CHAPTER 2
CURRICULUM SPECIFICATIONS

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.

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*

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

> 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.*

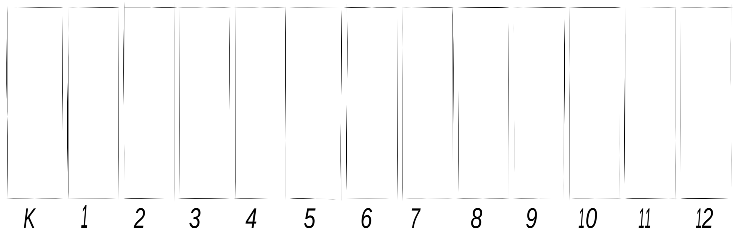
The design of curriculum within its prescribed boundaries involves a variety of aspects that we consider in this chapter under the headings of structure, content, and operation. Obviously there is likely to be interaction among the categories—decisions about structure have to take some account of the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

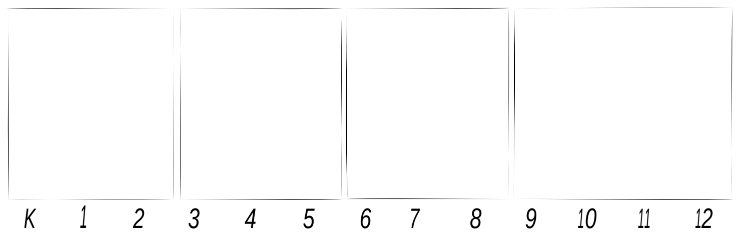
Curriculum Structure

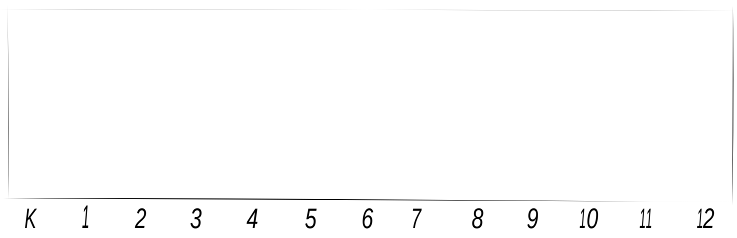
Whereas architecture deals with the configuration of space, curriculum deals with the configuration of time. Minutes and years are for curriculum design what inches and miles are for architectural design. In a sense, there are two time dimensions to a curriculum: clock time and calendar time. Clock time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

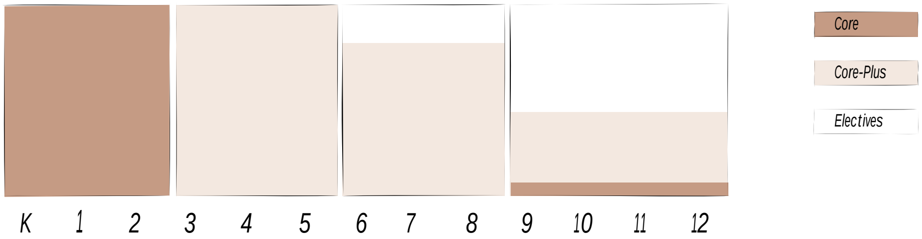
There are curricula in which all students take exactly the same program of studies (not altogether rare in private schools and the lower grades of public school systems); and there are curricula in which each student chooses a unique path, with no common core (more difficult to find in practice). But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

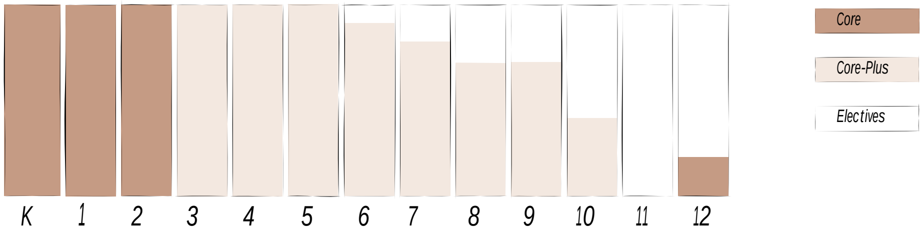
- Grade range K-2 will be all core, meaning all students have the same program of studies.
- Grade range 3-5 will be all core, but there will be options for students to pursue the topics at a more advanced level, though at pretty much the same time and location—call it "core-plus."
- Grade range 6-8 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.

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

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.

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.

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

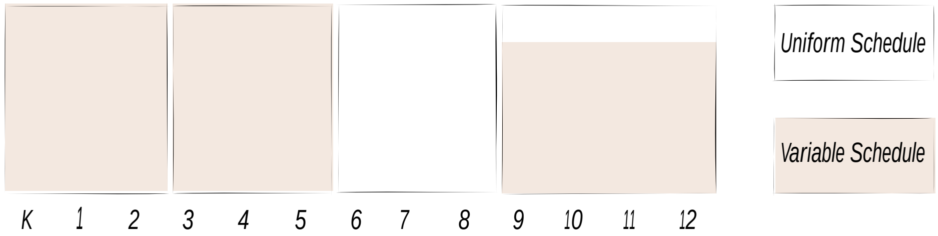
This is not to argue for either uniform or variable curriculum configurations, nor is it to suggest that curriculum designers should make the spaces first and then fill them up with content. Rather, it is to focus attention on the need in curriculum design to decide on what time constraints will have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

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.

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.

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 tradeoffs 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.

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 overseen by a person acting as a coach rather than as a traditional teacher.

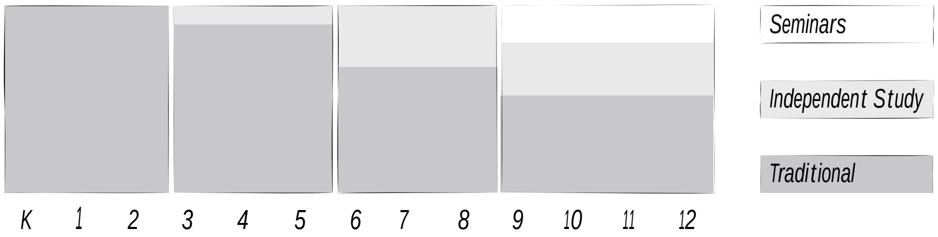
A particularly promising kind of project provides an opportunity for students to teach each other. Before being permitted to carry out the task, the would-be peer teachers should demonstrate their own competence in the material to be taught and must have their teaching plan approved by the project adviser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

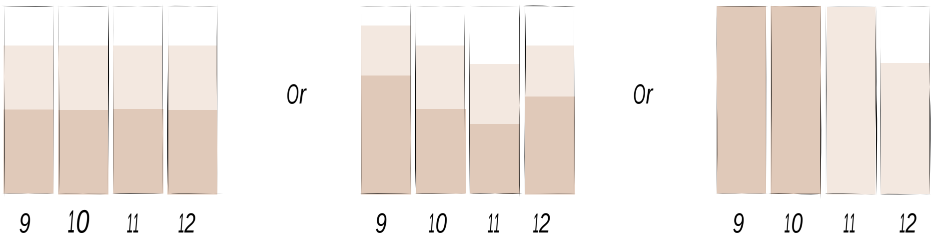
Thus, another structural property of the curriculum that can be depicted graphically is the proportion of instruction to be allotted to different formats. Suppose, after arguing the merits and drawbacks of these instructional formats in the light of the overall learning goals set for the new curriculum,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

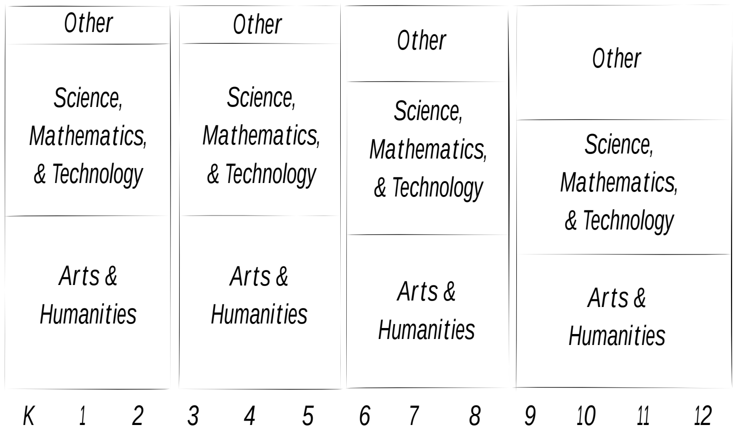
Content Distribution

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):

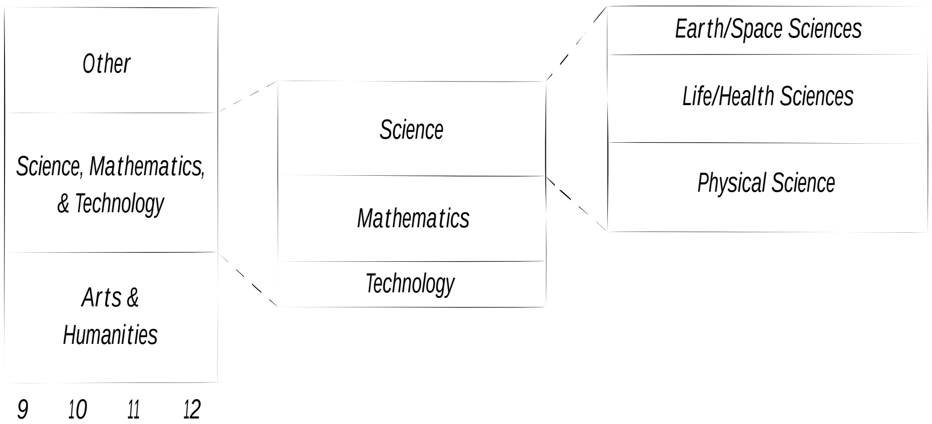
- Grade ranges K-2 and 3-5 decide to divide the curriculum into 50 percent arts and humanities (emphasizing reading); 40 percent science, mathematics, and technology (emphasizing arithmetic); and 10 percent other (health and exercise).
- Grade range 6-8 opts for 40 percent-40 percent-20 percent, thereby 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



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.



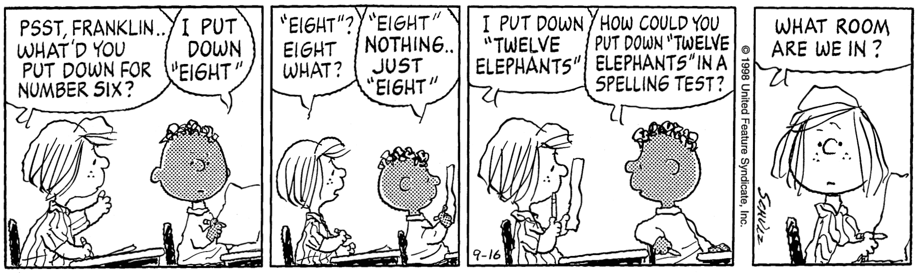
Content Organization

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

PEANUTS CHARLES M. SCHULZ



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.

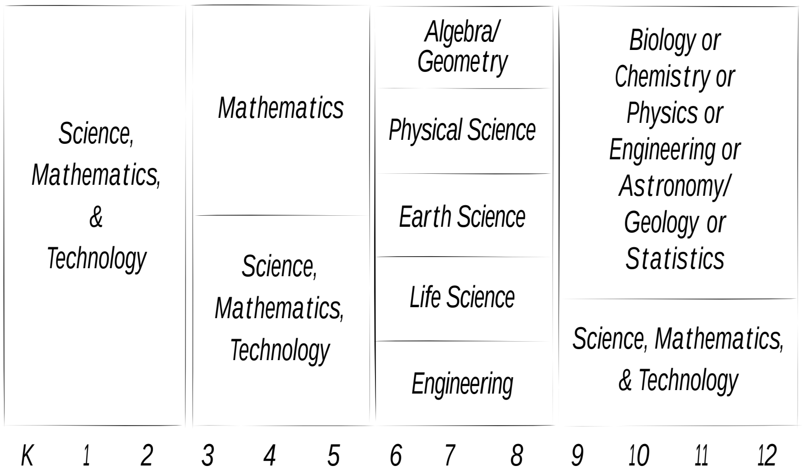
Still, design calls for decisions to be made. Should the curriculum be discipline-based, integrated, or partly discipline-based and partly integrated? In making such decisions, both content and pedagogical issues have to be taken into account, and clearly specified learning goals and constraints are 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.

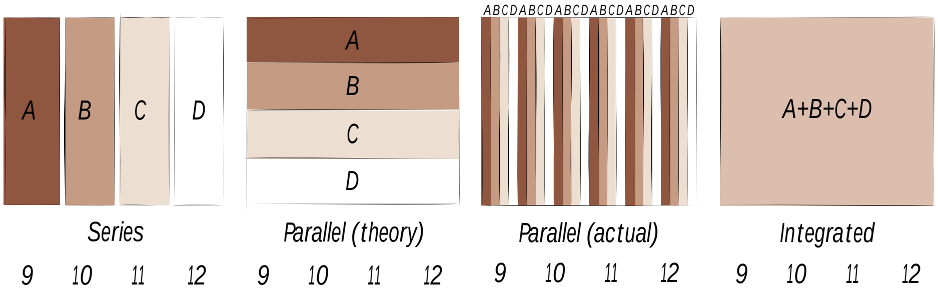
- Integrate science, mathematics, and technology in grades 9-12 around social and environmental issues for a third of the time and let students select one or two disciplines to pursue in depth for the rest.

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

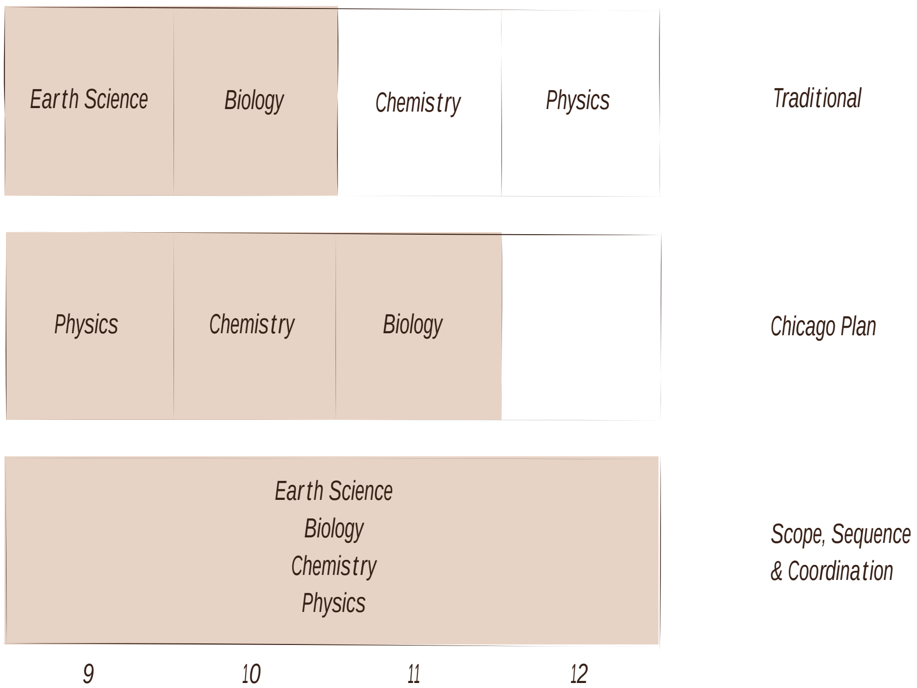


In a discipline-based organization, disciplines can appear one after the other or in parallel—that is, more or less concurrently. In series, students study each subject in turn for a considerable period of time, usually every day for a semester or year. In parallel organizations, students study all of 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:

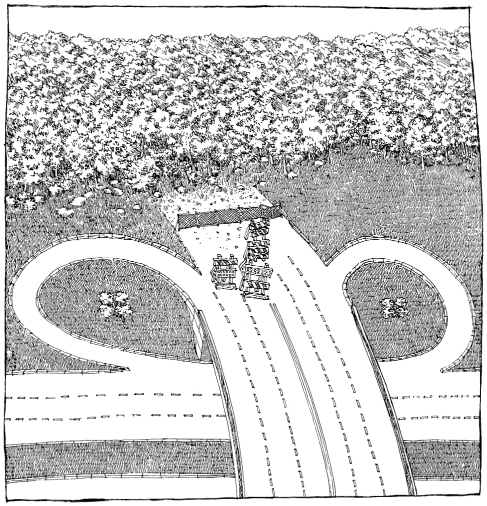
See the Bibliography for chapter-by-chapter references to relevant readings. *Designs on Disk* contains a number of these readings for easy access.

- 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:

- 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?



"Small Victory-Highway"

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:

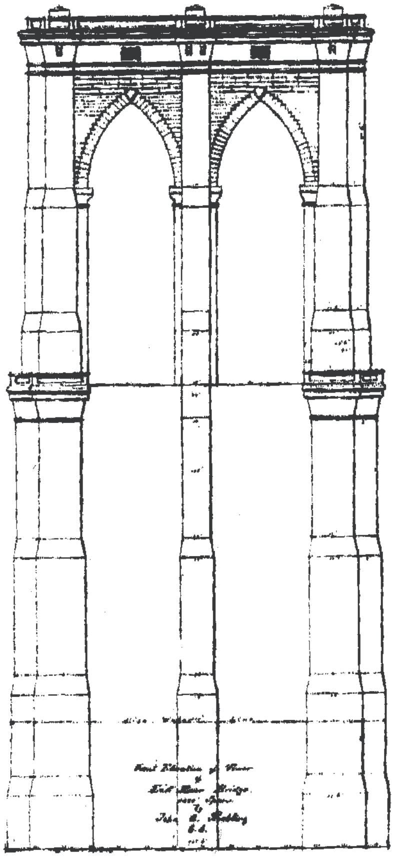
- How will we know whether the curriculum is having the intended effects? What will be the criteria for student performance? How often will major student assessments be made and at what checkpoints? Who will judge what the findings imply?

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.