, sometimes, new disciplines emerge. But for purposes of design, it is sufficient to think of a *discipline-based curriculum* as one organized on the basis of the knowledge, methods, structure, and language of one or more of the academic disciplines.

But recently (although not for the first time), some educators have urged turning away from basing the K-12 curriculum on the individual disciplines. They claim that, whatever their value for research, the disciplines are too compartmentalized, abstract, and remote from the interests and concerns of most people living in a complicated world to serve the general education needs of students. It would be better, they argue, to *integrate* parts or even all of the curriculum across fields and disciplines, organizing the curriculum around interesting phenomena, important cross-cutting themes, design

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projects, or urgent social and environmental issues. Content integration can take place at a high level of generality (science and art, for instance), within a broad domain (such as science, mathematics, and technology, or any two of those), or between areas within disciplines (algebra and geometry, or physics and biology), but what distinguishes an integrated curriculum is that something other than the disciplines determines how the content will be organized.

That is not to say that discipline-based curricula necessarily neglect environmental issues, say, or that integrated curricula disregard knowledge and methods from the disciplines. The same set of specific learning goals could be pursued within either form of organization. The difference is more of a foreground/background situation. In a discipline-based curriculum, particular academic disciplines or fields catch our eye first (with applications of one kind or another coming in to view from time to time), whereas in an integrated curriculum, phenomena, themes, or issues are out front (with disciplines behind the scenes). Cogent arguments have been made for both approaches (as evident in the articles cited in the Bibliography), but there is little empirical evidence for any advantage in results of one over the other.

Still, design calls for decisions to be made. Should the curriculum be discipline-based, integrated, or partly discipline-based and partly integrated? In making such decisions, both content and pedagogical issues have to be taken into account, and clearly specified learning goals and constraints are essential. How will a strictly discipline-based curriculum ensure that students reach the thematic, historical, and other nondiscipline-based goals? How will an integrated curriculum ensure that they reach the learning goals in the physical sciences, life sciences, earth sciences, mathematics, and technology?

Taking all of this into account, it is useful to consider what would happen if a school district were to decide to do the following:

- Design a curriculum in which there is substantial but not complete commitment to content integration, and the integration will be mostly at the science/mathematics/technology level rather than the science/arts/humanities level.
- Integrate K-2 science, mathematics, and technology around phenomena of interest to very young children, rather than having a separate period of time for each subject.
- Treat mathematics separately in grades 3-5, as well as integrating it with science and technology around themes such as “scale” and “change.”
- Separate the disciplines in grades 6-8, dividing the available time equally among them.

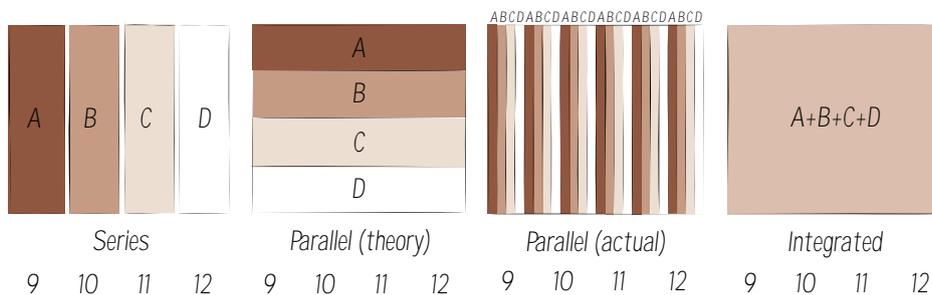
- Integrate science, mathematics, and technology in grades 9-12 around social and environmental issues for a third of the time and let students select one or two disciplines to pursue in depth for the rest.

Graphically, these decisions for the core curriculum in the domain of science, mathematics, and technology can be represented in this way:

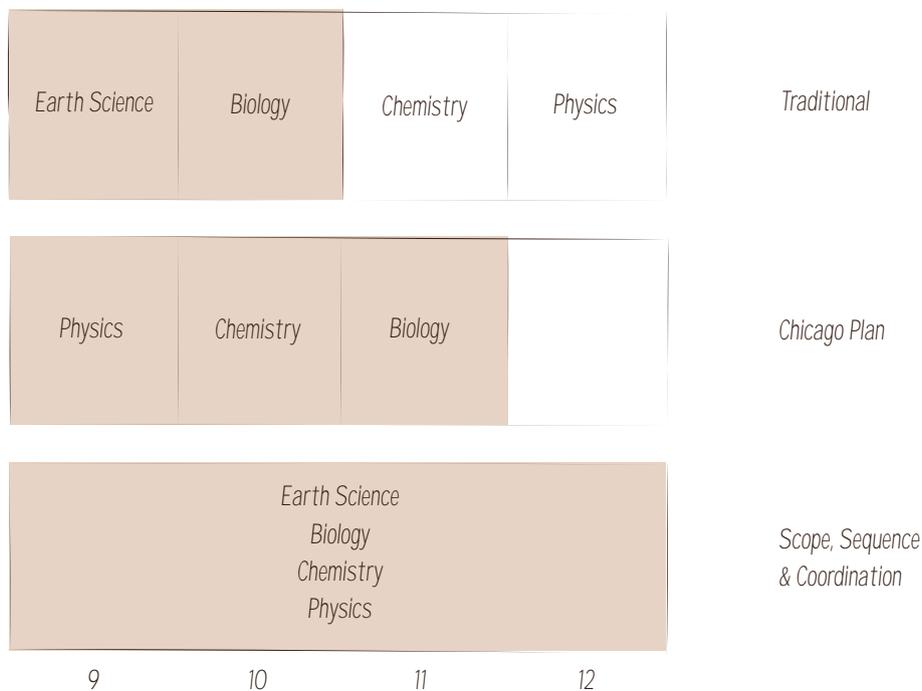
Science, Mathematics, & Technology	Mathematics	Algebra/ Geometry	Biology or Chemistry or Physics or Engineering or Astronomy/ Geology or Statistics									
		Physical Science										
		Earth Science										
	Science, Mathematics, Technology	Life Science										
	Engineering	Science, Mathematics, & Technology										
K	1	2	3	4	5	6	7	8	9	10	11	12

In a discipline-based organization, disciplines can appear one after the other or in parallel—that is, more or less concurrently. In series, students study each subject in turn for a considerable period of time, usually every day for a semester or year. In parallel organizations, students study all of the target subjects more or less simultaneously. (It would be rare, however, to study, say, physical *and* biological sciences every day—“concurrently” usually means more rapidly alternating from one day or week to the next.) Although this arrangement allows connections to be made among the disciplines, it still keeps them front and center. In a thematically integrated curriculum—say, one that focuses on lakes or spacecraft design—the disciplines may become indistinguishable and so sequence becomes truly parallel. Note that some curricula, despite their titles, are not actually integrated. A common example is middle-school general science, which often turns out to be a rotation of the individual science disciplines on a semester or six-weeks basis—essentially a series sequence.

The distinction between curriculum sequences can be portrayed as these hypothetical patterns of science courses in a single range:



The typical high-school science curriculum is configured in series. So is the arrangement proposed by a group of scientists and science teachers in Chicago, although the traditional sequence is reversed. In the *Scope, Sequence, and Coordination* type of curriculum proposed by the National Science Teachers Association there would be a parallel configuration in which students study four natural sciences every year for four years, the organization of topics within each science coordinated with the others in mutually supportive ways. In the following diagrams depicting these three arrangements, the shaded areas are what essentially all students take, and the unshaded ones are electives:



CURRICULUM OPERATION

Notions of how the finished products will be operated are built into the design of gardens, bridges, and buildings, and care is called for in anticipating how any such product will actually be used once it is off the drawing board. For example, an aircraft design requires consideration of the number and functions of crew members, how maintenance will be provided, and how passengers will board and exit the craft. These operations effectively become part of the design and are difficult to modify after the aircraft is in production.

So too with curricula. Four key features affect the operation of a curriculum and need to be taken into account in curriculum design: *student pathways* through the curriculum, *staff deployment*, the selection and use of *instructional resources* (including decisions about technologies), and *monitoring* and maintaining the effectiveness of the curriculum. Each is discussed briefly below. Most of the operational issues concern educational philosophy or limitations of resources. They are listed here only as questions that have to be argued and decided in the design process, but discussion of the many issues involved will be left to the considerable literature devoted to them.

Student Pathways

In designing a curriculum, it is necessary to identify the ways in which students will progress through their K-12 years. That information can be developed by posing a series of design-related questions:

- Will all students follow one path? If there will be more than one path, how many will there be? How will students be grouped on any one path? On what basis will students be placed on one path or another? Will they change paths at any point in their passage through the curriculum, or only at certain points?
- How will students advance through the curriculum—grade by grade or grade range by grade range? Will advancement be automatic, or will promotion be based on demonstrated performance?
- What are the criteria for a student to enter or exit a particular curriculum subject or course?
- What is required for graduation?

Staff Deployment

The following set of design-related questions can be used to identify staffing needs and resources:

See the Bibliography for chapter-by-chapter references to relevant readings. *Designs on Disk* contains a few important papers for easy access.

- At what point in the elementary-school curriculum will teachers be expected to be subject-matter specialists? In which subjects? Will secondary-school teachers need to be specialists in a broad domain, such as science, or a specific discipline, such as chemistry?
- In how many different grades or grade ranges will teachers have to be proficient? Will they have to cycle through the grades, or specialize in one or two?
- What skills other than those of traditional classroom teaching will teachers be expected to have: project coaching, seminar management, supervising independent study, overseeing peer teaching, training and supervising noncertified teachers, or others?
- Will the curriculum design permit teachers to specialize in one or two such functions (in contrast to subject-matter specialization)?
- Would it be legal to have students or uncertified adults conduct some of the teaching called for by the curriculum? Will teachers connected to the school only by television, the Internet, or regular mail have recognized status as faculty?

Instructional Resources

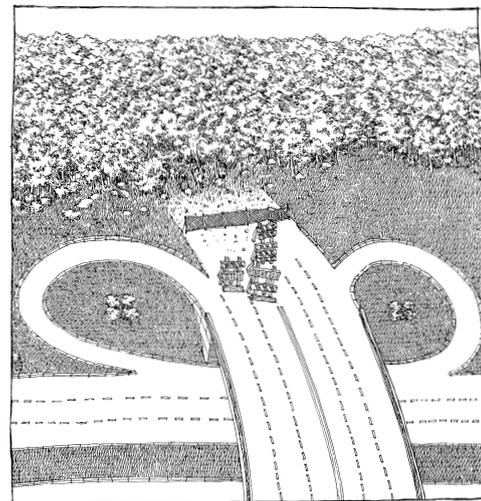
The following questions are aimed at identifying the need for and availability of such resources:

- If courses depend heavily on textbooks, how will the books be selected to ensure that they match the learning goals of the curriculum? If curriculum blocks do not use textbooks, how will the needed materials be identified, reviewed for relevance and accuracy, and selected? How will staff be trained to use them effectively?
- Will the curriculum operate with whatever spaces and technologies are available, or will it presume the availability of certain information and communications technologies? If so, which ones?
- If the curriculum will require the use of advanced technologies, what demands will that put on the deployment of teachers and the design of school facilities?

Curriculum Monitoring

The following design-related questions are intended to identify curriculum-monitoring needs and resources:

- How will we know whether the curriculum is having the intended effects? What will be the criteria for student performance? How often will major student assessments be made and at what checkpoints? Who will judge what the findings imply?



"Small Victory-Highway"

The Project 2061 publication *Resources for Science Literacy: Curriculum Materials Evaluation* provides suggestions for analyzing instructional materials and tests in relation to specific learning goals.

- What will be done with the results to ensure that deficiencies are corrected?
- What measures will be taken to detect unwanted and unanticipated side effects that may occur between student assessments? If it is known that the design may put some students more at risk than others, what special arrangements will be made to monitor their progress? What will be done about teachers who don't adapt well to the design?
 - What provisions will be made to monitor the financial, time, and political costs of implementing the curriculum design? What contingency plans will be in place if the cost of operating the curriculum exceeds estimates by an unacceptable amount?

SUMMING UP

In Part I we have considered the ideas of curriculum design in particular and proposed a way of thinking about curriculum that takes into account key properties that come into play across the entire curriculum. These properties—structure, content, and operation—can be summarized briefly by the questions they raise about a curriculum:

Structure

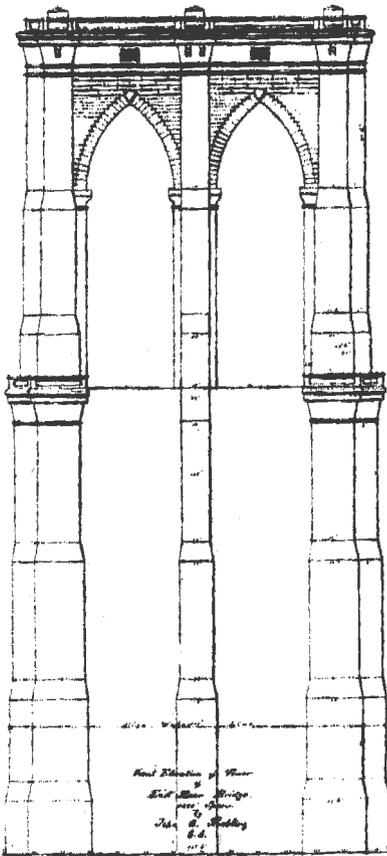
- What is the distribution between the core studies that all students must take and electives?
- Do all subjects have the same time configuration? If different time frames are permitted, what are they?
- What is the pattern across the curriculum of traditional instructional formats and alternatives such as seminars and independent study?
- Where are curriculum checkpoints?

Content

- What are the specific goals for student learning?
- Is content organized by discipline or is it integrated? If discipline-based, which ones? If integrated, at what level and on what basis?
- Is content arranged in series or in parallel sequences?

Operation

- What pathways through the curriculum are open to students, and how is it determined which students follow which routes?



- What capabilities do the staff need to have, and how are staff to be deployed?
- What resources are essential to operate the proposed curriculum?
- What provisions are built into the curriculum to find out if it is having its intended effects and not having unwanted ones?

Attention should be given to all of these issues from the beginning of the design process. Nevertheless, it is clear that the answers will be shaped in part by smaller-scale decisions that are made along the way, as actual curriculum components are considered and chosen. Not only must individual components—courses, for example—have their share of the desired properties, but collectively they must fit together into a coherent whole that will satisfy the specific goals for learning. The next set of three chapters proposes an approach to the design of a complete curriculum by selecting and sequencing components that have well-specified properties, particularly those outlined in this chapter.

Conceivably, a team of curriculum designers could undertake fixing, gathering, and constructing instructional components—lessons, activities, and units—to fit the specifications of the kind laid out above. In what follows, *Designs* proposes two other possibilities: Part II presents a long-term alternative based on the assumption that resources will eventually become available to make possible the local design of whole curricula; Part III suggests, how, in the short term, smaller-scale but still significant improvements in curricula can be undertaken as part of building capability for the long-term design venture.