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John Ramsey
University of Houston

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STATE INDICATORS IN SCIENCE AND MATHEMATICS EDUCATION: A COMPARISON OF IOWA AND THE UNITED STATES

John Ramsey, Ph.D.

Dept. of CUIIN

*University of Houston — Central Campus
Houston, TX 77204-5872*

The first state-by-state data of key indicators of the condition of science and mathematics in schools has been issued in a report from the Council of Chief State School Officers (CCSSO). This report, *State Indicators of Science and Mathematics Education*, is supported by a grant from the National Science Foundation. The project identified two objectives: (1) to improve the quality and usefulness of data on science and mathematics education so that state policy makers and program managers can make more informed decisions; and (2) to define and implement a set of indicators, national and state level analyses of progress in improving science and mathematics education in grades 9-12.

Two sources of data were used. First, state departments of education compiled data on students and teachers in public schools, including course enrollment data from 38 states and teacher data from 47 states. Second, data from the National Center for Education Statistics' Schools and Staffing Survey were analyzed. Similar reports will follow, with increased state participation and the inclusion of other indicators, e.g., data on implemented curricula.

This article will present summaries of national and Iowa data for the key CCSSO indicators. These data will provide a basis for comparison by Iowa mathematics and science educators.

Part I. Instruction and Participation in Science and Mathematics

Course-Taking in Mathematics. Based on data collected in 1989-90, an estimated nine percent of public high school students in the United States take calculus before they graduate. Nationally, 49 percent take Algebra II, and 81 percent take Algebra I (See Table 1). Two percent of students take advanced placement calculus (See Table 2). The proportion of students taking Algebra II varies among states from 65 percent to 33 percent. High school mathematics courses taught with an integrated curriculum approach are incorporated in the state indicators.

In Iowa, nine percent of students take calculus; 50 percent take Algebra II; and 92 percent take Algebra I (See Table 1).

Course-Taking in Science. Using 1989-90 state course-taking data in science, an estimated 20 percent of public high school students in the United States take physics before they graduate, 45 percent take chemistry, and 95 percent take biology. (Refer to Table 1.) The proportion of students taking chemistry varies by state from 62 percent to 33 percent. Enrollments in advanced placement courses are two percent in biology, one percent in chemistry, and less than one percent in physics (See Table 2).

Table 1.
Secondary Students in Science and Mathematics Courses:
Iowa and the United States
(Public Schools, 1989)

Mathematics Courses Taken	USA	Iowa
Algebra I	81%	92%
Algebra II	49%	50%
Calculus	9%	9%
Science Courses Taken		
Biology I	95 + %	95 + %
Chemistry I	45%	57%
Physics	20%	27%

Source: CCSO, State Education Assessment Center, Washington, DC, 1990

Table 2.
A Comparison of Iowa and United States Twelfth Grade
Students' Enrollment in Advanced Science and Mathematics
Courses (Public Schools, 1989)

Advanced Courses	USA		Iowa	
	Advanced Placement	Second Year	Advanced Placement	Second Year
Calculus	2%	7%	N.A.	9%
Biology	2%	16%	N.A.	8%
Chemistry	1%	3%	N.A.	N.A.
Earth Science	N.A.	4%	N.A.	N.A.

N.A. = Not Available

Source: CSSO, State Education Assessment Center, Washington, DC, 1990

In Iowa, 27 percent of public school students take physics; 57 percent take chemistry; and greater than 95 percent take Biology I (See Table 1).

Elementary Instruction. Elementary teachers in the median state report that they spend 4.9 hours per week on mathematics and 3 hours per week on science in grades 4-6. State figures for mathematics vary from 4.1 hours to 5.5 hours per week, and the time spent on science varies from 2.2 to 4.1 hours per week (See Table 3).

In Iowa elementary teachers report that they spend 4.3 hours per week on mathematics in grades 1-3 and 5.0 hours per week in grades 4-6. For science, 2.2 hours are reported in grades 1-3 and 2.7 hours per week in grades 4-6 (See Table 3).

Table 3.
A Comparison of United States and Iowa Weekly Instructional Time for Elementary Science and Mathematics (Public Schools, 1989)

Subject	USA (Median State)	Iowa
Science		
Grades 1-3	2.3 hrs/wk	2.2 hrs/wk
Grades 4-6	3.0	2.7 hrs/wk
Mathematics		
Grades 1-3	4.8 hrs/wk	4.3 hrs/wk
Grades 4-6	4.9 hrs/wk	5.0 hrs/wk

Source: CCSSO, State Education Assessment Center, Washington, DC, 1990

Part II. State Policies and Course-Taking in Science and Mathematics

The state indicators for high school course-taking as of 1989-90 confirm other research showing *increased* enrollments in science and mathematics during the 1980s when graduation requirements were raised in many states. State course-taking rates show somewhat higher enrollments at all levels, but the largest increases were in Algebra I (to 81 percent of students) and first-year biology (to 95 percent of students).

State Policies and Mathematics. Eleven states require from two and a half to three Carnegie credits in mathematics for graduation; 20 states require two credits; and four states, including Iowa, have no requirements. The states requiring from two and a half to three credits of mathematics have a median of 10 percent more students taking mathematics courses than states requiring two credits or fewer. However, the high requirement states have a median of only two percent more students taking upper level mathematics courses, e.g., geometry through calculus. These results indicate that, on average, higher state graduation requirements do not necessarily lead to significantly more students taking upper-level mathematics courses. Iowa and several other states are exceptions to this pattern.

The median state reports 91 percent of students taking mathematics; 35 percent taking upper level mathematics; and 34 percent taking review and informal mathematics. Iowa reports 86 percent of students taking mathematics; 43 percent taking upper level mathematics; and 20 percent taking review and informal mathematics (See Table 4).

Table 4.
A Comparison of Iowa and Other States
By Percent of Students Taking Mathematics Courses
in Grades 9-12 (Public Schools, 1989)

Credits Required	Taking Mathematics	Taking Upper Level Mathematics	Taking Review & Informal Mathematics
<u>2.5-3 Credits (11 states)</u>			
Median State	91%	35%	34%
<u>2 Credits (20 states)</u>			
Median State	81%	33%	26%
<u>0 Credits (4 states)</u>			
Median State	74%	36%	17%
Iowa	86%	43%	20%
Total (35 states)	84%	34%	27%

Source: CCSSO, State Education Assessment Center, Washington, DC, 1990

State Policies and Science. Five states require two and a half credits of science for graduation; twenty-three states require two credits; and seven states, including Iowa, require one or no credits. The five states requiring two and a half to three science credits have a median of nine percent more students enrolled in science than states requiring two or fewer credits. The high requirement states have a median of four percent more students taking upper-level science courses, e.g., chemistry, physics, and advanced biology. Some evidence supports the statement that a science graduation requirement above two credits is related to more upper-level science course-taking, but the data are not conclusive because of the small number of states with higher science requirements (See Table 5).

The median for all states indicated that 72 percent of students are taking science; 21 percent are taking upper-level science; and 23 percent are taking introductory science. In Iowa, 71 percent of the students are taking science; 23 percent are taking upper-level science; and 20 percent are taking introductory science.

Gender Differences. Girls and boys in all 16 states reporting data by gender have almost equivalent rates of enrollment in science and mathematics courses up to advanced course levels. In most states, boys have higher enrollments in physics and advanced mathematics courses, e.g., trigonometry and calculus, and girls have higher enrollments in advanced biology courses.

Table 5.
A Comparison of Iowa and Other States
By Percent of Students Taking Science Courses
in Grades 9-12 (Public Schools, 1989)

Credits Required	Taking Science	Taking Upper Level Science	Taking Introductory Science
<u>2.5-3 Credits (5 states)</u>			
Median State	80%	25%	29%
<u>2 Credits (23 states)</u>			
Median State	71%	21%	24%
<u>1 or 0 Credits (7 states)</u>			
Median State	71%	20%	22%
Iowa	71%	23%	20%
Total (35 states)	72%	21%	23%

Source: CCSSO, State Education Assessment Center, Washington, DC, 1990

Part III. Teacher Quality and Teacher Supply and Demand

In grades 9-12, there are approximately 111,000 teachers of mathematics and 102,000 teachers of science in the 50 states and the District of Columbia. In Iowa, there are 1,487 mathematics teachers and 1,423 science teachers in grades 9-12. One of the central national and state educational objectives during the 1980s was to improve the quality of teachers. The National Science Board (1983) and the Carnegie Forum on Education and the Economy (1986) identified the problem of under-qualified teachers in science and mathematics and impending teacher shortages. The National Science Teachers Association (1984) reported that 30 percent of all secondary science teachers were severely under-qualified or unqualified. Although state initiatives during the 1980s (such as alternative certification programs) have mitigated predicted teacher shortages, attrition rates still run between four and five percent. Shortages are still present in the harder-to-hire fields of chemistry and physics.

Teacher Preparation to Teaching Out-of-Field. One indicator of teacher shortage and/or teacher preparation is courses taught outside of the teachers' field. Among teachers in 30 reporting states, nine percent of high school mathematics teachers are not certified in math, and eight percent of biology teachers, eight percent of chemistry teachers, and 12 percent of physics teachers are not certified in these fields. State-by-state data show that some states have 20 to 30 percent of mathematics and science teachers assigned out-of-field while others have one percent out-of-field. Further, teachers with secondary assignments, particularly in chemistry and physics, are less likely to be certified in the field.

Table 6.
**A Comparison of the Percentages of Mathematics and
 Science Teachers with Specific versus Broad-Field Certification
 (Public Schools, 1989)**

	Certified in Specific Field	Certified in Broad Field	Assigned Out- of-Area
Mathematics	81%	_____	9%
Biology	61%	31%	8%
Chemistry	57%	45%	8%
Physics	50%	38%	12%

Source: CCSSO, State Education Assessment Center, Washington, DC, 1990

College Majors. Forty-two percent of all high school teachers of mathematics had a mathematics major, and 54 percent of all teachers of science majored in a science field. The percent of teachers with majors in mathematics varies by state from 20 to 62 percent, and in science from 31 to 73 percent. In Iowa, 64 percent of all mathematics teachers had a college major in mathematics or mathematics education. For science, 68 percent of all science teachers had a college science or science education major.

Equity in the Teaching Force: Gender. The majority of high school science and mathematics teachers are male, but the gender distribution varies by field. Forty-five percent of mathematics teachers are female, while 22 percent of physics teachers are female. The percent of female teachers in mathematics varies by state from 21-69 percent, and the percent of female teachers in physics varies by state from 10-49 percent.

Concerning Iowa mathematics teachers, 72 percent are male and 28 percent female. Of Iowa science teachers, 21 percent of biology teachers, 22 percent of chemistry teachers, and 20 percent of physics teachers are female (See Table 7).

Race/Ethnicity. State data on the race/ethnicity of science and mathematics teachers show that there is a wide disparity between the supply of minority science and mathematics teachers and the proportion of minority students in virtually all states.

Current Teacher Supply: Primary Assignments. State indicators of science and mathematics teachers are reported by primary vs. secondary assignments. In the median state, 82 percent of high school teachers of mathematics have their primary assignment in mathematics; 63 percent of teachers of biology have their primary assignment in biology; 52 percent of chemistry teachers have their primary assignment in chemistry; and 24 percent of teachers of physics have their primary assignment in physics.

Table 7.
A Comparison of the Gender of United States
and Iowa Science and Mathematics Teachers
(Public Schools, 1989)

	USA		Iowa	
	Male	Female	Male	Female
All High School Teachers	50%	50%	62%	38%
Mathematics	55%	45%	72%	28%
Biology	63%	37%	79%	21%
Chemistry	66%	34%	78%	22%
Physics	78%	22%	80%	20%

Source: CCSSO, State Education Assessment Center, Washington, DC, 1990

Table 8.
Minority Teachers in Science and Mathematics
in Iowa and the United States
(Public Schools, 1989)

	Mathematics	Biology	Chemistry	Physics
USA	11%	10%	7%	5%
Iowa	1%	1%	1%	1%

Source: CCSSO, State Education Assessment Center, Washington, DC, 1990

In Iowa, data concerning the primary assignment of mathematics teachers were not reported. However, 38 percent of biology teachers have their primary assignment and 62 percent have their secondary assignment in biology. Twenty percent of chemistry teachers have their primary assignment and 80 percent have their secondary assignment in chemistry. Forty-two percent of physics teachers have their primary assignment and 58 percent have their secondary assignment in physics.

Teacher Age. Based on state data, 19 percent of high school mathematics teachers and 22 percent of science teachers are over age 50. By comparison, 21 percent of all high school teachers are over age 50. The proportion of mathematics and science teachers over age 50 varies by state from 10 percent to over 30 percent. In Iowa, 67 percent of all mathematics teachers were 30-49 and 18 percent were over age 50. Sixty-five percent of biology teachers were 30-49 and 19 percent were over age 50. Sixty-three percent of physics teachers were 30-49 and 21 percent were over age 50.

School Conditions: Class Size. The average class size in high school mathematics is 21 students per class, and the average class size in science is 22 students per class. These figures compare with an average class size in high school English of 22 students per class. States vary in average mathematics class size from 14-29 students and in science class size from 15 to 28 students.

The average Iowa class size reported was 16 in mathematics and 19 in science.

Conclusion. The intent of this article has been to present summaries of important data that characterize the status of science and mathematics education nationally and in Iowa. Copies of the entire CCSSO report can be obtained for \$12 per copy from the Council of Chief State School Officers, State Educational Assessment Center, 400 North Capital Street, Suite 337, Washington, D.C. 20001.

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