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ABSTRACT

This study examines to what degree opportunities for scientific literacy were provided or denied to college bound and non-college bound students and the extent to which students utilized the available opportunities. An ethnographic approach was employed in this 3-year study of six high schools. Population descriptions and data are presented for four California schools and two schools in Utah. The schools' science curriculum structure, how opportunities are established, and how they are exercised are examined, as are students' science experiences and the schools' emphasis on the attainment of scientific literacy. Included among the study's findings are indications that: (1) teachers give priority to facts, methods, and attitudes; (2) scientific literacy components did not form an integral part of the curriculum; and (3) the size and make-up of the school population influence course offerings, teaching load, and science requirements. It was suggested that consideration should be given to ways of increasing the range of student choices of science courses and of improving the quality of science instruction for all students. (ML)

Opportunities for Scientific Literacy for High School Students

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Paper presented at the Annual Meeting of the American Educational Research Association, April, 1985

Far West Laboratory for Educational Research and Development

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OPPORTUNITIES FOR SCIENTIFIC LITERACY FOR HIGH SCHOOL STUDENTS

Larry F. Guthrie
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Introduction

Secondary science education has recently received widespread attention in the media and in the government. In the spate of reports on education appearing in 1983, science and technology have consistently been targeted as areas in need of immediate attention.

Concern about the quality of education Americans receive in the scientific disciplines is not new. The launch of Sputnik in 1957 brought about widespread curricular reform in precollege and college science. Emphasis was placed on the preparation of an elite corps of scientists. Today the emphasis has shifted slightly, and many now agree that all Americans must become scientifically literate. The National Science Board Commission on Precollege Mathematics, Science and Technology Education (1983, p. 2) declared that

> . . .during the last years of this century, the position of mathematics, science and technology, historically at the periphery of learning for all but a few American students, must shift to center stage for all.

In this study, therefore, we set out to examine to what degree an appropriate science education was available to all students. We describe the opportunity systems in six high schools and to what extent they develop students who are scientifically literate. More specifically, we were interested in the ways opportunities were provided or denied to college bound and non-college bound students, and the extent to which these students exercise the opportunities available to them. This paper is based upon a three-year study; more complete information is available in the study's final report (Guthrie, Mergendoller, Leventhal, Kauchak, & Rounds, 1984).

We began the study with the proposition that whether or not students attain scientific literacy depends on three factors, 1) how opportunity is established, 2) the exercise of opportunity by students, and 3) students' science experiences.

The opportunities schools establish for students to enroll in science classes depend on entry options and ability and curriculum grouping. If a school's science courses were arranged so that only college-bound students had access to further science courses after the first year of study, for example, we would argue that such a curricular arrangement denied opportunity. In contrast, a science curriculum composed of carefully articulated science offerings for students of different interests and abilities would be judged as facilitating opportunity.

Students exercise these opportunities through their choice of courses; inclusiveness and mobility describe the extent students utilize the opportunities the school has established and involve themselves in science study.

Once enrolled in a science class, students' science experiences, including the nature of the laboratory activities, the effectiveness of instruction, and the emphasis placed upon aspects of scientific literacy, will further influence the degree of <u>scientific literacy</u> students attain.

Despite the increased attention toward fostering scientific literacy, there remains a distinct lack of consensus as to what exactly is meant by the term. As Miller (1983, p. 29) notes, it is a term "often used but seldom defined." While useful as a rallying cry,it is nonetheless an elusive and imprecise concept suggesting different things to different people (Graubard, 1983). There is, however, agreement that scientific literacy is necessarily a multifaceted concept subsuming several areas of learning and experience (Roberts, 1983). In different discussions of this concept, several skills, capacities or attitudes are frequently mentioned.

In an attempt to synthesize current concepts of scientific literacy, we posit an operational definition that includes seven components (1) science facts and concepts, (2) an understanding of the process of scientific inquiry, (3) an understanding of the relationship of science, technology, and society, (4) an understanding of the knowledge necessary to maintain good health, be a successful consumer, and cope with a technological world (science for personal use), (5) an understanding of the history of science, (6) familiarity with vocational or educational opportunities for the further pursuit of science, and (7) the development of informed attitudes toward science.

Methods

This study employed a multiple site case study design to examine the opportunities for scientific literacy in six high schools. While the overall approach was ethnographic, the scope of inquiry was limited to the issues described in the previous chapter. In depth, open-ended interviews were conducted with science teachers, science department heads, counselors, and administrators at each of the schools. Documents such as courses lists, class schedules, course catalogs, student enrollment sheets, and school handbooks were also inspected. Finally, structured obserations were conducted in a wide variety of science classes at each school, and narrative descriptions of the observed classes were develcped and coded.

The emphasis was on a synthesis of findings rather than unique descriptions. Uniform data collection strategies were used in all sites. While telling six distinct stories, we also sought to highlight trends in the opportunities provided students of differing abilities and interests to become scientifically literate at the six schools.

Sample

Four high schools in California and two high schools in Utah were selected as study sites. California schools were selected to provide diversity on several criteria, including school location and enrollment, estimated socioeconomic status of parents, and available data on the science curriculum and school tracking system. Characteristics of the final sample are presented in Table 1.

The sample of six schools represents a diverse set of characteristics. Altogether, two urban schools, three suburban, and one rural school were included. Area populations ranged from under 10,000 to over 600,000, and schools had enrollments that varied from under 500 to nearly 3000. All but one were four-year high schools, housing grades nine through twelve. There were great differences in ethnic representation at the schools. The two schools in Utah were uniformly white, while those in California included a predominantly Hispanic school, a predomiantly Asian school, and two schools where one-fifth the students were Black. The minority enrollment at three of the California schools was 45 percent or greater. The number of science courses ranged from six at Suburban High School in California to 13 at Western High in Utah.

Framework for Analysis of Opportunity Systems

The research reported here employs a case study approach to describe variations in opportunity systems in six high schools. These constructs of opportunity systems and the relationships among them are illustrated in Figure 1.

Science Curriculum Structure

The opportunities students have to become scientifically literate depend, in part, on the science courses available to them. Course availability, in turn, is determined by the structure of the science curriculum. By science curriculum structure we refer to the patterns of science courses navigated by students, and the policies and practices that control their entry to one course and movement to another. The science curriculum structure is the roadmap that describes the sequences of science courses students may pursue.

Since the establishment of course sequences and enrollment control mechanisms occur at the school level, there is considerable diversity in the curricular structure of high schools. Researchers concerned with these issues and their relationship to students' attainments and aspirations have conceptualized the school curriculum structure in various ways. Most commonly, they have focused on the practice of <u>tracking</u> students, or channeling particular groups of students to particular courses (Anderson,

Table 1

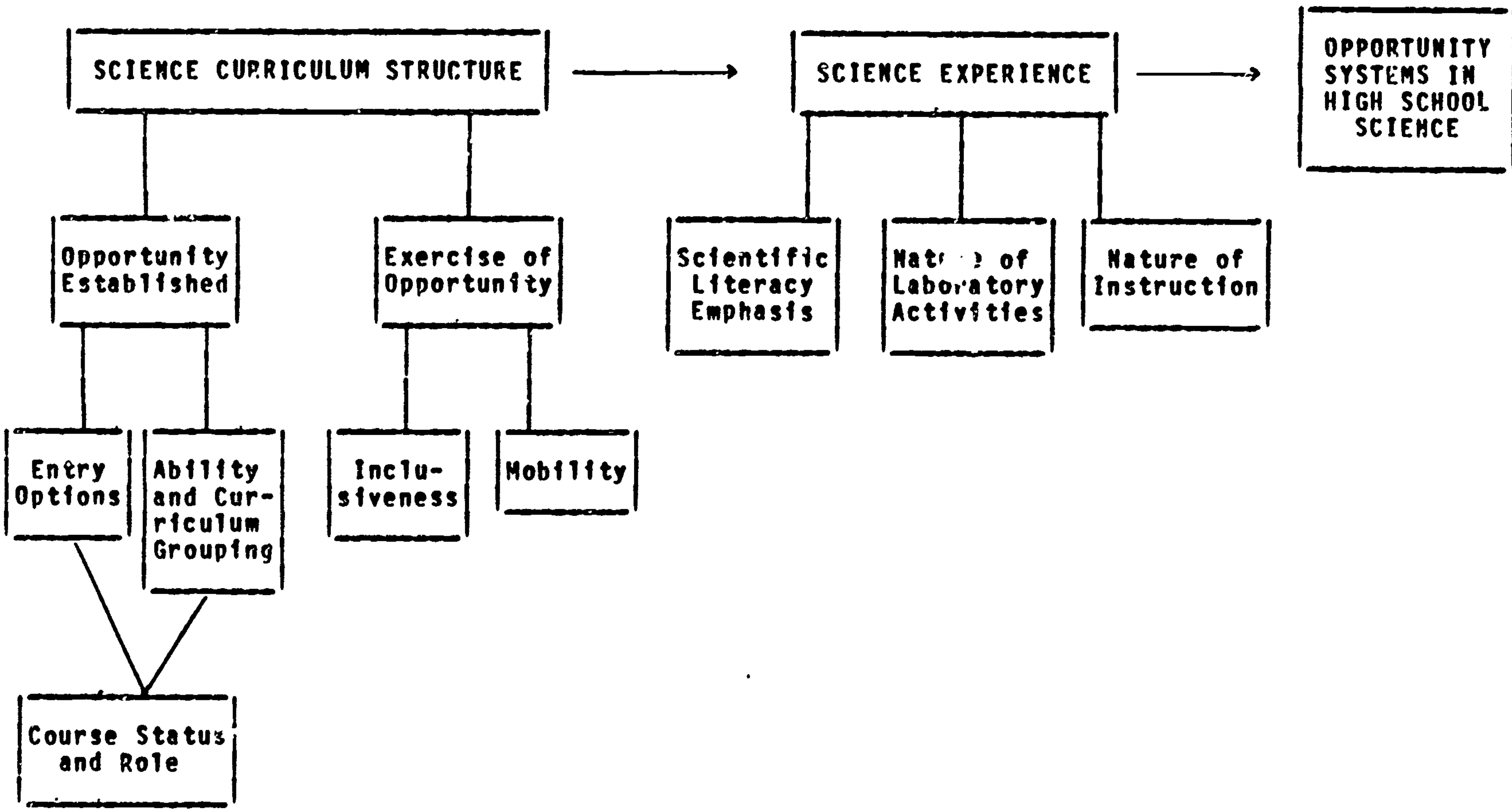
Sample Description

School	Location	Population[a]	School Enrollment	Grades at School	School Ethnic Population					No. of Science Courses Offered
					White	Black	Hispanic	Asian	Other	
California										
Suburban	Suburban	under 50,000	1,571	9-12	67.0%	18.0%	5.7%	8.0%	2.3%	6
Kirkland	Suburban	under 50,000	2,020	9-12	51.7%	9.0%	18.0%	19.7%	1.5%	10
South	Urban	over 500,000	1,148	9-12	16.0%	3.0%	61.0%	20.0%	---	7
Vista	Urban	over 500,000	2,900	9-12	19.0%	18.0%	3.0%	49.0%	11.0%	10
Utah										
Mountain	Rural	under 10,000	483	9-12	98.6%	---	.8%	.6%	---	7
Western	Suburban	over 150,000	1,972	10-12	99.0%	---	.5%	---	.5%	13

[a]To insure anonymity, figures are approximate

Figure 1

Framework for Opportunity Systems for Scientific Literacy



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Cook & McDill, 1978; Bowles & Gintis, 1976; Rosenbaum, 1976, 1978; Schafer & Olexa, 1971; Sorensen, 1970; Turner, 1965). These concepts that were originally used in the analysis of school-level tracking practices, can with slight modifications and additions, also serve as heuristics for understanding the organization of science curriculum structures and their consequences for student opportunity.

Implicit in our thinking is a distinction between the opportunity established by the science curriculum structure of each school, and the opportunity exercised by the students attending the school. Even though structural opportunities to become scientifically literate exist, students may not take advantage of these opportunities. In terms of traditional research design, the opportunities established by the science curriculum structure are independent variables. The opportunities exercised are dependent variables. Note, however, we do not assume a direct relationship between these variables. Instead, we assume that the relationship between opportunities established and opportunities exercised is mediated by other factors such as the demographic characteristics of the student population, the school climate for science learning, and the history and reputation of the science department.

In order to describe adequately the differentiation of students at the six schools in this study, and to draw conclusions regarding their opportunities to become scientifically literate, we have developed the following analytical scheme. The categories described below are in many respects based upon those of other analysts, and we attempt to make clear any significant departures.

Opportunity established. The structure of the science curriculum makes available the opportunity for different groups to learn science. Two factors contribute to the opportunity established, the entry options available and the way in which the curriculum is organized in terms of ability and curriculum grouping.

Entry options. The curriculum path each student follows will to a great extent depend on the number of options students have and the degree of choice. Consequently, we are concerned with the number of options upon entry. The more alternatives available does not necessarily mean students have more choice, however. In order to depict the entry alternatives, we have assessed the grade level at entry; the various criteria for placement; the degree of electivity or sponsorship in the system (i.e., how much choice students have); and the locus of control, or where the primary decision making power resides.

Ability and curriculum grouping. Ability grouping refers to a system in which students are assigned to courses on the basis of assumed ability, and curriculum to differentiation in curricula. In the modern American secondary school, grade differentiation is of course taken for granted, but students may have freedom to enroll in courses in different years.

In order to estimate ability or curriculum differentiation, we have taken into consideration the number of levels (college-prep, general, mixed, and remedial); the number of courses at each level (or the number beyond sorting course); the course enrollments at each level; the grade level at entry; the grade level for differentiation; the degree of divergence and convergence; and the degree of articulation between courses for different students. By divergence, we mean the degree to which recommended sequences are parallel. Articulation refers to the degree to which courses are sequentially patterned in terms of knowledge and skills.

Course Status & Role. Courses with the same title may serve very different functions in one science department or another. Biology at School A, for instance, might be intended as a college-prep course, leading directly to Chemistry and Physics. At School B, on the other hand, it might be a general course that all students are intended to take. While course role and status will necessarily be related to the content of a particular course, it cannot be assumed that, for example, a mixed Biology course at one school is less rigorous than one serving a "college prep" function at another.

We have therefore attempted to determine the role of the Biology course within the curriculum at each school and make comparisons across sites. Since the status and role of each course is an essential element of the Science Curriculum Structure at each school, this analysis has been reserved for the final chapter. The status of a course is based upon whether or not it is remedial, general, mixed or college-prep; terminal or sequential; or meets college entrance requirements. We have also examined the stated curriculum for each Biology course, comparing the topics covered, the texts, and other requirements.

Opportunity exercised. The opportunity exercised depends on the inclusivenessof the curriculum structure and the mobility students enjoy within it.

Inclusiveness. Inclusiveness refers to the degree to which a system leads many, rather than a few, students to a higher level of education. We estimated the inclusiveness by determining the number of courses; the course enrollment & percentages (by track/level and minority); prerequisites (& other criteria) for movement; the graduation and college entrance requirements; the grade level of entry; and the percentage of dropouts in the school/track.

Mobility. Mobility refers to the amount of student movement between tracks, or between different types of courses. Relevant here have been initial placement criteria; prerequisites (& other criteria) for movement; stated policies; informal rules for progressing; the degree of divergence; and the possibility of convergence.

Science Experience

While the science curriculum structure controls students' access to science courses, their experience within the course largely determines what they will learn. Consequently, we have included in our conceptualization of opportunity systems an analysis of the students' classroom experience from three points of view: (1) the emphasis teachers placed upon aspects of scientific literacy; (2) the nature of instruction students experience.

The definition of scientific literacy presented earlier provided a guide for our analysis of classroom instruction. If teachers do not stress scientific literacy, students are not likely to acquire it. At least two factors serve to indicate the degree to which students may gain knowledge and experience associated with the components of scientific literacy. First, teachers' perceptions of what constitutes appropriate curriculum content is important. We therefore interviewed teachers regarding these points and asked them to rate on a 5-point scale the emphasis given the elements of scientific literacy. Second, teachers' attention to scientific literacy in their instruction was noted in classroom observations.

Nature of instruction. We sought to characterize the nature of instruction through observed allocation of time to a variety of instructional formats, and through rating of selected items from the Science Class Description (SCD).

Course Classification

An essential part of the analytic scheme presented here is the way in which we have classified courses by level. Initially, we had thought it might be possible to distinguish tracks into which students were placed and followed for most of their high school carreer. We soon realized, however, that a more accurate approach would be to attempt to classify individual courses, rather than tracks. For one thing, school personnel at most of the sites did not think in terms of tracks, except perhaps in reference to college-prep courses. For another, the explicit policy in the California schools was to deny the existence of tracks. One could not deny, however, that some courses were intended to be more difficult than others, that some were directed at particular populations of students, and that some courses formed a sequence, while others did not.

We arrived at a classification scheme composed of four levels: remedial, general, mixed, and college-prep. <u>Remedial</u> courses are those intended for students with perceived deficiencies, usually in reading or the English language. When school personnel or documents explictly stated, for example, that a course was for students reading below grade level, that course was classed as remedial. <u>College-prep</u> courses are designed to prepare students to take college-level science or at least to gain them entry to universities. These courses almost always are sequential. Mixed courses are ones in which students of varying abilities and interests may be enrolled. There are two types: entry-level courses which all students are expected to take, and second-year courses with only minimal prerequisites, such as a year of science. General courses have, for the most part, a less academic orientation and are intended for students who may have less ability or interest in science. One function of the course often is to serve as the one science course students need for graduation.

Classifications were made primarily on the basis of the descriptions given by school personnel, science teachers, science department heads, counselors, and administrators. They were asked to define the role of each course in the curriculum and its academic orientation, to describe which students enrolled, and to tell whether it fit into a sequence and which one. Individual teachers also described the curriculum, goals, and student enrollment for each course they taught. In addition, we consulted course catalogs and determined which courses met university admission requirements. Finally, we based our decisions on data collectors' impressions of the course after conducting observations. All these pieces of data together gave us a composite view of each course, and allowed us to make our judgements with some certainty.

Results

In the case studies conducted at the six high schools, we describe in detail the opportunity systems for scientific literacy (Guthrie, et al., 1984). In this section, we attempt a synthesis of that information, emphasizing across-site comparisons. Following the order of the opportunity system model, we first examine the science curriculum structures at the schools, how opportunities are established and how exercised. Next, we describe students' science experience, the emphasis on scientific literacy, nature of laboratory activities, and the nature of instruction.

Opportunity Established

The variation in the science curriculum structures is represented in Figures 2 to 7 and Table 2. To compare this feature across schools, we have examined three aspects of the curriculum, (1) the levels offered, (2) the number of courses offered at each level, and (3) whether the courses at a level are part of an articulated sequence. The analysis of ability and curriculum grouping is designed to show the degree to which the curriculum is vertically or horizontally differentiated.

At Suburban High School, students choose from a list of only six courses, and South and Mountain offer only seven courses each. In contrast, a total of 14 different courses are taught at Western High. An obvious explanation for these differences would be the size of the school enrollment and teaching staff, and this certainly accounts for the limited offerings at Mountain, where there are less than 500 students and only two science teachers.

Figure 2

Science Course Chain at Suburban High

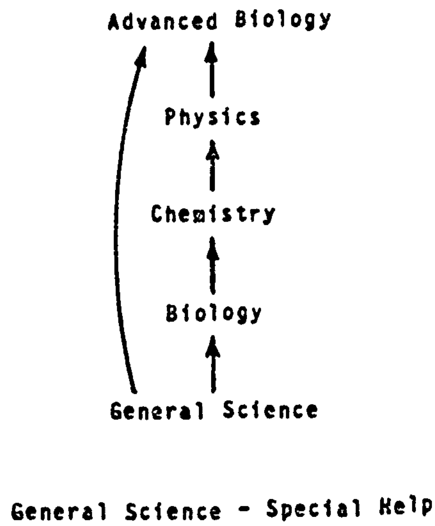

Figure 3

Science Course Chain at Kirkland High

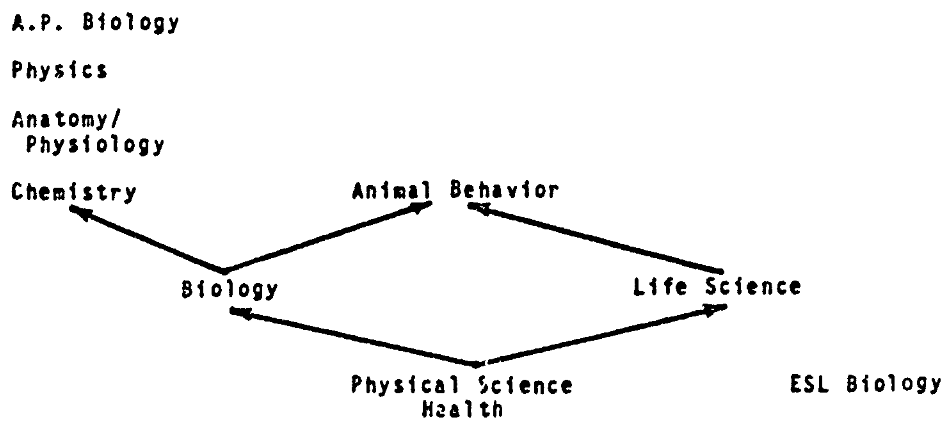

Figure 4

Science Course Chain at Vista High

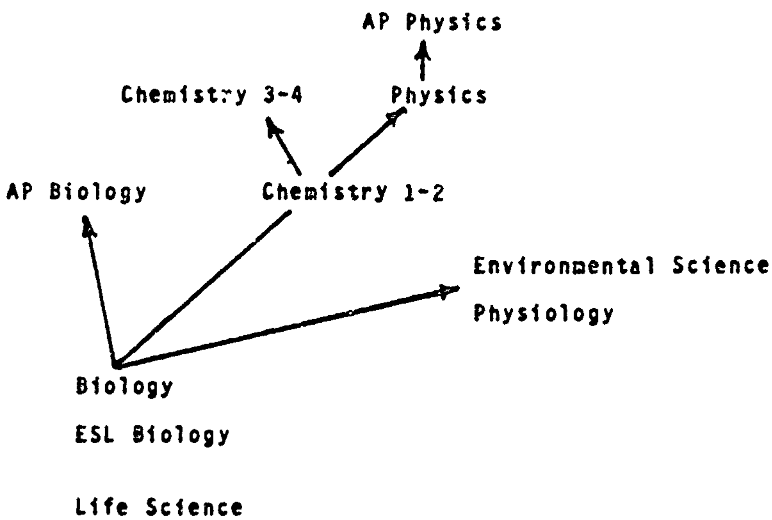

Figure 5

Science Course Chain at South High

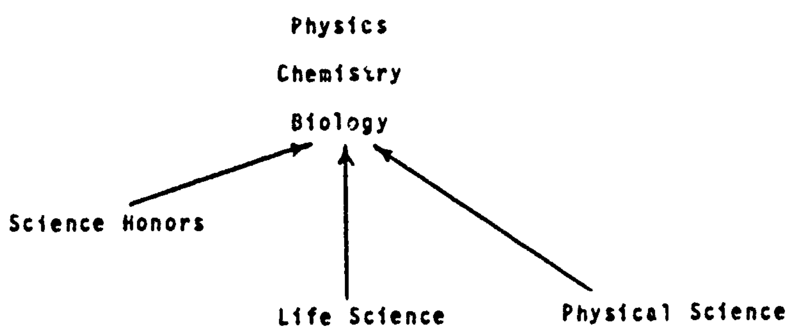

Figure 6

Science Course Chain at Mountain High

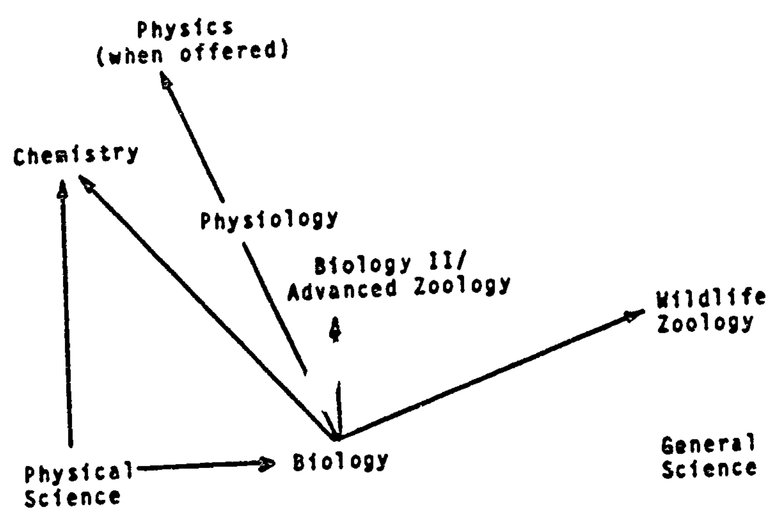

Figure 7

Science Course Chain at Western High

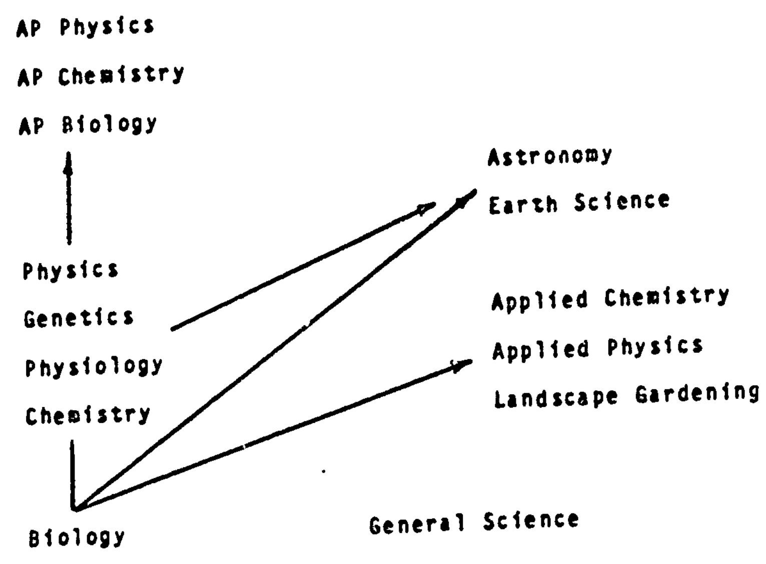

Table 2

Overview of Opportunities Established at Six High Schools

Variables	Suburban	Kirkland	Vista	South	Mountain	Western
	School					
Background						
Courses	6	10	10	7	7	14
Teachers	6	10	9	4	2	6
Average preps.	1.7	2.0	2.1	2.5	3.0	3.5 every two days
Period length (min.)	50	50	50	50	45	85
Graduation requirement for science (years)	one	two	one	one	one year of science plus a second year of either science or math	
Entry Options[a]						
Grade of entry	ninth	ninth	tenth	tenth	ninth	ninth
Levels	R G CP	R M G CP	R M (Adv)[b]	R G CP	R G M	R M (Adv)[b]
Percent at each level	11 43 45	3 88 15 5	16 70 14	3 76 22	15 9 76	0 81 19
Placement criteria	Reading scores	CP=test scores R,M,G=none	R=reading or limited English proficiency; M=none	R=limited English proficiency	R=reading G,M=none	M=none R=reading
Ability and curriculum grouping						
Levels	R G CP	R G M CP	R M CP	R G CP	R GM CP	R G M CP
Courses	1 1 4	1 1 3 5	2 3 5	1 2 4	1 21 3	1 5 1 7
Sequence	N N Y	N N N Y	N N Y	N N Y	N NN Y	N N N Y

[a]Grade of entry is that in which most students enter science. Levels are those available for entry. Percent is based upon number of students in grade of entry at each level.

bStudents in grade of entry enrolled in advanced courses.

Western, however, offers more than twice the number of courses as Suburban with only 400 more students and an equal number of teachers.

There is considerable variety in the ability and curriculum grouping at the six schools. Ability grouping is found at all schools, since each offers a sequence of college-prep courses. College-prep offerings range from three courses at Mountain to seven at Western. Outside the traditional core of Biology, Chemistry and Physics, we find Advanced Biology at Suburban, Anatomy/Physiology and AP Biology at Kirkland, Chemisty 3-4, AP Physics and AP Biology at Vista, Ninth Grade Honors at South, Biology II at Mountain, and AP Biology, Genetics, Physiology, AP Chemistry, and AP Physics at Western.

Only Western, Vista, and Kirkland provide significant alternatives based upon curriculum choices. Western offers six general level courses for students not planning to attend college; Vista offers two mixed courses; and Kirkland offers one mixed course.

Graduation requirements also differ somewhat across the six schools. Three of the California schools currently require only one year of science for graduation; the other, Kirkland, requires two. In Utah, students need a year of science plus an additional year of either science or mathematics for graduation. Teachers and administrative staff seemed to think, however, that most students opt for math in the second year, rather than science. By 1988, all six schools will require two full years of science for graduation; in California, 1987 graduates will need to meet this requirement.

Despite the variety of course offerings at the study one aspect of the curriculum is the same at all six schools; college-prep courses seem to be part of a sequence, while courses at other levels do not.

Policy choices are reflected as well in the number of preparations teachers are responsible for. At Suburban, for example, teachers must prepare an average of 1.7 different courses per day, while at Western the figure is 3.5 periods every two days. However, because of the longer class periods at Western, if calculated in terms of minutes per day, teachers at at Western are responsible for 149 per day, while those at Suburban have to prepare for only 85. The obvious implication of these figures is that the teaching load in the science department at Western is heavier than might be necessary.

Entry options. Factors having to do with entry options, the grade of entry, course levels available for entry and placement criteria, also varied across the schools. Schools recommend that students begin at either grade nine or ten, but in most cases this was not a strictly-enforced policy. The grade of entry listed is the grade at which most students enter the science curriculum. The levels (e.g., remedial, general, mixed, or college-prep) is the type of course in which students are enrolled. The percent is based upon the number of students in the grade of entry enrolled at each level.

Of the six schools we studied, three enrolled most students in science beginning in grade nine, and three in grade ten. At Vista, delaying science a year was a policy fairly strictly enforced. Less than 10% of the ninth graders were enrolled in science. The department at Kirkland took a different approach and required all ninth graders to enroll, in part to allow students four years in which to complete their two year graduation requirement.

One effect of the differences in policy can be seen in the levels of courses students in the grade of entry were taking. As shown on Table 2, the majority of entering students at Kirkland (88%), Vista (70%), Mountain (76%) and Western (81%) began science in a mixed course. At Suburban, about equal numbers went into general (43%) and college-prep (45%) courses, and at South, most entered with a general course (76%). Only Suburban, therefore, had enrolled a large proportion of students in the college-prep path by ninth grade. That school also had a larger proportion in a general course than did the others, except South.

Given the increase in graduation requirements, the question of grade of entry may be moot. Schools will almost certainly begin students in grade nine to allow them more years to take more science. A two-year graduation requirement at Kirkland, however, increased enrollment in lower-level science courses, but appeared to have little affect on the number ot students taking college-prep courses. As schools revise their science course offerings to accommodate the new requirements, they might do well to consider this example. Particular ability and curriculum grouping arrangements also differed from school to school, but in all cases the college-prep courses predominated. These were also the only ones which seemed to comprise a logical response.

Exercise of Opportunity

Inclusiveness. We have defined inclusiveness as the degree to which students of different ablilities and aspirations continue to enroll in science courses beyond the initial course. Table 3 gives the science enrollment percentages by grade at the six study schools. One indication of the inclusiveness of a system is the percent of the school enrollment taking science. Of the six study schools, Kirkland enrolls the greatest percentage of students (73.3%), presumably because two years of science are required for graduation. The smallest number are enrolled at South (38.4%) and Vista (43.7%). The low figure at South is explained by the overall low achievement level of the school and the low enrollment in college-prep courses. At Vista, overall science enrollment is affected by the school policy that recommends that students take their initial science course in grade 10, so that less than 10% of the ninth graders are enrolled. At Kirkland, over 97% of ninth grade students are taking science.

Table 3

Percent Science Enrollment by Grade

SCHOOL	GRADE				
	9	10	11	12	Total
Suburban	45.8	69.6	56.2	43.4	54.2
Kirkland[a]	97.3	100.0	49.3	30.6	73.4
Vista	9.7	70.5	63.3	38.3	43.7
South	18.0	58.1	45.3	33.7	38.4
Mountain	63.2	50.8	65.6	43.1	58.1
Western[b]	----	76.8	49.9	47.7	59.4

[a]Science course enrollment figures reflect initial course enrollments; school level enrollment is end-of-semester.
[b]Grades 10-12 only

Table 4 presents the percent of students enrolled at different levels at the six study schools -- remedial, general, mixed, and college-prep. These figures are an indication of the distribution of students across levels. As a more sensitive measure of inclusiveness, however, we have also calculated the percentages of students taking second-year courses as well as those enrolled in advanced college-prep courses, beyond Biology.

Second-year courses included any of those normally taken after the entry level courses. At different schools, these were college-prep, general, or mixed. Only South failed to enroll more than 20% of the school population in second-year courses. Mountain, Vista, and Western enrolled around 30% each. These higher enrollments at Mountain may be partially explained by the small enrollment of the school; two sections of a course can account for nearly 15% of the students. At Vista, two factors may be contributing to the higher enrollments. First, students normally do not take science until grade ten, and second, Biology is not acceptable for admission to the University of California. In addition, the large Asian population is heavily represented in the upper level courses. The higher enrollments at Western can be partially attributed to the numbers of students taking the general courses, such as Applied Chemistry, Applied Physics, and Astronomy.

Advanced college-prep courses included in the calculation of percentages were all of those other than Biology, which at Suburban, Kirkland, and South was classified as college-prep. While students at most schools may take Biology as a second course, it is always the initial college-prep course. At Kirkland, for example, Biology is the second science course for the majority of students, but most take it in grade ten, following the required Health and Physical Science sequence for freshmen.

Results of this analysis are presented on Table 4 and show that Suburban, Kirkland, Vista, and Mountain all enroll roughly 20% of the school enrollment in advanced college-prep courses. At South and Western, the figure is closer to 10%. Because of the overall student population at South, less participation in college-prep classes is not surprising. Students are largely lower-income Hispanics, and scored near the 30th percentile statewide in reading (Garet & DeLany, 1984). At Western, a different explanation is required. Many students (15.9%) have obviously elected to enroll instead in the array of second-year general courses. The University of Utah accepts any of these courses for admission, and students might also justifiably argue that chances for a good grade are probably better in the applied course.

In general, it appears certain policies regarding the science curriculum structure can affect inclusiveness. Offering mixed second-year courses, such as Environmental Science and Physiology at Vista, seems to raise inclusiveness without diminishing the number of students enrolling in college-prep courses. A range of general courses offered as alternatives to the

Table 4

Percent Science Enrollment by Level

SCHOOL	COURSE LEVEL						
	Percent School Enrollment[a]	Remedial	General	Mixed	College-Prep	Second-year Courses[b]	Advanced College-prep[b]
Suburban	54.2 (1571)	2.8	12.3	----	39.1	20.4	20.4
Kirkland	73.4 (2020)	1.4	14.1	27.3	30.6	20.2	18.4
Vista	43.7 (2703)	4.9[c]	----	24.2	14.6	28.7	21.2
South	38.4 (1148)	---	25.3	----	13.3	9.6	9.6
Mountain	58.1 (465)	5.6	11.2	24.9	16.3	30.6	22.4
Western	59.4 (1972)	3.0	7.3	37.4	11.8	27.7	11.8

[a]School enrollment in parenthesis
[b]Grades 10-12 only
[c]4.1% ESL

college-prep curriculum, however, may have the result of drawing off enrollments from the college-prep courses.

Increased course requirements for graduation has become a rallying cry for educational reform. Raising graduation requirements, however, has not significantly affect the enrollment of students in higher-level science courses, at least as far as Kirkland was concerned. The apparent result at that school was instead to raise the enrollments of ninth and tenth grade students in introductory courses (Table 3).

Mobility. Mobility has been defined as the degree to which students can and do move from one track to another within the curriculum structure. Given course prerequisites, departmental policies, and the courses available, how much do students change tracks. Since the curriculum structures at the schools in this study do not represent tracks in the traditional sense, we have focused on the extent to which students taking general, mixed, remedial classes may later enroll in courses at the college-prep level.

In several schools, however, opportunities for mobility are limited by the fact that many students only take one year of science. For those students originally enrolled in remedial or general classes, therefore, the question of mobility is irrelevant, since they take no further science. At Kirkland, for example, all ninth graders enroll in the Health/Physical Science sequence and are then placed in either Biology or Life Science. For Life Science students to move into the college-prep path would mean taking a third year of science, and very few elect to do so. A similar situation exists at Vista, Mountain, and Western. There are in most cases no rigid restrictions on students enrolling in college-prep science courses, but certain minimal prerequisites do apply.

At Suburban High, ninth graders are enrolled in either a remedial, a general or a college-prep course. After the first year, therefore, remedial and general students face the opportunity for mobility. School policy states that students wishing to enter Biology must read at the ninth grade level, but how strictly that rule is enforced is unclear. There are indications that quite a few General Science students do move on to Biology. At South High, the majority of students take only Life Science, but in general they enjoy considerable freedom of choice, since students are to a great extent responsible for designing their own programs.

Overall, the limited data on mobility that we do have indicate that the science curriculum structures at the study schools do not discourage mobility and in some ways actively encourage it. On the other hand, given the number of science courses students actually take, and the number required to exercise mobility, the issue becomes less relevant. Once graduation requirement are raised, however, and all students have to take two years of science, the question of mobility may take on additional importance.

Course Status and Role. In our examination of science opportunities, the issue of comparability of courses across schools naturally arose. We undertook, therefore, to compare the Biology courses at the six study schools. At three schools, Biology is intended to be a mixed course, providing all students with an introduction to science. At the other three, it gives a more select group entry into the college-prep curriculum.

Our analysis revealed no significant differences in terms of text, curricular topics, or science experience. Where variations did occur, they appeared to be attributable to teacher differences rather than characteristic of the course level. A homogeneous student population does not appear to be a prerequisite for offering a mixed entry-level course. Rather than cheat the college-bound students, the mixed Biology courses may provide additional opportunities for a broader group of students.

Science Experience

Teachers' Emphasis on Scientific Literacy. Once students get access to science courses, their opportunity for scientific literacy is further influenced by the emphasis given the components of scientific literacy and the nature of instruction.

Prior to being interviewed, each science teacher at the six study schools was asked to complete the Class/Schedule Description survey. They rated the degree of emphasis given various components of scientific literacy in instruction on a 5-point scale; this was collapsed to 3 points prior to analysis because teachers tended not to select on the outer limits. Results of this analysis for the entire sample of teachers are given in Table 5.

Teachers at all levels gave the strongest emphasis to facts/-concepts, attitudes, and science methods/process. With the exception of the college-prep teachers, they also emphasized science for personal use to some degree. History of science, science for college, and science, technology and society (STS) seemed to get the most consistently low ratings.

College-prep and general teachers rated facts highest, with methods and attitudes following. Mixed teachers ranked attitudes and facts highest, but reported emphasizing personal use as well. Remedial teachers placed methods first, followed by personal use and facts; attitudes they rated fourth highest. Taken by level, therefore, there is a trend toward an increasing emphasis on science for personal use as one considers levels from college-prep to remedial on the table.

Teachers at all levels reported giving little emphasis to the history of science, and all but the college-prep teachers also rated science for college low. None of the groups of teachers reported giving STS a strong emphasis in their teaching; the

Table 5

Teachers' Ratings of Science Emphasis by Level

Level	n^a	Facts/ Concepts	History of Science	Science Technology in Society	Personal Use	College	Vocation	Attitude	Methods/ Process
Remedial	5	2.40	1.80	1.75	2.60	1.75	1.80	2.50	2.60
Mixed	20	2.65	1.65	1.95	2.53	1.61	1.74	2.70	2.42
General	15	2.80	1.93	2.00	2.57	1.60	2.33	2.47	2.53
College-Prep	20	2.85	1.91	1.88	2.00	2.00	1.94	2.88	2.91
Mean Rating	74	2.75	1.84	1.92	2.29	1.79	1.96	2.73	2.68

$^a n$ = number of teachers

highest rating was from general teachers (2.0). Science for vocation received fairly low ratings from all levels except the general teachers.

These findings suggest that, regardless of the level of a course, teachers tend to emphasize scientific facts/concepts, methods/process, and science attitudes most. Science for personal use seems also to be given some emphasis, depending on the level. Teachers consider the other components of scientific literacy, such as science technology and society, the history of science, and science for vocation to be of less importance to their instructional goals. In a larger sense, these data suggest that the agenda of science educators, as articulated in Project Synthesis (Harms & Yager, 1981), for example, has not made a significant impact on the teachers in these schools. Of the four goal clusters identified by that project, personal needs, societal issues, academic preparation, and career choice, only two are emphasized to a great degree by the teachers in this study.

Nature of instruction. Students' opportunities to become scientifically literate are related to the classroom instruction they receive. Gaining access to classes and laboratories will mean much less if teachers are unable to effectively transmit to students the experiences of laboratory process and the components of scientific literacy. Therefore, in the observation of classes, we have taken into account the teaching behaviors of instructors in order to make an initial judgement of their instuctional effectiveness.

We have sought to characterize the nature of instruction in three ways. First, using the Class/Schedule Description, we asked teachers to estimate the percentage of time allocated to lecture/-recitation, seatwork, and laboratory activities. Second, in our observations of selected lessons, we recorded the time spent in various instructional formats: lecture/recitation, seatwork, discussion, demonstrations, laboratory, instruction by a surrogate, and in classroom management. Third, using the Science Class Description form after each observation, data collectors rated teachers on several factors associated with effective instruction.

Observed time use. A sample of 48 teachers were observed on two occasions each in the spring of 1984. During each observation, the data collector recorded the time spent in a variety of instructional formats. Table 6 displays the results of the analysis of this data by course level across all sites.

Results of the recording of actual time use in classrooms differed somewhat from the instructors' estimates. These data should be interpreted with caution, however. With a limited number of observations of each teacher, the time use reflects the particular activities of the day rather than an average time use for the class. We also made a deliberate attempt to observe lab activities in every class and to avoid tests or films. The percent of time spent in labs, therefore, is probably exaggerated somewhat.

Table 6

Mean Time Use in Science Instruction: Six High Schools[a]

Level	Seat-work	Reci-tation	Discus-sion	Demon-stration	Lab	Surro-gate	Non-Aca-demic	Proce-dures	Transi-tion/Waste	Total
Remedial (n^b=4)	13.4 (23.2)	23.1 (40.0)	---	1.1 (1.9)	11.5 (19.9)	---	.5 (.01)	4.3 (7.3)	3.9 (6.7)	58
Mixed (n=12)	14.3 (27.2)	12.4 (23.6)	---	.13 (.2)	14.9 (28.4)	2.9 (5.6)	.25 (.5)	2.9 (5.5)	4.7 (8.9)	50
General (n=9)	15.1 (22.3)	22.9 (33.8)	1.3 (1.9)	2.7 (3.9)	16.1 (23.7)	1.4 (2.0)	.7 (.97)	1.0 (1.5)	6.7 (9.9)	68
College-Prep (n=23)	8.1 (14.8)	19.9 (36.2)	1.6 (2.9)	1.7 (3.1)	14.7 (26.6)	2.2 (3.9)	.3 (.5)	3.3 (6.0)	3.3 (5.9)	55
Total percent	11.4 (20.1)	18.8 (33.1)	.99 (1.7)	1.4 (2.5)	14.7 (25.8)	2.0 (3.6)	.4 (.6)	2.9 (5.1)	4.3 (7.5)	57

[a]Number in parentheses is percentage
[b]n = number of teachers observed on two occasions

In the science classes we observed, the greatest amount of time-use was in lecture/recitation and lab activities. If we discount time use in peripheral activities like transitions, procedures, non-academic instruction, and discussions, aspects of instruction teachers did not include in their time estimates, the observed time use in various instructional formats is quite similar to the time use reported by teachers. For the total group of classes, the most common format was recitation, lab was second, and seatwork was the third. We saw very little use of certain types of activities, such as group discussion, and there were examples of instruction in non-academic areas. We wanted to observe teaching rather than materials produced in other contexts, and therefore observers avoided days when films were the major activity. Still, surrogate instruction (use of films, videos, or guest lecturers) was observed to a small degree and seemed to depend on individual teachers' styles.

The correspondence between estimated and observed time use was highest for the college-prep courses, where discounting peripheral activities, they followed the same relative order. The teachers' estimates and observed time use in mixed and general class were similar as well. The greatest discrepancy in figures was in the remedial course, where lab time was lower and lecture time considerably higher than teachers gave as an overall prediction of time usage.

Ratings of teaching behavior. After each observed lesson, data collectors completed the Science Class Description form, which contains 25 items associated with effective instructional behavior. Ratings on each item were based on a 5-point scale, and we have selected eight for analysis which seemed to form a composite of good teaching. Table 7 lists the Science Class Description items and mean ratings by level across the entire sample of teachers. Analyses of variance were conducted on the aggregated rating data for each teacher; $\underline{F}$ values are included in the table.

Results of the analysis showed that teachers of college-prep courses were rated highest on six of the eight items. The differences in three of these were statistically significant ($\underline{p}$ < were rated highest for monitoring lab and seatwork (item 24), and there appeared to be no differences in teachers' positive attitude about learning potential (item 28).

These findings suggest first that overall, the teachers in the college-prep courses practice more of those instructional behaviors believed to be associated with effective teaching. They especially seemed better prepared (item 9), more efficient in classroom management (item 22), and used time well, pacing the period (item 29). In addition, they maintained student attention (item 3) to a greater degree than did teachers at other levels, gave clearer directions (item 13) and were rated as more effective overall.

Table 7

Mean Ratings of Instructional Behavior by Course Level:

Six High Schools

Item No.	Item	Remedial (n=4)[a]	Mixed (n=12)	General (n=9)	College-prep (n=23)	Total (n=48)	F
		Course Level					
3	maintains student attention	3.63	3.58	3.44	4.19	3.85	2.29*
8	overall effectiveness of activities	3.13	3.25	3.59	3.94	3.64	2.48*
9	preparation for instruction	3.00	3.04	3.50	3.91	3.54	3.18**
13	clarity of teacher's directions	3.25	3.54	3.76	4.07	3.81	2.28*
22	efficiency of classroom management	3.25	3.21	3.19	4.06	3.61	3.08**
24	monitors lab and seatwork	4.25	3.17	2.50	3.10	3.10	2.59*
28	positive attitude about learning potential	3.25	3.46	3.33	3.86	3.61	0.924
29	paces period	3.38	3.08	2.30	3.61	3.21	3.209**

[a]n = number of teachers
*p = <.1
**p = <.05

The higher ratings of the college-prep teachers might be partially explained by the assumed make-up of their classes and the subject matter content. More academically-oriented students, for example, might be expected to pay attention more in class and to create an impression of effective classroom management. Their performance would also contribute to the overall effectiveness of activities. In addition, it seems that explanations of the more complex concepts covered in advanced college-prep courses might create the appearance that teachers are better prepared. By the same token, however, the lower rating college-prep teachers received for monitoring lab and seatwork might be attributed to their perception that college-prep students can work independently. Teachers in remedial classes had to provide more guidance and supervision than did their college-prep counterparts. Finally, it should be pointed out, however, that all of the ratings were relatively high, on all items. Only on two items was the mean rating less than three on a 5-point scale.

These qualifications aside, however, college-prep teachers did receive consistently higher ratings on most of the instructional behaviors associated with effective teaching. This is an indication that those students in college-prep courses may be receiving better instruction. Opportunities for science literacy are increased if one can gain access to those courses. Another possibility is that those teachers currently responsible for only college-prep courses might be asked to teach a wider range of students. While it is true that the some of the teachers in our sample were teaching across levels, we did not compare individual teachers' instruction across levels. For the most part, ratings of teachers at the mixed and general levels fell somewhere in between those of the remedial and college-prep instructors. On most items, however, their ratings were below the mean score for the overall sample.

Conclusion

Cross-site analysis of teachers' responses to the science emphasis survey indicate that teachers give priority to facts, methods, and attitudes. Science for personal use is emphasized somewhat by teachers at all levels, but mostly teachers of remedial and mixed courses. The other components of scientific literacy, (science, technology and society, history of science, and science for vocation) are more peripheral concerns. As pointed out above, these findings suggest that the priorities of national leaders in science education have influenced classroom teachers very little, if at all. Pressures to "cover the curriculum" and emphasize "the basics" have meant science applications take a back seat in their instruction. When interviewed, many teachers seemed to have well-articulated notions of scientific literacy issues, and several reported devoting class time to the different components. Our observations showed that while science literacy components were occasionally introduced into instruction, for the most part they did not form an integral part of the curriculum.

Students in college-prep courses may thus have increased opportunities for scientific literacy because of the instruction they are exposed to. This suggests that if opportunities for all students are to be increased, then teaching at the remedial and other levels must be improved. Teachers of college-prep classes might also be required to teach more of the introductory and remedial classes. There was a definite trend in the schools we studied to assign the non-expert teachers to the lower-level courses.

Local context factors such as the size and make-up of the school population no doubt influence policy decisions at the school regarding course offerings, teaching load, and requirements. It also appears, however, that these choices reflect more basic educational goals. The stream-lined science curriculum at Suburban and the eclectic offerings at Western provide contrasting examples. These choices affect the workload of teachers, the organization of the school day, and graduation requirements.

Opportunity seems to be increased when these factors are balanced against each other, so that students of varying interests and abilities are provided options, while teaching responsibilities are kept at manageable levels. Longer class periods are an attractive alternative and ways of acommodating them are worth exploration. The controversy which may arise from such policy changes, however, was described in the study of Mountain High.

The findings of the study have implications both for both teacher training and inservice and for the design and implementation of science programs. For teacher training, attention should be given to raising the level of awareness of teachers regarding the importance of scientific literacy. Consideration should also be given to raising the quality of teaching across courses of different levels. Our findings indicated, for example, that the instruction in college-prep classes was generally superior to that in other courses. In the design and implementation of programs, consideration should be given to ways in which aspects of the science curriculum structure can be manipulated to increase the range of students' choices and the quality of their science experience. The offerings for students of different interests, the entry options and the degree to which students take higher levels of science should be examined. Finally, the ways in which policies are implemented at the school level should be scrutinized. Raised graduation requirements, for example, may increase enrollments at lower levels, but not in advanced courses.

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