PACE

POLICY ANALYSIS FOR CALIFORNIA EDUCATION

Policy Paper No. PP88-2-1

Math, Science, and Foreign Language Instruction in California: Recent Changes and Prospective Trends

Helen H. Cagampang
James W. Guthrie

February 1988

This analysis was funded in part by a grant from the State Department of Education. A smaller, technical version of this analysis was delivered to the Department in 1987. Continuing interest prompted publication in this expanded format.

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Executive Summary

California's increased high school graduation and college entrance requirements have changed course-taking patterns among California high school students. Enrollment has increased in all levels of math, science, and foreign language instruction. More students are enrolled in advanced placement classes. In addition, California's new state frameworks for math, science, and foreign language contain state-of-the-art instructional guidance for district curriculum leaders and teachers. These accomplishments reflect the goals of recent school reforms and address the belief that in order to be competitive in tomorrow's economy, students need to develop competences in math, science, and foreign language.

In contrast, policy makers and analysts have questioned whether there is a sufficient supply of fully qualified and appropriately credentialed math, science, and foreign language teachers; whether secondary students take enough advanced math, science, and foreign language courses to prepare for college work in these fields; and whether all students are equally likely to enroll in advanced classes.

Policy makers currently have little information on these topics, such as the qualifications of current teachers, number teaching "out of field," and impact of state licensing requirements on teacher supply. Nor is there adequate information on enrollments in advanced math, science, and foreign language classes or on accessibility of these classes to members of traditionally underserved minorities.

To address this gap, we examined information from four public data bases and three independent surveys conducted specifically for this report. The resulting analyses regarding student enrollment in math, science, and foreign language classes, teacher supply and demand, and state policies affecting math, science, and foreign language instruction are offered as 1985-86 benchmarks against which to measure California's future performance. Highlights include the following:

- Public high school enrollment in math, science, and foreign language has increased sharply in recent years. Corrected for student population changes, enrollment in secondary math, science, and foreign languages increased by 1 percent, 27 percent, and 21 percent, respectively, between 1981-82 and 1985-86. During this same period, high school graduation and college entrance requirements increased.

- Although equity gains have been made over earlier years, female, black, and Hispanic students continue to be underrepresented in advanced math and physical science courses, while male students are underrepresented in foreign language and life science courses.

- More attractive wages and working conditions in private industry for individuals trained in math and science have resulted in a serious shortage of teachers in these areas.

- In order simply to place teachers in math and science classrooms, schools have used more than 5,600 teachers with temporary and emergency credentials in the last five years. Districts reported that 1,500 teachers of math, science, and foreign languages had emergency credentials or requirement waivers in 1985-86.

- Nearly one-third of high school math students and one-fifth of science students are taught by teachers who are not fully credentialed.

- Given projected enrollment increases and teacher attrition, California will require approximately 7,000 new math, science, and foreign language teachers by 1991-92, even if there is no decrease in average class size. An additional 1,700 teachers would be needed to staff every classroom with a teacher fully qualified in these subjects.

- The number of individuals entering teacher training institutions has increased as much as 300 percent in some subject areas, as has the number of individuals two or more years out of college who are considering applying to a teacher training program.

- When all factors affecting supply and demand are balanced, projections indicate a continuing teacher shortage in these subjects in the densely populated areas of Southern California. As a result, it is likely that a substantial portion of math and science classes will continue to be taught by teachers who are not fully qualified.

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Policy Analysis for California Education

Policy Analysis for California Education, PACE, is a university-based research center focusing on issues of state educational policy and practice. PACE is located in the Schools of Education at the University of California, Berkeley and Stanford University. It is funded by the William and Flora Hewlett Foundation and directed jointly by James W. Guthrie and Michael W. Kirst. PACE operates satellite centers in Sacramento and Southern California. These are directed by Gerald C. Hayward (Sacramento) and Allan R. Odden (University of Southern California).

PACE efforts center on five tasks: (1) collecting and distributing objective information about the conditions of education in California, (2) analyzing state educational policy issues and the policy environment, (3) evaluating school reforms and state educational practices, (4) providing technical support to policy makers, and (5) facilitating discussion of educational issues.

The PACE research agenda is developed in consultation with public officials and staff. In this way, PACE endeavors to address policy issues of immediate concern and to fill the short-term needs of decision makers for information and analysis.

PACE publications include Policy Papers, which report research findings; the Policy Forum, which presents views of notable individuals; and Update, an annotated list of all PACE papers completed and in progress.

Math, Science, and Foreign Language Instruction in California: Recent Changes and Prospective Trends

California's increased high school graduation and college entrance requirements have changed course-taking patterns among California's high school students. More college preparatory classes are being taught; at the same time, fewer general and vocational classes are offered. Enrollment has increased in all levels of math, science, and foreign language instruction. More students are enrolled in advanced placement classes. In addition, California's new state frameworks for math, science, and foreign language contain state-of-the-art instructional guidance for district curriculum leaders and teachers.

California still has much to do, however, before there is an appropriately credentialed teacher in every math, science, and foreign language class and before students of all racial and ethnic groups and both genders are equally likely to enroll in advanced classes.

This raises several concerns. While California has always imported education talent, its diversified economy has also provided a social and economic ladder for those less well educated, and members of groups who traditionally have not pursued higher education compose an increasing share of the state's population. But anticipated economic changes arising from an increasingly technological industrial base will make upward mobility more difficult for persons less well educated (McCarthy and Valdez 1986). As California's future economic competitiveness is believed to be closely linked to the quality of elementary and secondary education, demanding programs in math, science, and foreign language for a broad range of students may enhance the state's economic position as well as serve the personal aspirations of its citizens.

Similarly, the quality of California's future teachers depends in part on how well today's students are prepared for college. Only with adequate high school preparation can students complete demanding majors and consider careers which require advanced preparation. Assessments, contained in this report, of student enrollment in math, science, and foreign language classes, teacher supply and demand, and state policies regarding math, science, and foreign language instruction may fill a need for information and provide 1985-86 benchmarks against which California can measure its progress.

Organization of this Report

Following a summary of methodologies, procedures, and sources of data, Section One of this report contains information about students in secondary (grades 9 through 12)

math, science, and foreign language courses. Instructional time spent at elementary and middle schools on these subjects is reported.

Section Two describes factors that influence teacher supply and demand in math, science, and foreign language in California. The impact of working conditions on teacher supply, ascertained from a stratified random sample of public and private school teachers, is discussed. Qualifications and demand for both public and private school teachers are compared. Demand for teachers in math, science, and foreign language is estimated using subject-specific enrollment forecasts, and future supply is approximated from various sources of supply. An upper and a lower bound for both demand and supply is developed. The potential for shortage of qualified personnel is evaluated.

Section Three contains descriptions of programs to increase enrollment and college-going rates of members of underserved minorities. California's Performance Report for Schools and its curriculum frameworks, which embody state-level policy and curriculum guidance, are described. Teacher certification requirements are summarized.

Section Four contains a summary of findings and policy implications.

Summary of Methodologies, Procedures, and Sources of Data

California's Basic Educational Data System (CBEDS) was used to determine student ethnicity and gender (1985-86 School Information File–SIF) and teacher assignments and qualifications (1981-82, 1985-86 Professional Assignment Information File–PAIF). Student enrollment projections were prepared by the California Department of Finance (DOF).

Information on California teacher credentials is maintained by an independent agency, the Commission on Teacher Credentialing. Based on their published reports and additional data compiled specifically for this report, the rate of increase in the number of credentialed teachers was approximated. Attrition and re-entry information is provided for all K-14 employees by the State Teachers Retirement System (STRS). Educational Testing Service, which administers the California Basic Educational Skills Test (CBEST) for the Commission on Teacher Credentialing, analyzed data about CBEST test takers for this report.

In addition, a stratified random sample of secondary public and private school math, science, and foreign language teachers was surveyed. The sample, provided by Market Data Retrieval, was representative of urban, rural, suburban, low- and high-income districts throughout California. Fifty-nine percent of public school teachers surveyed (652 of 1,100) and 57 percent of private school teachers surveyed (200 of 350) responded.

Thirty-seven private school principals chosen from the 1986 State Department of Education Directory to represent the range of California private schools–evangelical to secular, low income to high income, rural to urban–also responded to a survey.

A three-step process was used to increase the rate of return for all three surveys: an introductory postcard, the survey, and a follow-up survey were mailed at one-week intervals. Surveys were formated as booklets and were accompanied by stamped, self-addressed return envelopes. A cover letter described the purpose and importance of the study.

Section One
Student Participation and Performance

This section describes 1985-86 secondary public school enrollment in math, science, and foreign languages, and teachers' perceptions of minority students' persistence in the advanced classes. It also reports time allocated in elementary and middle schools to these subjects. Data from both public and private schools is presented. Public school data were obtained from the California Basic Educational Data System (CBEDS), School Information File (SIF), and from a survey of teachers. Private school data were obtained from surveys of private school principals and teachers.

Enrollment in Math, Science, and Foreign Language Classes

Corrected for school population changes, enrollment in math, science, and foreign language classes for students in grades 9 to 12 increased between 1981-82 and 1985-86. Math enrollment, which increased 2 percent, includes students in consumer math and remedial classes as well as students in calculus. Similarly, the number of students enrolled in all levels of science, from general science to advanced placement physics, increased 27 percent. The number of language students, enrolled in classes as diverse as Spanish 1 and advanced placement Latin, increased 21 percent during this period. While some students enrolled in more than one class in each subject area in the same year, for example, Latin 1 and French 5, increases of this magnitude largely represent additional individuals, rather than the same individuals taking additional classes. These striking increases are a result of both a nationwide climate of school improvement as implemented by state legislatures and local boards of education and three specific changes adopted by the state legislature and institutions of higher education:

- Beginning with the graduating class of 1986-87, two years of science, two years of math, and one year of foreign language or fine arts are required for high school graduation (Senate Bill 813).

- The University of California (UC) and the California State University (CSU) increased admission requirements for high school students graduating in 1988 and thereafter (Table 1).

- UC, CSU, and many private colleges and universities now award extra weight for grades earned in honors and advanced placement classes.

TABLE 1

Graduation Requirements Established by SB 813 and Recommended By the State Board of Education, Admission Requirements for CSU and UC

Subject	SB 813	State Board of Education	CSU Required 1988	UC Required 1986
English	3[h]	4	4	4
Mathematics[g]	2	3	3	3
Algebra		(1)		
Geometry		(1)		
Science	2	2	1[d]	1[d]
Physical	(1)	(1)		
Life	(1)	(1)		
Social Studies	3	3	1[e]	1[e]
World Civ.	(1)	(1)		
U.S. History	(1)	(1)	(1)	(1)
Ethics		(.5)		
American Gov.	(1)[a]		(1)	(1)
Economics		(.5)		
Foreign Language	1[b]	2[c]	2[c]	2[c]
Fine Arts	1[b]	1	1[f]	
Computer Studies		.5		
Physical Education	2			
Electives			3	4

[a] Including civics and economics
[b] One year foreign language or fine arts
[c] Must be in same language
[d] Lab required
[e] U.S. History/Government
[f] Visual and performing arts
[g] Including remedial arithmetic
[h] Numbers represent years

SOURCE: California Postsecondary Education Commission and California State Department of Education.

Distribution of Math Enrollment

Math enrollment is concentrated in introductory level classes, but distribution between levels changed substantially between 1981-82 and 1985-86 (Table 2). Enrollment in remedial math classes declined 16 percent (corrected for enrollment growth), and enrollment in algebra and plane geometry increased 23 percent.

During the same period, enrollment in intermediate algebra and fourth-year math classes decreased slightly (4%). Enrollment in advanced placement (AP) math increased 36 percent, doubtless in response to change in calculating grades earned in AP classes. Nevertheless, fewer than three percent of more than one million math students enrolled in advanced math courses.

Nearly 70 percent of high school math students are enrolled in remedial and beginning courses. Thirty percent of high school students continue to receive remedial instruction, which, according to ***The Math Framework***, should have been completed in junior high school.

Distribution of Science Enrollment

While total science enrollment has increased, enrollment data indicate that it is concentrated in lower-level general science classes (Table 2). Ninety-five percent more class sections of introductory science were offered in 1985-86 than in 1981-82, and enrollment increased from 189,000 to 348,000 students, an increase of 38 percent, corrected for enrollment growth. Introductory classes account for 61 percent of the enrollment increase during this period. Actual enrollment in the three staples of high school science–biology, chemistry, and physics–increased 22 percent, 52 percent, and 30 percent, respectively, but some advanced and specialized sections were eliminated during the same period. The number of astronomy, aerospace, and aviation education sections, for example, declined by 14 percent between 1981-82 and 1984-85. Science for the gifted and talented is no longer offered, although nearly 7,000 students were enrolled in 202 sections in 1981-82.

Distribution of Foreign Language Enrollment

Foreign language enrollment increased in both introductory (first and second year) and advanced sections, 21 percent in the former and 62 percent in the latter (Table 2). Despite the increased enrollment in advanced classes, less than 20 percent of foreign language students are enrolled in third year and above. Enrollment in fourth year and

honors foreign languages cannot be evaluated because it is not listed separately on CBEDS. Combination classes account for eight percent of advanced foreign language enrollment, indicating that foreign language teachers frequently instruct combined levels during the same class period. Foreign language teachers in our survey reported that they often taught three levels of the same language in the same class period. Thus, a French teacher might teach second-, third-, and fourth-year students during the same hour. While second-year students might benefit from exposure to more advanced topics, fourth-year students probably receive less effective instruction in a combined class.

TABLE 2

Enrollment in Math, Science, and Foreign Languages, Grades 9 to 12, 1981-82 and 1985-86 (Corrected for Enrollment Growth)

	1981-82 Enrollment	1985-86 Enrollment	Percent Change
Remedial Math	365,995	319,738	-16%
Algebra and Plane Geometry	355,544	454,677	23%
Other Math	265,398	266,404	-4%
Advanced Placement Math	10,262	14,574	36%
Total Math	997,199	1,055,393	2%
Introductory Science	189,017	347,943	77%
Other Science	409,297	510,469	20%
Total Science	598,314	858,412	38%
First, Second Year Foreign Language	308,026	389,393	21%
Advanced Foreign Language	57,061	96,319	62%
Total Foreign Language	365,087	485,712	28%

SOURCE: California Basic Educational Data System, 1981-82, 1985-86.

More than 75 percent of first- and second-year foreign language class sections are Spanish (8,500 of 13,000). Only 67 sections (1,656 students) of introductory Asian languages of the Pacific Rim–Japanese, Chinese, Korean, and Vietnamese–are offered. Elementary and advanced Russian are studied by 600 students, or 0.1 percent of foreign language students.

It is difficult to know what to make of the large proportion of enrollment in introductory courses. On one hand, more students may be starting preparation for advanced study. On the other hand, students may be fulfilling new graduation requirements with general track classes, especially in science, where courses are traditionally discrete and not cumulative. When schools are preparing to meet more

rigorous requirements, enrollment may be concentrated more heavily in introductory classes because students lack appropriate preparation and faculties lack appropriately qualified teachers. A better judgment about the distribution of enrollment must wait until new standards have been in place longer.

Distribution by Ethnicity and Gender

In all of California in 1984-85, only 6,515 Hispanic and 3,312 black high school graduates completed the "a-f" requirements necessary for UC admission (Table 3). That represents 15 percent of Hispanic and 17 percent of black graduates, but an even smaller proportion of the age cohort because of the large number who drop out. Comparable percentages for other ethnic groups reported on CBEDS are: 14 percent of American Indian, 42 percent of Asian, 22 percent of Pacific Islander, 31 percent of Filipino, and 27 percent of white graduates. Similar differences in levels of enrollment can be found by gender and ethnicity in science, math, and foreign languages.

TABLE 3

Number of Graduates and Graduates Meeting a-f Requirements by Ethnicity, 1984-85

	Graduates	a-f Graduates	a-f Grads as % of Graduates
American Indian	1,839	254	13.8
Asian	16,788	7,093	42.2
Pacific Islander	1,208	269	22.3
Filipino	4,512	1,393	30.9
Hispanic	42,386	6,515	15.4
Black	19,285	3,312	17.2
White	141,008	38,698	27.4
Total	227,026	57,534	25.3

SOURCE: California Basic Educational Testing System, School Information File, 1985-86.

Students in advanced math (third-year math or second-year algebra) and physical science courses in 1985-86 in California were more likely to be Asian or white, and male. For example, Asians constituted only seven percent of total high school enrollment, yet 13 percent of algebra students, 21 percent of advanced math students, 20 percent of chemistry students, and 14 percent of physics students were Asian. One in three Asian high school students was enrolled in algebra or advanced math (intermediate algebra) at one

extreme, while at the other extreme only one of 17 Hispanic high school students was enrolled in those classes. Twenty percent of Asians, 14 percent of Filipinos, 10 percent of whites, 5 percent of blacks, 4 percent of American Indians, and 4 percent of Hispanics were enrolled in physics and chemistry (Table 4). Based on teacher reports, these percentages may understate actual percentages of ethnic minority enrollment. Schools and teachers have been observed to group successful minority students with white students rather than their actual ethnic group.[1]

Males are more likely to take science classes which require math proficiency. Males are also more likely to complete more years of math and science in high school. In contrast, enrollment in algebra and accelerated math in junior high school is evenly distributed by gender. The disparity between male and female enrollment in science classes is most pronounced in advanced physics, the science class most heavily dependent on mathematics. In 1985-86, 37 percent of 2,700 advanced physics students were female.

Eighty-six percent of male freshmen entering UC Berkeley in 1983 and 1984 had taken four or more years of high school math, compared to 76 percent of female freshmen. Although nearly the same percentage (60%) of males and females had completed one year or less of biological sciences, 75 percent of males had completed two or more years of physical science, compared to 63 percent of the women. Twice as many males (5.7%) as females (2.8%) had completed four years of physical science in high school (Frank 1985).

With the notable exceptions of black and Filipino females, males of all ethnic groups are more likely to enroll in high school physics and chemistry (54%) than females (46%) (Table 5); however, students in advanced life science and foreign language classes are more likely to be female (Table 6). In 1985-86, 60 percent of 18,000 physiology students and 56 percent of 3,500 anatomy students were female. Five thousand more females than males enrolled in biology. Females are also more likely to enroll in both beginning and advanced foreign language classes than are males. Fifty-five percent of students in introductory foreign language classes and 58 percent of students in advanced foreign language classes were female. Females entering UC Berkeley in 1983 and 1984 were more likely to have completed three or more years of high school foreign language. Seventy-seven percent of females had done so, compared to 66 percent of males (Frank 1985).

Information on the extent to which handicapped and gifted students enroll in math, science, and foreign language classes is not available from CBEDS. Teachers who responded to our survey reported that handicapped students rarely enroll in advanced classes, while gifted students are more likely to enroll. Private schools in our sample reported no handicapped students. Also, most private schools in our sample did not identify gifted students; therefore, they could not comment on enrollment or persistence

[1] Judith Bodenhausen raised this issue.

TABLE 4A

Ethnic Group as Percent of Total Enrollment and as Percent of Enrollment in Algebra, Advanced Math, Chemistry, and Physics, 1985-86

	Ethnic Group as Percent of Total Enrollment	Percent Algebra Enrollment	Percent Adv. Math Enrollment	Percent Physics Enrollment	Percent Chemistry Enrollment
American Indian	0.8	0.6	0.4	0.4	0.4
Asian	6.8	12.8	20.6	20.1	14.0
Pacific Islander	0.5	0.5	0.5	0.5	0.4
Filipino	1.9	2.6	3.1	3.4	3.0
Hispanic	23.6	12.7	9.4	8.3	12.3
Black	9.6	6.2	4.0	4.3	6.3
White	56.7	64.6	62.0	63.0	63.6

Table 4B

Total Enrollment in Grades 9 to 12 and Enrollment in Algebra, Advanced Math, Chemistry, and Physics By Ethnic Group, 1985-86

	Total	Percent Ethnic Group in Algebra	Percent Ethnic Group in Adv. Math	Percent Ethnic Group in Physics	Percent Ethnic Group in Chemistry
American Indian	12,777	5.9	2.2	1.1	3.1
Asian	101,087	15.5	15.1	7.0	12.9
Pacific Islander	6,962	8.8	5.5	2.6	5.6
Filipino	28,221	11.3	8.2	4.3	10.0
Hispanic	353,617	4.4	2.0	0.8	3.3
Black	144,317	5.3	2.1	1.0	4.1
White	848,113	9.4	5.4	2.6	7.0
Total	1,495,094				

Note: Members of minority ethnic groups may be undercounted because of teacher misidentification.
SOURCE: California Basic Educational Testing System, School Information File, 1985-86.

TABLE 5

Female Enrollment in Four Subjects By Ethnic Group, 1985–86

	Algebra		Advanced Math		Chemistry		Physics	
	Total Enrollment	Percent Female	Total Enrollment	Percent Female	Total Enrollment	Percent Female	Total Enrollment	Percent Female
American Indian	756	43	280	45	395	47	142	33
Asian	15,709	47	15,214	45	13,068	46	7,081	40
Pacific Islander	615	47	383	51	392	51	182	35
Filipino	3,201	51	2,319	46	2,825	52	1,205	46
Hispanic	15,581	49	6,935	56	11,538	49	2,940	39
Black	7,679	56	2,983	45	5,898	57	1,504	50
White	79,387	49	45,792	45	59,556	48	22,223	37
TOTAL	122,928		73,906		93,672		35,277	

SOURCE: California Basic Educational Testing System, School Information File, 1985-86.

among this group of students. The remainder indicated that nearly all their students were gifted. CBEDS contains statistics on enrollment by race or ethnicity only in algebra, advanced math, chemistry, and physics, so it is not possible to report the frequency with which members of racial or ethnic minorities enroll in other classes. CBEDS information for 1986-87 will contain that data, however, as well as data on ethnic group enrollment in all science classes which meet University of California admission requirements.

TABLE 6

Enrollment in Elementary and Advanced Math, Science, and Foreign Language Classes By Gender, Grades 9 to 12, 1985-86

Class	Enrollment	Percent Male	Percent Female
Remedial Math	319,738	54	46
Algebra and Plane Geometry	454,677	50	50
Advanced Math	280,978	52	48
Total	1,055,393	52	48
Introductory Science	347,943	52	48
Advanced Life Science	22,703	46	54
Advanced Physical Science	7,994	62	38
Other Science	479,772	52	48
Total	858,412	51	49
Introductory Foreign Language	389,393	45	55
Advanced Foreign Language	96,319	42	58
Total	485,712	45	55

SOURCE: California Basic Educational Testing System, Professional Assignment Information File, 1985-86.

Persistence[2]

Enrollment statistics do not tell the whole story. Minority students may enroll in challenging classes but not complete them. Female students were more likely to drop classes than male students, according to 11 percent of teachers who responded to our

[2] Dr. Pamela Arbuckle raised this concern.

survey, while gifted students were seen as more likely to drop out, according to only five percent of respondents. Fifty-two percent of public school teachers in the survey affirmed that limited-English-proficient students were more likely to drop out of advanced classes than were other students. Forty percent of teachers responding to the survey reported that black students were more likely to drop out, and 38 percent reported that Hispanic students were less persistent. Again, these estimates may be biased upward due to the tendency of teachers to group successful minority students with white students.

From CBEDS data it appears that students from minorities other than Asian are less likely to enroll in advanced classes than their white and Asian peers. At the same time, 24 percent of public school respondents indicated that their schools had special programs to increase minority and female participation and persistence in advanced classes. (These programs will be described in Section Three.)

Private school headmasters and teachers reported that minority and majority students were expected to take and complete the same program. As with public schools, UC admission requirements determine college preparatory programs at most private high schools in the survey sample. As with public schools, minority enrollment is concentrated in a few large urban private schools.

Instructional Time in Grades 2, 4, 6, and 8

Elementary and junior high school classes in math, science, and foreign language provide crucial preparation for high school study. In 1985-86 for the first time, CBEDS contains school-level data on instructional time for each subject in grades 2, 4, 6, and 8. Time spent is, of course, not synonymous with effective instruction. Nevertheless, it reflects the extent to which students are exposed to math, science, and foreign languages. The state of California and local districts establish minimum instructional time for each subject at each grade level. Therefore, in some instances, these data may represent mandated rather than actual instructional time.

As Table 7 indicates, the majority of students in grade 2 spent between 38 and 58 minutes per day in math class, while grade 8 students spent 52 minutes on average per day. Science was emphasized less than math at every grade level, while foreign languages were taught an average of 15 minutes per day in grade 2.

More interesting, however, is the fact that of 4,400 elementary schools, only 671 reported teaching foreign language at grade 2. The number and percentage of schools with foreign language programs decreased steadily through grade 8, although the time spent increased (Table 8).

TABLE 7

Instructional Time in Grades 2, 4, 6, and 8 in California School Districts, Mean (and Standard Deviation) Minutes per Week, Total and Selected Subjects

Grade	Math Minutes per Week	Science Minutes per Week	Foreign Language Minutes per Week
2	239.8 (51.0)	148.0 (55.0)	67.9 (51.6)
4	268.8 (41.0)	174.6 (50.6)	64.4 (54.0)
6	267.1 (42.9)	181.2 (51.8)	73.7 (67.7)
8	258.6 (54.7)	231.1 (68.5)	190.3 (87.0)

Note: Minutes per day can be obtained by dividing these values by 5.

SOURCE: California Basic Educational Testing System, School Information File, 1985-86.

TABLE 8

Number of Schools Reporting Instructional Time in Grades 2, 4, 6, and 8, By Grade Level and Subject, 1985-86 (N=6,053)

	Number of Schools at Grade Level	Math	Science	Foreign Language
Grade 2	4409	4397	4389	671
Grade 4	4380	4344	4336	650
Grade 6	3874	3785	3773	604
Grade 8	1745	1687	1633	566

SOURCE: California Basic Educational Testing System, School Information File, 1985-86.

Section Two
Supply and Demand for Qualified Teachers

This section describes factors that affect supply and demand for California math, science, and foreign language teachers. Teacher working conditions, a significant factor affecting supply, are described. Qualifications and demand for public and private school teachers are compared. Teacher demand in the three fields is projected and future supply is estimated. Upper and lower boundaries for demand and supply are developed, and the likelihood of a shortage of qualified personnel is evaluated.

Factors Influencing Teacher Supply and Demand

Because of California's size and geographical diversity, the teacher labor market is complex and diverse. The state's economy, the seventh largest in the world, offers many employment alternatives for people skilled in subjects in which there is also high demand for teachers. Abundant employment opportunities for math and science professionals make teacher shortages in those fields more likely. The relatively larger supply of foreign language teachers may result from fewer employment alternatives for foreign language specialists.

High demand for a small number of skilled math and science professionals in business, industry, and higher education raises entry-level and lifetime salaries beyond those available to school teachers (Levin 1985). In particular, defense-related industries attract many math and physical science professionals. Increasing opportunities in genetics and other biological fields may lure life scientists.

In contrast, skills in foreign languages have been less in demand. Native speakers, who are also fluent in English, are available for business and industry. Fewer employers require expertise in foreign languages than require science expertise. Many positions requiring foreign language expertise pay lower salaries and require frequent travel. For these reasons, specialists in foreign languages may find school teaching more attractive than alternatives in business and industry. What has been true in the past, however, may not be so in the future. Foreign language specialists are increasingly sought for computer programming, where their ability to learn languages and communicate effectively, using nontechnical language, has become an asset.

As a consequence of current differences in employment alternatives, however, lower levels of qualifications are expected among math and science teachers than among foreign language teachers. In the random sample of teachers surveyed for this report, 44 percent of teachers with bachelor's degrees in science also held advanced degrees in science, compared to 68 percent of teachers with both bachelor's and advanced degrees in

foreign languages. California's Basic Educational Data System (CBEDS) data indicate that foreign language teachers more frequently have advanced degrees. However, CBEDS data do not specify the academic discipline in which the advanced degrees were earned (Table 9).

TABLE 9

Highest Educational Level Attained By Teachers of Math, Science, and Foreign Language, 1985-86

	Math (N = 10,811) Percent	Science (N = 7,667) Percent	Foreign Language (N = 4,474) Percent
Less than BA	0.8	0.7	0.7
BA	9.1	8.8	7.5
BA + 30	44.3	44.3	43.8
MA	14.6	13.9	14.7
MA + 30	29.9	30.4	30.7
Doctorate	1.4	1.7	2.2
Missing	0.1	0.2	0.3

SOURCE: California Basic Educational Data System, Professional Assignment Information File, 1985-86.

Teacher shortages in math and science are exacerbated because females are more likely to teach than are males, yet are less likely to study physical science and math. Affirmative action programs in business and industry may further reduce the number of female science teachers available to become mentors for prospective female scientists.

While special conditions reduce the supply of math and science teachers, other labor market factors influence the availability of all teachers. Prevailing wages in some geographical areas exceed teacher salaries (Fulton n.d.). High transportation costs (both time and distance) may reduce the attractiveness of teaching (Yamahara 1986). High housing costs outpace teaching salaries in some areas (Fulton 1984). Extreme isolation or weather conditions reduce availability of trained professionals who have employment options in more favorable locations (principals' survey). Even within geographical areas or within a district, large differences in working conditions make it difficult for some districts, and for schools within districts, to hire and retain skilled teachers (Bruno 1986).

Salaries and Working Conditions

In teacher opinion surveys (Koppich 1985; Cagampang 1986; Harris 1985), current and former teachers mention two discouraging labor market factors most frequently: salaries and working conditions. Each is clearly very important for teachers at all stages of their careers. Many teachers, demoralized by declining salaries and worsening working conditions, have sought other employment. Today's experienced teachers began their careers during the 1960s when teacher salaries often exceeded those available to other professionals with equivalent education. They naturally expected that advantage to continue. Instead, teachers forfeited job security because of declining enrollment, and their salaries declined relative to comparably experienced professionals.

Recent college graduates, on the other hand, have opportunities to earn much larger beginning and lifetime salaries in business and industry. The teaching profession involves sacrifices in income and working conditions.

More than 50 percent of both public and private school teachers in California chose the profession because they enjoy the subject matter and enjoy working with young people. The chance to make a difference in the lives of students and in society is an important motivation. Neither public nor private school teachers feel, however, that psychic rewards substitute entirely for financial rewards, and they are extremely dissatisfied with their salaries. Sixty-one percent of public school teachers and 69 percent of private school teachers in the California sample ranked low salaries among the most important reasons for considering leaving teaching. The next most frequent reason (lack of administrative support) was chosen by half as many teachers.

These findings echoed those of the *Metropolitan Life Survey of Former Teachers in America* (Harris 1985). Of that national sample, 60 percent of former teachers left because of low salaries. Of those considering leaving, 62 percent cited low salaries as the main reason. Sixty-five percent of those likely to leave blamed low salaries (Table 10). Offered a theoretical choice between a large salary increase or much reduced class size, 80 percent of California private school teachers and 75 percent of public school teachers preferred a $10,000 salary increase to a class size lowered by 10 students. Both groups of teachers were even more in favor of a $1,000 increase than a class size reduction of one student (private 96%, public 89%). Although most teachers are motivated to enter the profession for reasons other than salary, as Feistreizer states (1985), they do not willingly forego adequate salary in exchange for psychic rewards.

Even though teachers in our survey frequently expressed a great love of teaching and of working with young people, they emphasized that poor working conditions are demoralizing. A science department chairman in one of California's leading high schools described working conditions in his high school: janitorial services were nonexistent; broken windows were unrepaired for a full year; antique, shredded window shades were

not replaced; outdated duplicating equipment was located a full city block from the classroom; 28 staff members shared one telephone in the supply closet; teachers used their own typewriters because the department typewriter did not work; the newest laboratory equipment was purchased in the 1960s with National Defense Education Act (NDEA) funds; textbooks were outmoded and in short supply; only with parent donations could the department purchase a hose to fill the donated fish tank, a multi-outlet extension cord, and styrofoam for biological models. The annual supplies budget of $135 per class would not stretch far in preparing experiments for 35 students.

TABLE 10

Reasons for Leaving Teaching

	Former Teachers	Those Considering Leaving	Those Likely to Leave
Low Salaries	60%	62%	65%
Poor Working Conditions	36%	41%	45%

Note: Percentages sum to greater than 100 percent, because of multiple responses.

SOURCE: The Metropolitan Life Study of Former Teachers in America (Harris 1985), Table 7, page 19.

This department chairman's school had a particularly difficult time maintaining adequate equipment. Laboratory scales, desirable items for the local drug trade, were frequently stolen. A television and VCR, purchased with scarce equipment funds, were never used in the classroom. Teachers tested the new equipment one Thursday afternoon and returned it to its specially built storage cabinet under lock and key for the evening. On Friday morning, they discovered the cabinet demolished and the equipment stolen. Worst of all, the department chairman reported three science instructors taught science in rooms without laboratory facilities. With no rooms of their own in which to prepare experiments and demonstrations, the three teachers regularly traded rooms with other teachers, thus disrupting twice as many classes. In this district six candidates applied for five openings created when experienced teachers retired at the same time that graduation requirements increased. One of the six was not even marginally qualified to teach science; fortunately, each of the remaining five applicants was acceptably qualified.

That districts have not provided supplies for laboratory classes is an example of particularly discouraging working conditions. Sixty-one percent of public school teachers

strongly agreed that they had enough textboooks to give one to each student in every class. In contrast, only 22 percent strongly agreed with the statement, "The administration provides my students with basic learning materials (other than textbooks) they need, for example, laboratory equipment."

In an attempt to maintain a quality program, teachers have become fundraisers. In a new incarnation of an old fundraising standby, an enterprising chemistry teacher organized a multi-district Chemathon. Students solicited donations for every experiment they completed. These donations were used to buy equipment and supplies for chemistry classes in the participating students' districts. That is how one group of teachers coped with insufficient funds for laboratory supplies.

Eighty-five percent of private school teachers, but only 63 percent of public school teachers, strongly agreed with the statement, "I have enough chairs and desks in my classroom for all my students." Once again, private school teachers reported better working conditions–65 percent, compared to 48 percent of public school teachers, strongly agreed that their classrooms were large enough for the number of students they taught each period. Thirty-two percent of public school teachers and 46 percent of private school teachers strongly agreed that they had ready access to the audiovisual equipment they needed to do their work.

It might be expected that private schools would face more difficulty in hiring teachers because wages are typically lower than those in public schools. The mean salary in our sample for private school teachers was $20,000, while it was $30,000 for public school teachers. One private school headmaster said the one element that would most improve his school's program was "money to pay his excellent teachers what they deserved." Better working conditions apparently offset the wage differential for many private school teachers, however. A young biology teacher who earned only $12,000 per year, plus housing, said it was well worth it because the working conditions were ideal–12 students per class, motivated students, and adequate laboratory facilities.

Poor working conditions and uncompetitive salaries reduce teacher effectiveness and increase attrition. As data displayed in the next section indicate, attrition will account for the increased demand for teachers in the next five years.

Demand Projections

A single computation, even with allowances for differing time periods, cannot reflect the balance between demand and supply for California as a whole, for local areas, or for specific subject areas. Teacher labor markets are, to a great extent, localized and subject specific. Teachers have been unwilling to commute great distances. Furthermore,

movement from district to district is curtailed because districts rarely allow more than five years of seniority on the salary schedule for prior teaching experience. Nor can teachers always transfer from district to district with permanent status, no matter how many years of experience they had in a prior district. Teachers commonly undergo a probationary period when they change districts.

Demand for teachers depends on three elements: enrollment, the ratio of students to teachers, and the attrition rate. Each will be considered in turn.

Projected Enrollment in Math, Science and Foreign Language Classes

Enrollment is declining in general-track classes in a representative sample of high schools and in vocational classes throughout California, whereas enrollment is increasing in college-track classes (Grossman, et al. 1985; Guthrie, et al. 1986). Given these changes and the previously reported enrollment increases, enrollment in math, science, and foreign language classes is expected to remain high. In the absence of further changes in high school graduation and college admission standards, enrollment will not increase as rapidly in the next five years as it has in the past three. The State Department of Finance projects that total high school enrollment will decline between 1985-86 and 1989-90. Because of the overall population cohort decline, the *number* of students enrolled in the three subject areas may decline in the next three years, but the *percentage* of students enrolled is likely to increase or remain the same as in 1985-86. Since the emphasis on more rigorous standards is expected to continue, the percentage of students enrolled in math, science, and foreign language will likely remain stable or increase in the next five years toward statewide targets in the school Performance Reports developed by the State Department of Education.

Enrollment in math, science, and foreign language classes is projected in two ways: first, using a weighted average of participation rates over the past three years; and second, using the 1985-86 enrollment percent for each subject (79.4 percent for math, 64.6 percent for science, and 36.6 percent for foreign language). Using the two methods, an upper and a lower estimate of projected enrollment in the three fields through 1991-1992 were constructed (Appendix Table A1).

For purposes of estimating demand, student-teacher ratios are assumed to remain constant during the projection period. The 1985-86 student-teacher ratio in each subject is used for the projections. The constant ratio assumes that the 1985-86 ratio is also the preferred ratio and that it will not increase in response to fiscal pressures nor decrease in response to teacher bargaining.

These assumptions may not prevail over the next five-year period, however, as the following possibilities suggest. California is under increasing pressure to reduce class size

toward the national average; yet survey respondents overwhelmingly preferred higher salaries to smaller classes, so teachers may bargain accordingly. Although teachers desire both smaller classes and higher salaries, taxpayers may be unwilling to increase funding for K-12 education (Osman 1985). The Gann limit may restrict school expenditures. Districts, caught between demands for higher salaries and smaller classes, and at the same time facing declining per-pupil revenues, may be forced to increase salaries and class size. Thus, student-teacher ratios may increase or decrease, depending on the outcome of state-level and district-level bargaining.

Replacement for attrition accounts for 80 percent of demand for new teachers. Attrition includes separations for retirement, occupational change, personal leave, disability, or death. Separations vary between districts and subject fields and are influenced by working conditions, wages in nearby districts, and the overall health of the local economy. Teacher characteristics such as gender, age, family status, and educational level, as well as teaching field, can be reasonably assumed to influence attrition rates. In the absence of individual identifiers which would permit calculation of age- or subject-specific attrition rates, State Teachers Retirement System data were used to estimate California's attrition rate.

Attrition was estimated in two ways. The lower bound attrition rate is the average of the annual attrition rates. The upper bound of attrition is provided by the trend of average annual attrition rates for the last eight years.

Summary of Demand Due to Enrollment Change and Attrition

Table 11 summarizes the projected range of demand for secondary math, science, and foreign language full-time-equivalent (FTE) teachers for the five years to 1991-92, taking enrollment, attrition, and current student-teacher ratio into account. (See Appendix Table A2 for annual projections.) California will need between 2,770 and 3,060 new math teachers (FTE), between 1,750 and 2,480 new science teachers (FTE), and between 1,270 and 1,400 new foreign language teachers (FTE) by 1991-92 to maintain current class sizes.

TABLE 11

Summary of Cumulative Demand, FTEs Needed Due to Enrollment Change and Attrition, 1985-86 to 1991-92

	Low[1]	High[2]
Math	2,744	3,058
Science	1,751	2,476
Foreign Language	1,267	1,404

[1]Lower bound uses weighted average of enrollment percent and the average of annual attrition rates from State Teachers Retirement System, 1977 to 1985.

[2]Upper bound uses 1985-86 percent of total enrollment in each subject and the trend of the annual attrition rates from State Teachers Retirement System, 1977 to 1985.

The emphasis on FTEs in the previous paragraph is important. With current staffing patterns, the number of individual teachers in the three fields is nearly twice as large as the number of FTEs. If that relationship continues, then twice as many teachers will be needed by 1991-1992 to maintain current class sizes.

Demand for Qualified Teachers

Because many teachers in the current year are teaching "out of field," demand cannot be projected mechanically from the number of FTEs in a subject area from one year to the next. Therefore, teacher qualifications must also be considered. In addition to demand due to enrollment changes and attrition, demand to replace unqualified teachers must be accounted for.

California Basic Educational Data System information (1985-86) indicates that a large proportion of teachers instruct outside the subject fields for which they are certificated. A teacher who reported neither an appropriate single-subject credential nor a general secondary credential (which would technically qualify him or her to teach *any* secondary subject) was designated as "improperly certificated." Although California has complex and comprehensive requirements for teacher certification, it also provides a wide range of options by which districts circumvent those requirements so as simultaneously to avoid layoffs, operate within a single salary schedule, and fill teaching positions with full-time personnel.

Many teachers who have general secondary credentials, although technically qualified to teach, may not, in fact, have optimum qualifications described in the state curriculum frameworks (Section Three of this report). If a teacher obtained teaching credentials authorizing service in math, German, and French 15 years ago, she may have felt qualified to teach all three subjects in a college preparatory program at that time. After a career of teaching only math, however, she may no longer feel qualified to teach German or French, although technically she remains qualified. Similarly, a high school physical education teacher may once have been authorized to teach biology or mathematics in addition to P.E. This teacher's program might today be filled with several periods of biology or mathematics, yet the teacher would be likely to find the contents of the new biology or math text as unfamiliar as her students. Although both these teachers meet technical requirements for qualification, neither could be considered adequately qualified. In addition, teachers holding General Secondary Credentials *can be required* to teach even though they feel unqualified. In contrast, those with Standard Credentials *must agree* to an assigment outside a primary teaching field.

More teachers may be appropriately credentialed than CBEDS indicates. Teachers may have been confused when reporting their credentials because credential alternatives on CBEDS are not those used by the Commission on Teacher Credentialing. The secondary choices included "All Subjects (General Secondary)" and 13 specific subject alternatives. Teachers may be more likely to think of their credentials as Life, Clear, Preliminary, Emergency, Limited Assignment, or Single Subject credentials. Emergency and limited-service credentials and waivers are not listed options, nor are Fisher Act (or Standard) credentials. Teachers with an emergency credential could not have indicated that.

Teachers with science credentials could be found at all levels of the educational system, from superintendents to teachers of special education. The same was true for teachers credentialed in math and foreign languages. Fewer math teachers were assigned to other subjects than were science and foreign language teachers. Of teachers credentialed in math, 2,353 (26%) had assignments in areas other than math, while 3,832 (42%) credentialed science teachers had nonscience assignments and 3,362 (47%) credentialed foreign language teachers had nonforeign language assignments in 1985-86. Approximately 21 percent of those with math, science, and foreign language credentials were administrators or counselors. Table 12 indicates the percentage of math, science, and foreign language teachers distributed in other fields. The largest proportion of math teachers not teaching math taught science, while the reverse was true for science teachers. The largest proportion of foreign language teachers not teaching foreign language taught secondary English and social studies.

TABLE 12

Credentialed Math, Science, and Foreign Language Teachers Instructing in Other Fields

Field in Which Credentialed			Field in Which Working
MATH N = 2,353 (in Percent)	SCIENCE N = 3,832 (in Percent)	FOREIGN LANGUAGE N = 3,362 (in Percent)	
20	21	23	Administration & Counseling
8	11	16	Other Elementary
36	46	41	Other Secondary
4	6	5	Special Education
6	6	2	Vocational
12	10	12	Resource Teachers
14	0	1	Other
100	100	100	Total

SOURCE: California Basic Educational Data System, Professional Assignment Information File, 1985-86. PACE analysis.

About the same number of teachers had inappropriate credentials to teach their math, science, and foreign language assignments. In 1985-86, inappropriately credentialed teachers taught 20 percent of introductory physical science sections, containing 32,000 students. Nineteen percent of math classes were taught by teachers who had neither a general secondary nor a single-subject credential in math. Among foreign language classes, 18 percent were taught by teachers not appropriately certificated. Table 13 displays the percentages of classes in each subject field taught by inappropriately qualified teachers.

TABLE 13

Total Number of Math, Science, and Foreign Language Classes and Percent Taught By Teachers with Neither a General Secondary Nor an Appropriate Single-Subject Credential, 1985-86

	Number of Classes	Percent of Classes Taught Without Appropriate Credential
Remedial Math	11,891	30
Introductory Math	14,567	14
Advanced Math	6,878	18
Other Math (Including AP)	3,316	6
Total	36,652	19
Introductory Science	24,753	18
Non-introductory Science	4,549	26*
Total	29,302	19
Introductory Foreign Language	12,834	19
Advanced Foreign Language	3,747	16
Total	16,681	18

* Note: More than half of these sections are "other science" courses.

SOURCE: California Basic Educational Data System, Professional Assignment Information File, 1985-86. PACE analysis.

Given the large proportion of teachers teaching without appropriate credentials, a more educationally focused definition of demand would reflect the need for qualified teachers in every classroom. Approximately 12 percent of FTEs in each of the three fields did not fully meet certification requirements for the field (Table 14). An additional 792 FTEs would have been needed to place a fully qualified math teacher in every math class in 1985-86. For science classes to be staffed by fully qualified teachers, an additional 655 FTEs would have been required; for foreign language classes, another 358 FTEs.

TABLE 14

Additional Secondary FTEs Needed to Replace Teachers Instructing Out of Field

	1985-86 FTEs	Percent Out of Field	Additional FTEs Needed
Math	6,535	12	792
Science	5,240	12	655
Foreign Language	2,970	12	358

Districts' Projected Hires

Districts indicated to CBEDS (1985-86) that they expected to hire 941 math teachers (FTEs), 1,009 science teachers (FTEs), and 247 foreign language teachers (FTEs) in 1986-87. Yet our high projections indicate that 431 math teachers, 362 science teachers, and 206 foreign language teachers will be needed (once again expressed in FTEs) (Table 15).

TABLE 15

Comparison of Projected Demand for Math, Science, and Foreign Language Teachers for 1986-87 and District Reported Anticipated Hires for 1986-87

	Projected Demand (FTEs)	Anticipated Hires*	Projected Demand as Percent of Anticipated Hires
Math	431	941	46
Science	362	1009	36
Foreign Language	206	247	83

SOURCE: *California Basic Educational Data System, County-District Information File, State Department of Education.

The discrepancy can be explained, at least in part, by differences between local and state perspectives on teacher attrition. Double counting results when districts count, as part of the teaching force lost to attrition, teachers leaving one district for another, but not leaving the teaching force altogether. Of course, *districts* do have to replace those teachers who leave for other districts, but *California* does not have to replace them.

Cumulatively, district-reported demand would be twice as high as state demand if one-half of teachers leaving were moving to other districts in the state. In fact, nearly one-half of teachers in their first year in a district in 1985-86 were experienced teachers (Table 16). The other half-914 math teachers, 585 science teachers, and 221 foreign language teachers–were new to the profession as well as new to the district. In 1985-86, inexperienced teachers accounted for approximately one-half of all teachers in their first year in a district.

TABLE 16

Number of Teachers in First Year of District Service (DY) and in First Teaching Year (TY), Secondary Only

	DY ≤ 1	TY ≤ 1	First Year Teachers as Percent of Teachers New to District
		1985-86	
Math	1,838	914	50
Science	1,103	585	53
Foreign Language	507	221	44
		1984-85	
Math	1,736	768	44
Science	1,321	649	49
Foreign Language	479	172	36

SOURCE: California Basic Educational System, Professional Assignment Information File, 1984-85, 1985-86.

Newly hired, inexperienced teachers are not a proxy for demand, however, for at least four reasons. First, experienced teachers returning after an absence from teaching of one or more years would not have been included in any district's prior year's attrition, and their positions would have represented "real" state-level demand. The 50/50 ratio understates the net number of new positions statewide to a degree than cannot be determined currently.

Second, demand might have been greater than supply in certain subjects. Districts might have used inappropriately certificated teachers already on staff rather than hire unqualified teachers. In attempting to rectify these misassignments, the district might report demand above that required to account for enrollment and attrition.

Third, districts might have preferred to offer more classes, for example, in science, than could be staffed with available teachers. Unable to locate experienced teachers (or afford to hire them), a district might cancel classes. These shortages could not be discovered from prior years' enrollment and staffing ratios and might be expressed, on CBEDS, as higher than expected demand, based on past enrollment and course offerings.

Finally, districts might report demand for more teachers than could be projected from past enrollment and staffing ratios because they expected to use teachers in two or more fields. For example, districts might require teachers to teach Spanish for two periods per day and social studies for three, but include the full FTE under Spanish since that is the primary demand.

Distribution of Anticipated Hires

Of the anticipated hires, the five largest California counties expected to hire 60 percent of math teachers, 63 percent of science teachers, and 55 percent of foreign language teachers who will be hired in California in 1986-87. Los Angeles County, alone, expected to hire 42 percent of math teachers required in California in 1986-87.

Demand for Private School Teachers

The additional demand for math, science, and foreign language teachers attributable to private schools is estimated to be between 550 and 600 for the period between 1986-87 and 1991-92. Demand for private school teachers was estimated using Department of Finance private school enrollment projections and two different scenarios for class size, class load, and attrition. The following assumptions underlie the first estimate:

1. That student-teacher ratio is approximately 18:1 (U.S. DOE 1986)

2. That private school teachers have the same class load as public school teachers–5.6 classes per day

3. That the percentage of private school students enrolled in these three subject areas is comparable to the percentage of public school enrollment in 1985-86

The discrepancy can be explained, at least in part, by differences between local and state perspectives on teacher attrition. Double counting results when districts count, as part of the teaching force lost to attrition, teachers leaving one district for another, but not leaving the teaching force altogether. Of course, *districts* do have to replace those teachers who leave for other districts, but *California* does not have to replace them.

Cumulatively, district-reported demand would be twice as high as state demand if one-half of teachers leaving were moving to other districts in the state. In fact, nearly one-half of teachers in their first year in a district in 1985-86 were experienced teachers (Table 16). The other half-914 math teachers, 585 science teachers, and 221 foreign language teachers–were new to the profession as well as new to the district. In 1985-86, inexperienced teachers accounted for approximately one-half of all teachers in their first year in a district.

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3. That the percentage of private school students enrolled in these three subject areas is comparable to the percentage of public school enrollment in 1985-86

4. That teacher attrition in public and private schools is approximately equal

Assumptions two through four are used in the absence of systematic longitudinal private school data.

An alternative estimate is calculated using the average class size of private school teachers who responded to the survey–20–and the average class load for full-time teachers–4.7 classes per day. These two scenarios for calculating demand provide a lower and an upper bound, respectively, of demand.

Cumulative demand for private school math teachers is between 240 and 258 FTEs for the period between 1986-87 and 1991-92. For science, private schools will need between 196 and 210 new teachers to replace those lost to attrition and to account for increased enrollment. Between 111 and 119 new foreign language teachers will be needed (Appendix Table A3).

Teacher Supply

Labor Market Influences on Teacher Supply

As complex as it is to project teacher demand, projecting supply is more complex yet. As Stephen M. Barro (1986) and others (e.g., Rumberger 1985) have emphasized, the supply of potential teachers cannot be accurately observed in the market place, especially when districts are not hiring. Neither can supply be accurately projected independently of wages in alternate employment, working conditions, and individual preferences. When there are few jobs, the number of teachers hired in one year does not approximate the number who might have wanted to work. Many more teachers might be willing to work in any one year at prevailing wages than are hired. Certainly, that is true in Marin County where one private school reported 75 applicants (the average applicant had a Ph.D. in science) for one science teaching position (Private School Survey). Since any college graduate can become legally qualified to teach in 10 months, and is, therefore, a potential teacher, sufficiently attractive incentives might convince more college graduates to consider teaching, thereby increasing supply. Even without additional incentives, many more people might choose to teach if positions were available.

Enrollment in teacher training programs declined during the 1970s was probably due to a lack of jobs rather than uncompetitive salaries and working conditions. Potential teachers would be unlikely to prepare for a career in which there were no available jobs. In turn, salaries fell in relation to other occupations because there was an excess supply of

teachers. Had jobs been available, however, many might have wished to teach at prevailing salaries. Enrollment in teacher training programs in California has climbed steadily since 1982 in response to the increased availability of jobs and higher starting salaries. First-time enrollment in science teacher preparation programs, for example, increased 215 percent from 184 in 1981-82 to 580 in 1984-85.

As Barro has demonstrated, teacher supply can be accurately projected only with a highly refined model which incorporates factors potential teachers consider when deciding whether to apply for teaching positions. Such factors would include teacher salaries (compared to salaries in other occupations), student enrollment trends, demand for the prospective teachers' skills in other market sectors, geography, school and district location, composition of student population, cost of living, prevailing wages, working conditions, and private versus public school employment. Individual characteristics, such as age, gender, marital status, field of specialization, and family responsibilities, must also be incorporated in a comprehensive model. Such a model has yet to be constructed for California.

Lacking this comprehensive model, the future availability of teachers may only be approximated by examining such factors as enrollment trends in California teacher training programs, credentials granted to teachers trained outside California, and number of emergency credentials issued. In addition, characteristics of people taking the California Basic Education Skills Test (CBEST) suggest the composition of the future pool. From CBEST data, trends can be identified in the number and types of people considering entering teaching. Each of these will be discussed in turn.

Enrollment in Teacher Training Programs

Of 67 California teacher training institutions, 47 train math teachers, 50 train life science teachers, and 42 train physical science teachers. Only 12 programs train teachers of critical foreign languages–Chinese, Japanese, Korean, Vietnamese, and Russian (defined by the Department of Defense)–while 35 programs train Spanish teachers.

Enrollment in teacher training programs, especially in math and science, has increased in the past four years, as Table 17 indicates. The number of people first enrolled in math programs increased 315 percent in the four-year period, while science enrollment increased 215 percent. Foreign language enrollment increased nine percent over the three years for which there are available data. The California State University, which trains 70 percent of the state's teachers, estimates that enrollment will increase 40 percent in each of the next two years.

TABLE 17

Number of Individuals First Enrolled in Single-Subject Credential Programs, 1981-82 to 1984-85

	1981-82	1982-83	1983-84	1984-85
Math	110	162	239	457
Science	184	282	487	580
Foreign Language	NA	179	152	195

SOURCE: Commission on Teacher Credentialing 1982-84, 1984-85; Guthrie and Zusman 1982.

There is a relationship between enrollment in teacher training programs and credentials issued subsequently, but it is not a simple one. Although first-time enrollment has increased, a large proportion of newly enrolled students are people who have already found employment using Emergency or Limited Assignment Credentials (cf. Indicators of Shortage, page 38, and Teacher Qualifications, page 48). Thus, they do not represent a potential contribution to the supply of new teachers. Many people take more than one year to complete credential requirements. Others with emergency credentials, who are already part of the teacher work force, enroll in teacher training programs to retain their emergency credentials. They do not constitute part of the supply pool, that is, teachers available for employment. Nevertheless, the effect on supply of those who obtain additional credentials is positive: although they do not contribute to the supply of new teachers, their new credentials may reduce the number of improperly certificated teachers. Unfortunately, available data bases cannot distinguish between new enrollees who are already teaching and those who have never taught.

Credentials Issued

Another way to approach teacher supply is to examine the number of first-ever credentials issued. Newly credentialed teachers may be part of supply, while emergency and limited-service emergency credentials indicate teacher shortage. If the number of first credentials issued increases annually, then one may safely infer that the supply of potential qualified teachers is increasing.

As Table 18 indicates, the number of first credentials in the three fields has increased each year, with the exception of 1983-84, when CBEST was first required. As school of education enrollment continues to increase, one may expect the number of first

credentials to increase as well, although not as rapidly (for the reasons mentioned above), with a corresponding increase in the pool of credentialed teachers.

TABLE 18

First-Ever Credentials (Clear, One-Year Preliminary, Five-Year Preliminary), 1981-82 to 1985-86

	1981-82	1982-83	1983-84	1984-85	1985-86	*Total*
Life Science	228	215	183	236	250	1112
Physical Science	54	64	40	75	75	308
Math 208	208	163	159	214	235	979
Foreign Language	316	264	142	197	198	1117
Combinations of Two of Above						
Language & Science	3	129	75	98	125	602
Language & Math	2	69	31	60	89	323
Life & Physical Sciences	14	71	62	107	129	476
Math & Science	12	57	30	49	57	235

SOURCE: Commision on Teacher Credentialing.

A PACE analysis, conducted with the assistance of the California Commission on Teacher Credentialing (CTC) and State Teachers Retirement System (STRS) in 1985, indicated that only 50 percent of teachers who obtained first credentials between 1981 and 1985 were teaching in 1985 (Cagampang, et al. 1986). Available data do not indicate why people obtaining regular credentials do not enter or remain in teaching. The other 50 percent of newly credentialed teachers may have decided to pursue other work, may have decided against moving to areas where jobs were available, may live in an area where there is an adequate teacher supply, or may have lost out to experienced teachers.

Teachers Trained in Other States

In three of the four years between 1981-82 and 1984-85 (Table 19), except in life sciences, the Commission on Teacher Credentialing issued more credentials to math, science, and foreign language teachers trained in other states than to California-trained teachers. The imposition of the California Basic Educational Skills Test (CBEST) in 1983 was associated with a 50 percent decline in the number of teachers trained outside California who obtained credentials in 1983-84. Subsequent regulatory changes made it possible for these teachers to obtain one-year nonrenewable (OYNRE) credentials while waiting to take CBEST, so out-of-state teachers once again contributed to the supply pool. Since math and science teachers are in short supply throughout the United States, teachers of these subjects may more easily find teaching positions closer to home. However, a surplus of math teachers in Europe led California to recruit in Germany for the first time in 1986-87.

TABLE 19

Number of Single-Subject Credentials Issued to Teachers Trained in California and Teachers Trained in Other States, 1981-82 to 1983-84

	1981-82			1982-83			1983-84			Total		
	D	R	T	D	R	T	D	R	T	D	R	T
Math	129	100	229	100	89	189	65	103	168	294	292	586
Life Science	106	144	250	112	129	241	50	152	202	268	425	693
Physical Science	51	28	79	63	31	94	23	39	62	137	98	235
Foreign Language	196	136	332	157	117	274	59	95	154	412	348	760

D Teachers trained in other states apply directly to Commission for credential.
R Teachers trained in California are recommended by the training institution.
T Total credentials issued in year and subject

SOURCE: Commission on Teacher Credentialing.

Teachers Returning from Personal Leave

State Teachers Retirement System (STRS) matched a random sample of credentialed teachers with their retirement system membership (Cagampang 1986). That analysis indicated that all but one of the teachers in the sample had taken at least one year off from teaching during the working career. Supply estimates must allow for this

continual churning of the teacher work force. In any given year, a large number of experienced teachers will be returning to part- or full-time employment, as well as leaving teaching entirely. Although teachers indicate on CBEDS if they are teaching in a district for the first time, they are not asked to indicate whether they are returning from a leave of absence. From STRS it appears that 20 percent of new entrants to the retirement system in 1985 were teachers who had taught in the recent past. Although this proportion may approximate the re-entry rate for math, science, and foreign language teachers as well, it may overstate re-entry rates for secondary teachers because male teachers, who make up 50 percent of the secondary teaching force, may be less likely to take personal leaves.

California Basic Educational Skills Test Examinees

Another way to estimate the trend in teacher supply is to examine changes over time in the characteristics of CBEST examinees. Many people consider teaching after having been out of college for two years or more.

The number of people taking CBEST because they were considering applying to a teacher training program rose between 1983-84 and 1985-86. The number of undergraduates considering applying increased 45 percent, from 2,200 to 3,200, while potential applicants who had been out of college for between 2 and 20 years increased 133 percent from 900 to 2,200 (Table 20). An additional 5,000 people took CBEST in the three-year period as a condition for obtaining an Emergency Credential (Table 21). Two-thirds of those had been out of college for two or more years. Potential teachers come increasingly from the group of people who have been out of college for two or more years and who have been employed in fields other than education or not employed outside the home. Of the total first-time examinees in 1985-86, 65 percent (25,000 individuals) belonged to these groups. That compares with 57 percent (21,000 individuals) from the 1983-84 test cohort. If these trends continue, a major "new" source of supply will materialize, and California will not have to rely solely on the shrinking cohorts of recent college graduates for its teachers.

TABLE 20

Degree Status of CBEST Examinees Considering Applying for Admission to Teacher Training Programs, 1983-1985

	1983	1984	1985	Percent Change
Undergraduate	2212	2685	3214	45%
Graduate	811	923	1513	53%
Not Attended College in More Than 2 years	925	1513	2154	133%

SOURCE: Educational Testing Service, 1986.

TABLE 21

Emergency Teaching Credential Candidates by Current Employment Status and Degree Status, 1983-1985

	COLLEGE STATUS		YEARS SINCE COLLEGE				
	Undergrad.	Grad.	2	3-9	10-20	> 20	Total
1983							
Employed not in education	35	123	135	132	55	11	493
Not employed outside the home/student	45	133	93	101	83	20	477
1984							
Employed not in education	101	242	272	306	117	24	1065
Not employed outside the home/student	150	270	160	233	134	29	982
1985							
Employed not in education	102	230	291	345	131	16	1119
Not employed outside the home/student	153	223	176	227	105	26	912

SOURCE: Educational Testing Service, 1986.

Indicators of Shortage

The actual shortage of teachers is masked by the common practice of placing teachers in assignments for which they are inadequately qualified or not qualified at all.

Teacher shortage is indicated by cancelled classes and by teachers teaching out of field or with emergency or limited-assignment credentials. Districts sometimes cancel or combine classes when an appropriately credentialed teacher is not available. The shortage of credentialed teachers in math, science, and foreign language is indicated by the more than 6,000 emergency and limited-assignment emergency credentials issued in the three fields between 1981-82 and 1984-85 (Table 22). Districts reported that 1,500 teachers of math, science, and foreign language had emergency credentials or waivers in 1985-86. Neither of these credentials can be issued unless a district governing board formally declares that a shortage exists.

TABLE 22

Emergency and Emergency Limited Assignment Credentials, 1981-82 to 1985-86

	1981-82	1982-83	1983-84	1984-85	1985-86	Total
Life Science	101	191	168	303	419	1182
Physical Science	58	77	84	161	182	562
Math	733	741	696	984	766	3920
Foreign Language	175	93	49	99	103	519
Total	1067	1102	997	1547	1470	6183

SOURCE: 1981-85. Commission on Teacher Credentialing.
1985-86. County District Information File. California Basic Educational Data Service.

Although fewer math than science or foreign language teachers taught out of field, teachers without appropriate credentials taught math in every California county. Only three counties–Lassen, Trinity, and Plumas–reported that all their science teachers had either a general secondary or a science single-subject credential. Eight northern and rural counties had no inappropriately certificated foreign language teachers. Fifty-three percent of the inappropriately credentialed math teachers were in three counties–Los Angeles, San Diego,

and Orange. Those same counties employed 45 percent of California's math teachers. The same three counties reported 54 percent of inappropriately credentialed secondary science teachers compared with 42 percent of all secondary science teachers. Five counties, with San Diego the leader, employed 74 percent of secondary foreign language teachers without an appropriate credential. Those same counties employed 47 percent of all foreign language teachers in California (in FTE).

Shortages continue even though the number of people first enrolled in teaching credential programs and the number of credentials issued increased annually. Despite increasing education school enrollment and credential completion, more emergency credentials than first credentials of other types were issued.

At this time, Commission on Teacher Credentialing and CBEDS data bases have not been compared to ascertain whether new teachers are teaching with emergency, preliminary, or clear credentials. Instead, the number of emergency credentials issued by subject was compared with the number of teachers by subject in their first year of teaching. Because CTC had not yet compiled data on the number of emergency and emergency limited-assignment credentials issued in 1985-86, the number issued in 1984-85 was compared with the number of first-year teachers that year. While 768 new secondary math teachers began teaching in 1984-85, 984 (128 percent) teachers obtained emergency math credentials. Apparently, some experienced teachers or elementary teachers obtained emergency credentials in math. This would be the case if districts assigned current teachers to classes for which they were not credentialed (see Section Three). Six hundred forty-nine new secondary science teachers entered the field, and 464 emergency science credentials were issued (71 percent). One hundred seventy-two foreign language teachers began their first year of teaching, and 99 emergency credentials were issued (58 percent). As might be expected, the shortage of qualified teachers is less serious in foreign languages than in the other two fields.

Summary of Supply and Shortages

High school enrollment will continue to decrease until 1990-91 but enrollment in math, science, and foreign language classes will increase as students comply with increased high school graduation requirements, expectations enunciated in California's school Performance Reports, and increased college admission requirements. As a result, teacher shortages will continue, especially in densely populated areas of Southern California and in high-demand/ low-supply fields such as math and science. As more of the teacher pool is composed of people who have been out of school for a number of years, and who are likely to be established in their communities, teachers who are not able to find teaching positions in their local communities or commute ranges will constitute a larger part of the pool.

Districts, as well as private schools, will continue to prefer experienced teachers. Inner city urban districts will have higher turnover as more jobs become available in surrounding suburban districts. Some portion of newly trained teachers, then, will not find teaching positions in their local communities and will be unwilling to move to obtain jobs. They are ambiguous members of the supply pool–they are trained and willing to teach, given current salaries and working conditions, but only in certain areas, not necessarily those in which there are teaching positions. District administrators can be expected to continue to place a large number of experienced teachers in positions for which they are not appropriately qualified as they seek to cover classes with existing staff on a single-salary schedule and with very tight budgets.

Shortages will be masked by out-of-field assignments, use of emergency credentialed teachers, and class cancellations. Shortages will continue as long as salaries are substantially below those for similarly qualified individuals in other professions and as long as lack of adequate induction procedures and poor working conditions contribute to high attrition rates. The disparity between higher expectations for students and lower qualifications for teachers may imperil school reform.

Section Three
Programs, Guidelines, and Teacher Qualifications

The policy structure within which students and teachers undertake math, science, and foreign language instruction is composed of school and statewide Performance Reports, state curriculum frameworks, and teacher training and certification. An assessment of secondary math, science, and foreign language programs must not stop at recording numbers of current and future participants, but must examine programs designed to expand scholastic opportunities, statewide curriculum policy, and policies for evaluation. These policies and programs focus resources and efforts toward increased student achievement and instructional quality and guide California's efforts to prepare its youth for active participation in the economic, cultural, and political life of the next century. This section, then, describes representative programs assisting underrepresented minorities in college preparation, state-level policy for school performance evaluation, frameworks for curriculum and program development, and requirements for teacher credentials.

Programs to Increase Enrollment and College-Going and Completion Rates

There are two types of programs to increase math and science participation by female and minority students: student support programs and teacher inservice training programs. In the former group are programs such as Math, Engineering, Science Achievement (MESA), Upward Bound, and Professional Development Program (PDP), which encourage and support minority youngsters interested in attending college. Statewide, 1,500 students participate in Upward Bound, 5,148 in MESA. These programs emphasize tutoring, peer support, increased opportunities, and exposure to role models.

The Professional Development Program (PDP), sponsored by University of California faculty, is designed to increase the number of black, Hispanic, Native American, Filipino, and female students who enter college and pursue careers in mathematics-based fields, primarily engineering. PDP has sponsored programs since 1975 in Bay Area high schools and at the undergraduate and graduate level at UC Berkeley. Approximately 200 students from 45 Bay Area high schools participated in 1985. Dr. Robert Fullilove, director of PDP, reports that fewer students qualify for its program now because fewer minority students earn acceptable grades in high school math classes than in the past. In addition, recruiting college-bound black and Hispanic youngsters has become even more difficult because financial aid has declined. Dr. Fullilove has observed that, as the Asian reputation for success in math and physical sciences has grown, black and Hispanic students have become even less inclined to pursue those fields. Nevertheless, PDP students have been substantially more successful in college-level math courses at Berkeley than students who did not have that support (Table 23).

TABLE 23

Proportion of Professional Development Program (PDP) and Other UC Berkeley Students With Grades of C- or Below in Undergraduate Mathematics Courses, Fall 1984 Semester, By Race

	P	1A	1B	16A	50	TOTALS
PDP (Blacks Chicano/Mexican) (N = 120)	6%	21%	28%	0%	17%	17%
Blacks (N = 311)	30%	62%	45%	45%	69%	48%
Chicano/Mexican (N = 216)	26%	53%	47%	3%	63%	44%
Chinese (N = 603)	6%	24%	14%	15%	22%	19%
Whites (N = 1944)	16%	29%	26%	25%	29%	27%

Note: Non-PDP grade data are derived from fall 1984 grade/enrollment reports. PDP data represent grades earned in both fall and spring semesters of the 1984-85 academic year and are aggregated here for purposes of analysis.

SOURCE: Office of Admissions and Records (OAR), UC Berkeley.

The Cooperative College Preparatory Program (CCPP), funded by the University of California, Berkeley, is an example of a program targeted to assist traditionally underserved minority high school students. Working intensively with both teachers and students in the Oakland Unified School District, CCPP tutors students, supports teachers, and upgrades math curricula in specific junior and senior high schools where black students comprise at least 50 percent of the student body (Berman, Weiler & Associates 1985).

EQUALS, a teacher education program at the Lawrence Hall of Science, University of California, Berkeley, is an example of a teacher inservice training program. EQUALS "provides methods and materials to assist elementary, secondary, and preservice teachers to increase the number of female and minority students participating in mathematics and computer education. The EQUALS program consists of a 30-hour inservice, with 15

hours of follow-up each year for participants who have taken the basic program. In the last nine years, 10,000 K-12 California teachers have taken EQUALS training and used EQUALS materials in their classrooms" (Kreinberg n.d.).

Performance Reports and State Frameworks

Since his election in 1982 as California Superintendent of Public Instruction, Bill Honig has led a statewide effort to increase curricular rigor and breadth. State and school Performance Reports and higher expectations for math, science, and foreign language instruction are key elements of this reform effort. Performance Reports provide an evaluation tool for California schools while frameworks describe curriculum and program. Performance Reports, rather than the frameworks, are more likely to guide actual practice because the former *evaluate* school progress and performance against similar California schools, while frameworks *model* good practice.[3]

The Performance Report is the keystone of the accountability program that emphasizes academically rigorous core courses for all high school students. Each school in the state is compared with a group of 160 similar schools on a variety of quality indicators, such as increased enrollment in selected academic courses, improved test scores, reduced dropout rates and increased performance on SATs, Achievement Tests, and Advanced Placement exams. Statewide improvement targets through 1990 were established for each indicator. The report contains two parts: the first, prepared by the state, uses statewide indicators; the second, prepared by the school, contains locally developed descriptions and evaluations of program quality.

Quality indicators in math, science, and foreign language report students taking three or more years of math and advanced placement mathematics, and those taking three or more years of science, chemistry, physics, and advanced science. The school receives a score related to the number of students who have taken three or more years of foreign language.

Performance reports contain statewide averages and targets for each year to 1990. The target for mathematics–that 75 percent of students complete three years of high school math–was surpassed in 1985-86. The expectation that 50 percent of seniors complete three years of science has yet to be accomplished. In 1985-86, 40 percent of high school seniors had taken three years of science. The Performance Report targets 61 percent of juniors and seniors to complete advanced science (that is, science which meets UC admission standards includes laboratory practice). The 1989-90 foreign language target is for 32 percent of high

[3]Gregg Bender called this distinction to our attention.

school seniors to have taken three years of a foreign language. The 1985-86 level was 26 percent (Performance Report for California Schools 1986).

Performance Reports delineate expectations of accomplishment and quality. They provide quantitative measures of qualitative program improvements. When implementing a core academic curriculum, students, parents, teachers, and administrators can evaluate their efforts against those of their peers by comparing schools that have students similar in ethnic background, economic levels, and proportion of limited-English-speaking students.

Performance Reports quantify performance outcomes. Frameworks guide curricular content, teaching, and staff development processes that are intended to develop positive performance outcomes. Each framework describes the contents of a model program and is designed to guide local districts and teachers in preparing curricula. Frameworks describe optimal preservice preparation, effective teaching, expected outcomes, and improvement strategies. They suggest model inservice training and program evaluation techniques. Each of the three frameworks will be discussed in turn.

Mathematics Framework

The ideal preservice preparation for elementary and secondary mathematics teachers is reproduced here from the Mathematics Framework (1985) (Table 24). As do other guides, the Mathematics Framework advocates instruction that stimulates curiosity, incorporates several modes of problem solving, and is closely tied to practical applications.

> As a statement of philosophy and vision, this framework holds that *every* student can enjoy and use mathematics to real advantage and that the power of mathematical thinking is not reserved for only an academic elite. It also holds that a more encompassing core curriculum is needed at all grade levels (SDE 1985).

TABLE 24

Math Requirements for California Elementary and Secondary Math Teachers

Level I	Course 1: Fundamental Mathematical Concepts I Course 2: Fundamental Mathematical Concepts II Course 3: Geometry for Elementary and Middle School Teachers Course 4: Algebra and Computing for Elementary and Middle School Teachers
Level II	Courses 1-4 from Level I Introduction to Calculus Four additional Level III courses (other than Calculus)
Level III	Calculus Sequence (three courses) Discrete Mathematics Introduction to Computing Mathematics Appreciation Linear Algebra Probability and Statistics Number Theory Geometry Abstract Algebra History of Mathematics Mathematical Modeling and Applications

Teaching Levels	Recommended Minimum Preparation
Early Childhood (Nursery, Kindergarten)	Courses 1, 3
Grades 1-6	Courses 1, 2, and 3
Elementary Mathematics Specialist	Level II
Middle School	Level II
High School	Level III
Calculus	Level III and advanced work in analysis

SOURCE: State Department of Education, State Framework for Mathematics.

Teachers should model creative problem-solving behavior whenever possible, as this excerpt from the Mathematics Framework recommends:

> To help students develop the attitudes and strategies useful in problem solving, teachers should:
>
> - Model problem-solving behavior whenever possible, exploring and experimenting along with students.
>
> - Create a classroom atmosphere in which all students feel comfortable trying out ideas.
>
> - Invite students to explain their thinking at all stages of problem solving.
>
> - Allow for the fact that more than one strategy may be needed to solve a given problem and that problems may require original approaches.
>
> - Present problem situations that closely resemble real situations in their richness and complexity so that the experience that students gain in the classroom will be transferable (14).

The Mathematics Framework recognizes that many teachers may not have been exposed to this kind of mathematics instruction:

> Many teachers have learned mathematics in a way that leads them to view it as a collection of algorithms to practice until either mastery or exhaustion occurs. Mathematics should be viewed differently. The teacher must exhibit an attitude of exploration and invention, conveying the idea that all students can learn, enjoy and use mathematics (6).

The framework suggests that many teachers will need retraining, in both teaching methods and curriculum, because they have not been exposed to this kind of teaching. Retraining should include organized programs that extend over a period of time in which coaching and other modern methods of inservice training can have a beneficial long-term effect. Programs such as EQUALS and Bay Area Math Project (BAMP) combine hands-on practice and follow-up peer support to help teachers improve their teaching skills. In fact, teachers in our sample firmly supported inservice training which involved helping new teachers and observing experienced teachers.

Of the public school teachers who responded to our survey, 34 percent reported that they participated in subject-matter inservice training more than once a year. Seventy-two percent of these indicated that the training lasted less than a week. Only 18 percent participated in inservice training lasting more than three weeks.

Science Framework

Science instruction should proceed in a context much larger than that traditionally found in classrooms where memorizing facts is the prime objective. Science, according to the framework (SDE 1978), should encompass two definitions:

> In the first category of definitions, science is viewed as a body of collected knowledge comprised of interconnected sets of principles, laws, and theories that explain the universe. When people who take this view talk about science, they refer only to its content–the facts, principles, and laws used to describe the world around them.
>
> In the second category of definitions, science is viewed as a set of processes that can be used to systematically acquire and refine information. People who take this view consider the scientific enterprise to be a set of processes for obtaining information. . . . The dynamic relationship between systematic processes and pieces of knowledge is the essence of the enterprise (SDE 1978, 1).

Given the importance of both approaches to science, the following goals of California's science programs are established:

> The goals for science instruction are described under the following categories: (1) achieving scientific attitudes; (2) achieving rational and creative thinking processes; (3) achieving manipulative and communicative skills; and (4) achieving scientific knowledge (SDE 1984, 1).

The Science Framework stresses process in equal measure with content.

Foreign Language Framework

Similarly, the Foreign Language Framework (1980) recognizes that students may be taking foreign languages for a variety of reasons and with a wide range of commitment to their study. Communication is the primary goal. Students should be able to read and

comprehend and to speak and write so that others may understand them. The secondary goal is that students become well enough acquainted with cultural attitudes, traditions, and cues to function in a variety of social contexts in the second language (SDE 1980). Classroom activities should be structured to meet a variety of learning styles and objectives. Small and large group instruction allow the teacher to accomplish different objectives and meet individual needs. "The skillful, knowledgeable, and imaginative foreign language teacher will devise an assortment of activities that will provide students with opportunities to communicate in the foreign language" (SDE 1980).

Teacher Qualifications

Private school principals in our sample preferred a teacher with a degree in the subject to be taught, plus experience teaching at the appropriate level, to one with a state-issued teaching credential. They indicated that prior teaching experience and subject-matter competence were more important considerations in the hiring decision than ability to work with children. Teachers with no prior teaching experience, regardless of employment experience in the subject field, were unlikely to be hired. Exclusive private schools located in rural areas reported no difficulty hiring qualified science teachers. One private school director in a metropolitan area and one in a rural area reported difficulty in locating and retaining skilled science teachers (6%).

Requirements for public school teachers are more complex. Not only must they have a bachelor's degree in a subject other than education and verified competence in the subject to be taught, they must also pass CBEST and obtain a credential. A teaching credential is required for employment in California public schools. The credential is awarded either upon completion of an authorized teacher training program at a California college or upon demonstration by a teacher trained in a state outside California that the minimum requirements have been met. Several types of emergency credentials can be obtained in lieu of a full credential if the district board of trustees declares that a shortage exists. Actual credential requirements are set by schools of education, thus course content and preparation differ from school to school.

The Commission on Teacher Credentialing issues over 20 types of multiple and single-subject credentials. New teachers may obtain a preliminary (one-, four-, or five-year), clear, one-year nonrenewable, or emergency credential, depending on the preservice training they obtained (Table 25).

TABLE 25

Summary of Teaching Credential Requirements, By Type of Credential

Types of Credentials	BA (not in Education)	CBEST	No Training: Teaching Position	Out of State Training	California Training: Student Teaching	Methods Courses	NTE/Waiver	U.S. Constitution	Misc. Courses	Fifth Year
Emergency	*	*	*							
OYNRE	*		*	*						
One Year Preliminary	*	*		*	*	*				
Four Year Preliminary	*	*		*	*	*	*	*		
Five Year Preliminary	*	*			*	*	*	*	*	
Clear	*	*			*	*	*	*	*	*

One Year Professional Training

OYNRE–One year nonrenewable
CBEST–California Basic Educational Skills Test
NTE/Waiver–Acceptable score on National Teacher Exam or completion of Subject Matter Waiver Program
Methods Courses–No more than nine units of methods courses, plus course in teaching reading.
Miscellaneous Courses–Mainstreaming Handicapped; Health, Nutrition, and Drug Abuse Prevention, Computer Education.

- Teachers trained outside California normally apply for OYNRE, One Year Preliminary, or its extension, Four Year Preliminary credentials.
- Teachers trained in California ordinarily obtain a Five Year Preliminary credential or a Clear Credential.

To read this chart:

- To obtain an Emergency Credential, a person must have a B.A. degree in a subject other than education, pass CBEST, and have a teaching job.
- To obtain a Clear Credential, a person must have a B.A. degree, pass CBEST, complete the requirements under "California Training," and complete a fifth year of study beyond the B.A.

SOURCE: Commission on Teacher Credentialing.

Teachers Trained in California

The California Commission on Teacher Credentialing approves teacher training programs that meet minimum requirements established by the commission and by the legislature. The programs, in turn, recommend credentials for individuals who meet certain minimum requirements. Minimum requirements for a preliminary credential include the possession of a bachelor's degree, verification of subject matter competence, completion of one semester of full-time student teaching, nine units of methods courses, and a group of miscellaneous courses. Teachers must be at least 18 years old, have fingerprint cards processed for character and identification clearance, and swear to uphold the constitution and laws of California and of the United States (CCFSF 1984). The candidate must demonstrate competence in the subject-matter field either by completing a series of courses approved by the training institution (subject matter waiver) or by passing the National Teachers Examination in the subject field with a score that equals or exceeds the established standard. Prospective math teachers must complete 30 semester units of math and 15 units of related subjects, including demonstrated proficiency in first- and second-year calculus, geometry, statistics, probability, computer programming, history of mathematics, and number theory. Life science teachers must have completed courses in, or directly related to, biology, physiology, ecology, zoology, botany, and marine biology, while physical science teachers must master courses in chemistry, physics, and earth science. Foreign language programs must include 30 units of upper division college work in language, culture, linguistics, and literature (Commission on Teacher Credentialing 1985, Title V, Section 80086).

Upon completion of these requirements a teacher is granted a five-year preliminary credential. During the five-year period, he or she completes the fifth year of training required for a clear credential. Alternatively, the applicant may obtain a clear credential if the professional preparation program is completed during the fifth year of study beyond the bachelor's degree. Beginning September 1, 1985, those who have professional clear credentials must teach at least one semester and complete 150 clock hours of professional training every five years to renew the credential.

Beginning in 1983, each credential applicant must also pass the California Basic Educational Skills Test (CBEST) either to obtain a credential or to obtain employment if the individual has not worked in a position which required a credential in the past 39 months. A passing score on CBEST is also required to obtain additional credentials.

Requirements for Teachers Trained Outside California

Teachers trained outside California may apply for either a one-year *nonrenewable* (OYNRE), or a preliminary, credential. The first authorizes the applicant to teach (without having taken and passed CBEST) in a district in which a shortage of qualified teachers exists. The one-year period allows the individual to teach while completing the CBEST requirement. The one-year *preliminary* credential, obtained by passing CBEST and the paper screening of professional preparation, can be renewed for a four-year period to allow time to complete the fifth year and specific California requirements in health and nutrition, mainstreaming handicapped children, and computer education. At the end of the five-year period, a teacher receives a *clear* credential. Beginning September 1, 1985, all credential holders must teach at least one semester and complete 150 clock hours of professional training every five years to renew the credential.

Requirements if a Shortage Exists

School districts may hire teachers who do not have the required credential when no credentialed applicants are available. Under conditions of shortage, districts have several choices. After the school board certifies that no fully credentialed applicants are available, a teacher already employed in the district may be granted a *limited-service* credential or waiver to teach the subject, on condition that she or he completes 10 semester units of upper division college course work in the subject in the next five years. If no teacher is available under this program, the district may hire a teacher trained outside California on a *one-year nonrenewable credential,* while the teacher completes the CBEST requirement.

The district may also choose to hire a teacher with an *emergency* credential. Any college graduate with a bachelor's degree may obtain an emergency credential by passing CBEST and finding a teaching job. The emergency credential can be renewed annually, as long as the district continues to certify that a shortage of credentialed teachers exists. The teacher must complete six units each year until all requirements for the clear credential are completed. The emergency credential clearly fills a need in certain areas of the state. Districts reported that emergency credentials or waivers were held by 601 science teachers, 766 math teachers, and 103 foreign language teachers in 1985-86. This apparently does not include emergency credentialed teachers from prior years who continued to teach.

Districts may also establish a teacher trainee program if there is a shortage of fully qualified teachers. Trainees must:

- Possess a bachelor's or higher degree with a major or minor in the subject to be taught
- Pass the California Basic Educational Skills Test
- Pass the appropriate National Teachers Examination
- Obtain a Certificate of Clearance for health and police record

Districts must complete an employer's statement of need and state that supervision by a mentor teacher will be provided.

School boards must certify annually that a shortage of qualified applicants exists in order to continue to employ teachers with limited assignment and emergency credentials.

Impact of Credential Requirements on Teacher Supply

An important policy issue is the effect of teaching credentials on the supply of available teachers. A single new requirement may reduce teacher supply. Following imposition of the CBEST requirement in 1983, noticeably fewer credentials were issued. Many highly educated people (mostly women) who had been substituting felt insulted by the requirement and refused to take the test. Others feared they would not pass it and did not take it the first year it was required. Other problems with administering the test may also have reduced the number of test takers. Many districts experienced a severe shortage of substitute teachers the year that CBEST was first required. The number of credentials issued increased again in the following year.

CBEST clearly prevents many people who want to teach from doing so. The failure rate for black and Hispanic applicants has been twice that of white applicants, although it has declined recently (Table 26). As a result, fewer minority teachers are part of the applicant pool. Rather than eliminating the basic skills requirement, the best approach may be to ensure that prospective minority teachers receive sufficient training to enable them to pass the test (Gifford 1986).

There is considerable debate about the efficacy of credential requirements as currently constituted. Knowledgeable observers suggest that current requirements discourage many academically able individuals from pursuing teaching and fail to prepare those who do complete the requirements for effective classroom service. For additional information on this topic, readers should refer to the report of the California Commission on the Teaching Profession (1986), and to Stoddart, Losk, and Benson (1984).

TABLE 26

CBEST Passing Rates By Ethnic Group, First Time Test Takers

	1982-83		1985-86	
	Number Tested	Percent Passed	Number Tested	Percent Passed
Asian	1,259	50	1,125	62
Black	2,040	26	1,997	37
Mexican American	2,133	39	1,759	50
Other Hispanic	754	38	754	48
White	24,540	75	33,563	81
Other	1,326	61	1,421	49
Total	32,039		40,619	

SOURCE: Commission on Teacher Credentialing, 1985.

Section Four
Summary and Policy Implications

Student Performance

Enrollment in high school math, science, and foreign language classes has increased dramatically in California since 1982 in response to three policy changes:

- Increased graduation requirements
- Increased college entrance requirements
- UC and CSU policy for evaluating grades earned in honors classes

Seventy-nine percent of secondary students enrolled in a math class in 1985-86, 65 percent in a science class, and 37 percent in foreign language. Corrected for student population changes, high school math enrollment increased nearly 10 percent; science, 47 percent; and foreign language, 31 percent between the pre-reform year of 1981-82 and 1985-86.

All groups of students have not benefited equally, however:

- Enrollment is concentrated in introductory-level courses, many of which do not meet many university and college admission standards.
- Black, Hispanic, female, and handicapped students are far less likely to enroll in advanced classes than are their male, white, and Asian counterparts.
- Up to one-fifth of teachers in the three fields are not appropriately credentialed to teach the subjects to which they are assigned.

If dropout rates and continuation school enrollment also increased during the same period, as has been surmised, some students are not benefiting at all from increased expectations. Black, Hispanic, and female students, fewer of whom take advanced math and science classes, benefit to a lesser extent from increased requirements.

Even students enrolled in more advanced classes may not benefit from increased standards if their teachers are not appropriately qualified. Twenty percent of all math sections were taught by teachers who indicated they were not certificated to teach math. Most surprising, 18 percent of *advanced* math classes and 6 percent of *advanced placement*

math classes were taught by teachers without appropriate credentials. An equal percent of science teachers were not appropriately qualified to teach science.

State frameworks for math, science, and foreign language contain state-of-the-art instructional guidance for district curriculum leaders and teachers. A concerted effort to implement the recommendations and programs described in the frameworks would substantially advance the teaching of these three subjects in California. Equally important should be a concerted effort to train teachers to involve and encourage students who have traditionally not participated in advanced study in math, science, and foreign language. This will be a particularly effective investment during the coming decade as the current highly experienced teaching force is rapidly replaced by new teachers.

Teacher Supply and Demand

In order to meet demand from enrollment growth and attrition, California will need 2,750 to 3,060 new math teachers; 1,750 to 2,480 new science teachers; and 1,270 to 1,400 new foreign language teachers by 1991-92. At least an additional 800 math teachers, 650 science teachers, and 360 foreign language teachers will be needed to place an appropriately credentialed teacher in every secondary class. *These requirements are expressed in full time equivalent teachers (FTE), not individuals.* Our analysis of CBEDS indicates that approximately two individuals are equivalent to one FTE in the subject area. An additional 240 to 258 math FTEs will be needed for private school demand. Private schools will need approximately 200 new science teachers and 115 new foreign language teachers.

Close to 50 percent of public school teachers (FTEs) in 1990-91 will have been hired in the previous five years to provide for increased requirements and enrollment growth and to replace teachers lost to attrition (including retirement). If current patterns continue, a similar number of teachers will have moved from one district to a neighboring one. Although California schools of education will continue to train new teachers in the three fields, a large proportion of the newly trained teachers may be unwilling to move to obtain teaching positions. In the absence of a change in policy on teacher assignments, the distribution of newly hired in the next five years will likely be similar to their distribution in the past five years despite the "availability" of newly trained teachers: approximately 50 percent will be experienced and 50 percent inexperienced. Even experienced teachers hired to teach math may have limited-service or emergency credentials. Of the inexperienced teachers, as many as 70 percent may have emergency credentials. As many as 25 percent of experienced teachers may be assigned to teach courses for which they are not trained. Preservice, induction, and inservice training will become even more important in the next five years to ensure the quality of the teaching force and the level of student achievement.

Although the pool of newly trained teachers will increase, large numbers of them may not find jobs; at the same time, districts experiencing shortages in other parts of California may hire many teachers with emergency credentials. A larger proportion of new teachers will be people seeking a second career in education. We may expect that change to have an effect on school climate and instructional focus.

What are the implications for California's future of differences in levels of student attainment? As the white portion of California's school-age population declines, the group of students from which the state has traditionally obtained most of its skilled technical labor pool will become a smaller and smaller part of the total work force. Asians, who pursue technical careers at a much higher rate than do members of other ethnic groups, will clearly fill some of the gap in the required labor supply. Even though the Asian population is growing rapidly, however, there will not be enough technically skilled workers unless women and members of Hispanic, black, and other minorities become involved. Furthermore, without technological skills, women and minority group members will find themselves increasingly relegated to lower paying service sector employment. California's economy as a whole will suffer because much of its labor force will have limited earning potential. Business and industry, forced to locate where it can find skilled workers, will leave California with less attractive employment options and a lower state payroll. The ripple effect will touch all economic sectors. As a consequence of the widening earnings gap between exceptionally high wage earners and service workers, the middle class will decline absolutely and as a proportion of the total population (BRIE 1986).

California's economic self-interest argues for more intensive specifically targeted efforts to increase the distribution of traditionally underserved female and minority students throughout advanced-level classes in math, science, and foreign languages. It argues for increased preservice and inservice training to improve math, science, and foreign language teaching and for increased emphasis on the languages and cultures of the Pacific Rim. It argues for the substance as well as the appearance of higher expectations and achievement.

Policy Implications

Teacher Quality and Student Participation

1. The foundation for high school work is built in elementary schools. Excellent elementary math, science, and foreign language programs will lead to increased participation and achievement in high school classes.

2. Members of traditionally underserved minorities (including parents of children in elementary schools) need information about opportunities in technical fields, encouragement to pursue them, and connections to obtain them. Well informed teachers, in

addition to specially funded programs such as MESA, play a vital role in this information transfer.

3. Programs to increase student participation and achievement, such as EQUALS, MESA, and PDP, should be part of every California high school's staff development program and curriculum.

4. Educational strategies for involving traditionally underserved minorities and females in challenging math, science, and foreign language classes should receive as much emphasis in teacher training programs as does subject-matter competence.

5. Schools need to continue to explore delivery systems which may improve services for working parents (e.g., year-round schools and childcare) and programs to improve minority retention to graduation.

6. High schools should identify and implement policies to develop the same level of female enrollment in advanced high school math classes as prevails in junior high schools.

Supply of Teachers

7. Despite recent improvements arising from SB 813, teacher salaries, particularly in Southern California, are still not high enough to attract an adequate number of trained teachers, especially in math and science.

8. As long as teachers can be assigned to teach out of their field or can be hired with emergency credentials, the extent of the shortage of math and science teachers and the need to deal with the problem will continue to be masked.

9. A differentiated salary schedule, with competitive salaries for individuals whose skills are in short supply, would increase the supply of skilled math and science teachers, without providing a windfall for teachers in fields in which shortages do not exist.

10. When more emergency credentials are issued than first-year teachers are hired, preservice teacher training and the teacher credentialing process have little impact on the quality of teachers hired.

11. The credentialing system, as currently constituted, appears to be a roadblock, rather than an incentive, to qualified teachers.

12. Concentrating teacher training in geographical areas of high demand would be a more efficient allocation of limited resources, since few teachers apparently relocate to obtain teaching positions.

13. If California districts gave teachers more credit on the salary schedule for previous teaching experience, the number of trained teachers hired would increase.

14. To maintain or improve the quality of the teaching profession, school districts will need additional revenue either to raise salaries sufficiently to attract credentialed teachers or to provide extensive education and inservice training.

Program Quality

15. Requiring students to take classes for which qualified teachers cannot be provided is of limited educational benefit.

16. Teachers require adequate texts, desks, materials, and equipment for long-run productivity. To provide less but expect high productivity is unrealistic and constitutes poor management of the primary resource available to education.

17. Thorough training in subject-matter frameworks, both preservice and inservice, and in their guidelines and processes would improve education in California. This effort would directly support achievement of Performance Report objectives.

18. Educational strategies for involving traditionally underserved minorities and females in challenging math, science, and foreign language classes should receive as much emphasis in teacher training programs as does subject-matter competence.

19. Adequate preservice and inservice training is as important for elementary and junior high school teachers as for high school teachers.

APPENDIX TABLE A1

Projected Public School Enrollment in Math, Science, and Foreign Language Classes, Grades 9 to 12, 1985-86 to 1991-92

Year	Projected Total Enrollment[1]	Math		Science		Foreign Language	
		Wtd. Avg.[2]	85/6 Ratio[3]	Wtd. Avg.[2]	85/6 Ratio[3]	Wtd. Avg.[2]	85/6 Ratio[3]
1985-86	1,328,849	78.9%	79.4%	59.9%	64.6%	35.7%	36.6%
1986-87	1,315,128	1,037,373	1,044,475	787,367	849,573	469,106	480,679
1987-88	1,291,902	1,019,052	1,026,029	773,462	834,569	460,821	472,190
1988-89	1,268,750	1,000,790	1,007,641	759,601	819,613	452,563	463,728
1989-90	1,258,956	993,064	999,863	753,737	813,286	449,070	460,148
1990-91	1,281,506	1,010,852	1,017,772	767,238	827,853	457,113	468,390
1991-92	1,323,966	1,044,344	1,051,494	792,658	855,282	472,259	483,910

SOURCE: Department of Finance, 1986.

[1] DOF projections do not include students in ungraded classes (Special Ed.), ROC/ROP, or Adult Ed. Hence total enrollment represents students in "regular" secondary schools. Hence, this total enrollment does not agree with total enrollment (Table 3) calculated for SIF.

[2] Wtd. Avg.=Weighted average of annual enrollment as percent of total secondary enrollment for 1983-84 (x1), 1984-85 (x2), and 1985-86 (x3).

[3] 1985-86 enrollment as percent of total secondary enrollment.

APPENDIX TABLE A2

FTEs Needed For Enrollment and Attrition, Annual and Cumulative, 1985-86 to 1991-92

	Lower Bound				Upper Bound			
MATH								
Year	FTEs Needed	Remain	FTEs Reqd	Cum	FTEs Needed	Remain	FTEs Reqd	Cum
1985-86	6535	6045			6535	6016		
1986-87	6404	5923	359	359	6447	5930	431	431
1987-88	6290	5819	367	726	6334	5819	404	835
1988-89	6178	5714	359	1085	6220	5709	401	1236
1989-90	6130	5670	416	1501	6172	5659	463	1699
1990-91	6240	5772	570	2071	6283	5755	623	2322
SCIENCE								
Year	FTEs Needed	Remain	FTEs Reqd	Cum	FTEs Needed	Remain	FTEs Reqd	Cum
1985-86	5240	4847			5241	4825		
1986-87	4807	4446	-40	-40	5187	4770	362	362
1987-88	4722	4368	276	236	5095	4681	325	687
1988-89	4637	4290	270	505	5004	4592	322	1009
1989-90	4602	4256	312	817	4965	4553	373	1382
1990-91	4684	4333	428	1245	5054	4630	502	1884
1991-92	4839	4476	506	1751	5222	4778	592	2476
FOREIGN LANGUAGE								
Year	FTEs Needed	Remain	FTEs Reqd	Cum	FTEs Needed	Remain	FTEs Reqd	Cum
1985-86	2970	2747			2970	2734		
1986-87	2869	2654	135	135	2940	2704	206	206
1987-88	2818	2607	177	312	2888	2654	184	390
1988-89	2768	2560	174	486	2836	2603	183	573
1989-90	2747	2541	199	685	2814	2580	211	784
1990-91	2796	2586	268	953	2865	2624	284	1068
1991-92	2888	2672	315	1268	2960	2708	336	1404

APPENDIX TABLE A2 (Continued)

1. **Lower Bound**

   FTEs Needed is projected using weighted average of enrollment percents for 1983 to 1985 and average of class sizes for subject for 1983 to 1985.

   Remain is FTEs remaining after attrition, using average of eight years attrition rates from STRS. 7.95%

   FTEs Reqd is difference between FTEs needed and "Remain."

   Cum sums FTEs needed from year to year.

2. **Upper Bound**

   FTEs Needed is projected using 1985/86 percent of total enrollment and average of three years' class sizes.

   Remain is FTEs remaining after loss to attrition. Attrition rate is trend of annual attrition rates, 1977 to 1984, for all members of STRS.

   FTEs Reqd is difference between FTEs needed and "Remain."

   Cum sums FTEs needed from year to year.

APPENDIX TABLE 3

Private School FTEs Needed For Enrollment and Attrition, Annual and Cumulative, 1986-87 to 1991-92

MATH

	Lower Bound				Upper Bound			
Year	FTEs Needed	Remain	FTEs Reqd	Cum	FTEs Needed	Remain	FTEs Reqd	Cum
1986-87	926	856			993	918		
1987-88	886	819	29	29	950	879	32	32
1988-89	853	789	34	63	915	847	37	68
1989-90	835	772	45	108	895	828	48	117
1990-91	831	769	59	167	891	824	63	180
1991-92	842	778	73	240	902	835	78	258

SCIENCE

Year	FTEs Needed	Remain	FTEs Reqd	Cum	FTEs Needed	Remain	FTEs Reqd	Cum
1986-87	753	697			808	747		
1987-88	721	667	24	24	773	715	26	26
1988-89	694	642	28	52	745	689	30	56
1989-90	679	628	37	89	728	674	39	95
1990-91	676	626	48	137	725	671	52	147
1991-92	685	633	59	196	734	679	63	210

FOREIGN LANGUAGE

Year	FTEs Needed	Remain	FTEs Reqd	Cum	FTEs Needed	Remain	FTEs Reqd	Cum
1986-87	427	395			458	423		
1987-88	408	378	14	14	438	405	15	15
1988-89	393	364	16	29	422	390	17	31
1989-90	385	356	21	50	413	382	22	54
1990-91	383	354	27	77	411	380	29	83
1991-92	388	359	34	111	416	385	36	119

APPENDIX TABLE A3 (Continued)

1. **Lower Bound**

   FTEs Needed is projected using weighted average of enrollment percents for 1983 to 1985 and average of class sizes for subject for 1983 to 1985.

   Remain is FTEs remaining after attrition, using average of eight years attrition rates from STRS. 7.95%

   FTEs Reqd is difference between FTEs needed and "Remain."

   Cum sums FTEs needed from year to year.

2. **Upper Bound**

   FTEs Needed is projected using 1985/86 percent of total enrollment and average of three years' class sizes.

   Remain is FTEs remaining after loss to attrition. Attrition rate is trend of annual attrition rates, 1977 to 1984 for all members of STRS.

   FTEs Reqd is difference between FTEs needed and "Remain."

   Cum sums FTEs needed from year to year.

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