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An Evaluation of Science Education in Minnesota: Grades 7-12

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There is a national priority for change in education, and in science education particularly (1). In a review of national data, the National Science Board (2) states that American students perform poorly in comparison with students from other industrialized nations and even with students from some third world countries. The 1986 National Assessment of Educational Progress science assessment (3) provides evidence that student understanding of science concepts is improving from the recent past but still has not compensated for declines in the 1970s. The NAEP science data suggest that a majority of our nation's 17-year-olds are poorly equipped for informed citizenship and productive performance in the workplace, let alone postsecondary studies in science.

But what is the status of science education in Minnesota? Data from a survey of principals and science teachers in grades 7-12 conducted in 1989 throughout Minnesota can provide some answers. Two comprehensive questionnaires were designed, one for principals and one for science teachers, using items from previous assessments of science teachers both from within Minnesota (4,5) and from national surveys (6,7). This duplication of items allowed for comparisons within Minnesota over time and with science teachers nationally. The principals' questionnaire was six pages long and contained the following two sections: 1) background information - school enrollment, science course offerings and enrollments, the principal's own subject area background, science budget, and factors affecting science instruction; and 2) computers - availability and numbers of computers, and factors affecting the use of computers in the science instruction in that school. The teacher questionnaire was 21 pages long and contained the following sections: 1) background information - age, teaching experience, academic background, certification, teaching assignments, sources of new ideas about science topics and methods, factors influencing science instruction; 2) texts and courses - numbers of students in an exemplar class, text and strategies used, objectives for science instruction, time spent on various activities, homework, and assessment; and 3) computers - comfort and preparation in the use of computers, time, and various uses of computers by teachers and sources of software.

To represent a cross-section of the districts in Minnesota schools, districts were divided into six population strata based on a combination of total student population and location within the state. The strata are presented in Table 1. "Cities of the first class" included Minneapolis, St. Paul, and Duluth. The "Seven County Metro Area" included all districts in the seven countries around and including Minneapolis and St. Paul. All schools outside the Metro Counties except Duluth fall into strata 3-6. Within each stratum the number of schools selected reflected the percentage of the total number of students in that stratum. Schools were selected randomly within strata. Once the school was selected, two teachers at the school were randomly selected. Principals received letters asking them to participate by giving the enclosed science teacher questionnaires to the preselected teachers. All questionnaires were accompanied by stamped return envelopes. Nonrespondents were followed up with a telephone reminder. Table 1 shows the percent of students in the State contained in each stratum, the number of schools sampled, and the response rates for teachers and principals by stratum. The selection of teachers provided approximately equal numbers of life science, earth science, physical science, biology, chemistry, and physics teachers. The overall rate of response was 79 percent.

The data from the questionnaires were summarized using frequency counts and percentages, and additionally some were analyzed by stratum or subject area. This report will present data on demographics, science classes, and teacher and principal perceptions.

Demographics

What is a typical Minnesota science teacher like? The answer would be male, 43 years old with 18 years of teaching experience, a certification in life science or physical science and recent in-service training experience. More specific data are presented in Table 2; the national data were obtained from Weiss' survey results but statistical comparisons were not conducted because the national data were not available in a computerized data set. The teacher age and number of years of teaching experience data indicate that Minnesota's science teaching force is stable and somewhat older than the national average. Minnesota's junior high school science teachers are also much more likely to be certified to teach science than junior high school teachers nationally; in Minnesota 96 percent of the 7-8 grade science teachers reported science certification compared to 73 percent of the 7-9 grade teachers nationally. Further, Minnesota science teachers were much more likely to have participated in in-service science or science education training (88%) than science teachers nationally (73%). Although 27 percent of Minnesota science teachers reported receiving no support in order to improve their teaching, most have received help

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Table 1. Percent of Student, Number of Schools, and Percent Response for Principals and Teachers

Stratum	Students %	Principals # Sent	Principals % Response	Teachers # Sent	Teachers % Response
Cities of the First Class	10	23	70	57	53
Seven County Metro	37	89	71	207	79
More than 2000	22	64	86	125	78
1000-1999	12	36	81	69	93
500-999	10	30	77	55	84
Less than 500	8	24	88	34	74
Total		266	79	547	79

Table 2. Percent of Women, Number of Years Teaching, and Age of Science Teachers by Stratum and Subject Area

	Percent of Women	Years Teaching	Age
Minnesota Data			
Overall Strata	14	19	43
Cities of the First Class	12	18	46
Seven County Metro	11	18	43
More than 2000	11	21	45
1000-1999	9	17	41
500-999	15	18	41
Less than 500	30	18	41
Subject Area			
life	17	20	43
earth	3	17	42
physical	14	16	41
biology	18	19	44
chemistry	21	19	44
physics	8	20	46
National Data			
Grades 7-9			
1977	38		
1985	41	13	39
Grades 10-12			
1977	24		
1985	31	14	40

from various sources. The two most common sources were release time from teaching (57%) and travel and/or per diem expenses (29%).

As can be seen from Table 2, there are few women in our science teaching force, and those that are present are mostly in the lower grades or the life sciences/biology area. The 14 percent overall of women can be compared to 32 percent nationally. The issue of encouraging women in science is a critical one, and in this context it is interesting to examine the percent of females in science classes. These data are presented in Table 3. Despite the low number of female science teachers, consistently about half of the students in science classes are female, except in physics.

Table 3. Percent of Female Students in Science Classes

	1983	1989
Life Science	48	49
Earth Science	49	49
Physical Science	51	47
Biology	50	50
Chemistry	49	48
Physics	38	36

Descriptions of Classes

What would a typical science class in Minnesota be like? Overall the amount of time spent in a science class was about one hour. This was split up among various activities (national averages are presented in parentheses). Thirty-nine percent (22%) of the time was reported as being spent working with hands-on or laboratory materials, 25 percent (38%) as lecture, 14 percent each as reading (8%) or testing (6%), and 9 percent (12%) as daily routines. Minnesota classes appear to have more time spent on laboratory and less on lecture than nationally.

The teachers were also asked to rate their use of various teaching techniques. The mean score ratings of these are presented in Table 4. Items were rated on a 5-point scale with 1 = never and 5 = just about daily. As can be seen, the most

Table 4. Mean Ratings of Degree of Use of Various Teaching Techniques (5 = daily use)

Lecture/demonstration	4.5
Students use hands-on, manipulative, or laboratory materials	4.0*
Students answer questions/problems from text	3.9*
Students work in paired laboratory groups	3.9*
Tests or quizzes	3.6*
Teacher demonstrations	3.5*
Students read from text	3.4
Films, video-tapes or filmstrips	3.0
Student reports or projects	2.4
Cooperative groups	2.3
Student work at chalkboard	2.0*
Library work	1.8*
Computer-assisted instruction	1.8
Field trips, excursions	1.5*

*These mean scores showed significant differences between subject areas (p of F less than .05).

popular techniques were lecture/demonstration, student use of hands-on materials, student work in paired laboratory groups, and student work answering questions from textbook. The least used technique was field trips. These data were examined to determine if there were any subject matter differences using an ANOVA and Student-Newman-Kuells (SNK) post hoc comparisons, and several differences were found. The biology and life science teachers used the library the most. The physics teachers had the students work at chalkboard the most and the biology teachers the least. The physics teachers had the students answer questions from the text the most. The physical science teachers used the hands-on approach and the paired groups the most. The earth science teachers used the media the most, and the physical sciences, chemistry and physics teachers used it the least. The biology teachers used tests the most, and the chemistry teachers used them the least. The life science and biology teachers used field trips the most, and the chemistry teachers used them the least. The physics and physical science teachers used demonstrations the most.

Assessment of students is another important teaching task. The average ratings of the amount of emphasis given to various types of assessment by the surveyed teachers are presented in Table 5. The most emphasized method was classroom tests followed by homework. Least emphasized was designing experiments. These data were examined by subject matter using ANOVA and SNK and differences were found to exist. Secondary teachers placed more emphasis on classroom tests. Earth science, chemistry, and physics teachers placed less emphasis on laboratory tests. Chemistry teachers placed the least emphasis and life science teachers placed the most emphasis on science projects.

Table 5. Mean Ratings of Amount of Emphasis Given to Types of Assessment (5 = very much emphasis)

Classroom tests	4.3*
Homework	3.3
Laboratory tests	3.2*
Laboratory notebooks	3.2
Class discussion	2.6
Attendance	2.3
Science projects	2.3*
Behavior	2.1*
Designing experiments	2.0

*These mean scores showed significant differences between subject areas (p of F less than .05).

As seen in Table 5, homework is an important issue for the teachers as well as the students. Ninety-six percent of the surveyed teachers reported assigning homework, most commonly for 2-3 nights a week. The average number of minutes per night by subject area is presented in Table 6. The numbers were the teachers' estimate of the amount of time students would need to complete the assigned homework. On the average Minnesota science teachers assign 22 minutes of homework per night. This is slightly below the national average of 23 minutes for students in grades 7-9 and 28 minutes for students in grades 10-12. Also, as can be seen, the number of minutes assigned increases with grade level. Probably in conjunction with this homework, 95 percent of Minnesota science teachers reported using textbooks once a week or more, and 27 percent reported using textbooks every day. The most popular publishing companies were Holt, Rinehart and Winston, and Merrill, which were also the most popular textbook publishing companies for science teachers nationally.

Another significant component of science classes is the computer. Science teachers were asked about the availability of computers and whether or not they used them in their classes. Only 8 percent of Minnesota science teachers reported that computers were not available to use compared to 28 percent of science teachers nationally. Only 20 percent of Minnesota science teachers, however, felt computers were readily available, quite similar to the 18 percent of science teachers who reported computers as readily available nationally.

Science teachers were also asked about how useful they found various sources for getting new ideas about what topics to teach and about how to teach science. These data

Table 6. Average Number of Minutes of Homework Assigned per Day

Overall	22
Life Science	18
Earth Science	18
Physical Science	19
Biology	22
Chemistry	25
Physics	27

are presented in Table 7. The sources were rated 1 to 3 with 3 being very useful. The highest rated sources were other teachers for both topics and how to teach. College courses were also rated highly as a source for new topics. These data were examined by subject area and differences were found using ANOVA and SNK. The biology teachers felt the in-service programs were most useful, and the earth science teachers felt they were least useful as a source of *topics*. Physics teachers felt meetings were the most useful and, life science teachers felt meetings were the least useful as a source of *topics*. Physics teachers felt professional meetings were most useful as a source of *how* to teach. Physics teachers felt publications were the most useful and earth science teachers felt they were least useful as sources of *how* to teach. In spite of the sources for new topics, 38 percent of the teachers reported never using instructional materials that emphasized the relationships among science, technology, and society in their classes, as has been recommended nationally.

Teacher and Principal Perceptions

The science teachers were asked whether or not they enjoyed teaching science and how their enthusiasm had changed in recent years. The sampled Minnesota teachers were overwhelmingly positive with 95 percent of those responding saying they enjoy teaching science. This compares favorably with 93 percent of science teachers nationally. Also, 74 percent of Minnesota science teachers reported their level of enthusiasm was as high or higher than in recent years; 42 percent reported their enthusiasm had increased.

Information on factors that might affect science instruction was obtained from both principals and teachers. These data are presented in Table 8. As can be seen, teachers were much more likely to rate the factors as serious problems than the principals. Approximately one-third of the teachers saw large classes and funds for equipment as serious problems while only 4 percent and 10 percent of the principals felt this way. In addition, about 82 percent of the science teachers reported inadequate student skills in reading and mathematics as at least somewhat of a problem. Only about half of the principals saw these as problems.

Teachers and principals were also asked three questions about science education. Their answers and the comparable national answers are presented in Table 9. Teacher and principal perceptions were much more closely matched here. Over two-thirds of the principals and teachers felt that science was not a difficult subject for children to learn. Over 90 percent of both felt that hands-on experiences were worth the time and expense and about 80 percent of each felt that laboratory-based classes were more effective than non-laboratory-based ones. Approximately the same percentages found for Minnesota were found for science teachers and principals nationally.

Table 7. Mean Ratings of Usefulness of Various Sources for New Ideas about Science Topics and about How to Teach Science (3 = very useful)

Source	Topic	How
Teachers	2.4	2.5
College course	2.4	2.1
Journals and other professionals publications	2.3	2.1*
Federally sponsored workshops	2.1	1.9
Meetings of professional organizations	2.0*	1.9*
Local in-service programs	1.8*	1.8
Publishers and sales representatives	1.6	1.4
Local subject specialists/coordinators	1.5	1.5
State department personnel	1.4	1.3
Parents	1.3	1.1
Principals	1.2	1.2
Teacher union meetings	1.2	1.2

*These mean scores showed significant differences between subject areas (p of F less than .05).

Table 8. Percentage of Teachers and Principals Rating the Following Factors as Problems.

	Serious Problem		Somewhat of a Problem		Not a Significant Problem	
	T	P	T	P	T	P
Belief that this subject is less important than other subjects.	6	5	32	9	63	90
Inadequate facilities.	19	10	45	36	36	54
Insufficient funds for purchasing equipment and supplies.	32	10	44	44	24	46
Lack of materials for individualized instruction.	26	8	46	41	28	51
Out-of-date teaching materials.	13	3	35	23	52	74
Lack of student interest in science.	19	3	45	40	36	56
Inadequate student reading abilities.	25	6	58	53	17	41
Inadequate student mathematical ability.	24	5	58	44	18	51
Lack of teacher interest in subject.	2	1	16	8	83	90
Teachers inadequately prepared to teach subject.	4	1	19	12	77	87
Lack of teacher planning time.	27	3	45	23	29	94
Not enough time to teach subject.	16	1	41	19	44	79
Class size too large.	33	4	39	35	29	60
Lack of readily available advice or help for teachers in science instruction.	11	2	40	27	49	71
Inadequate access to computers	16	4	42	42	42	55
Student absences	26	7	49	31	26	62

Table 9. Percentage of Teachers and Principals Agreeing with Statements about Science Education.

	Strongly Agree		Agree		No Opinion		Strongly Disagree		Disagree	
	T	P	T	P	T	P	T	P	T	P
a. Science is a difficult subject for children to learn?										
Minnesota	3	2	28	23	2	5	54	49	40	22
Nationally	4	1	30	23	5	3	46	61	11	13
b. Hands-on science experiences aren't worth the time and expense.										
Minnesota	2	2	3	1	1	1	31	33	63	63
Nationally	1	1	2	1	3	3	35	37	55	56
c. Laboratory-based science classes are more effective than non-laboratory classes.										
Minnesota	46	45	34	40	8	6	8	5	4	3
Nationally	43	28	36	53	7	8	9	6	2	2

Conclusion

The data presented here provide a snapshot of science teachers and classes in Minnesota. The teachers are experienced, enthusiastic about teaching science, and well-prepared to do so. The science teaching force is mature and stable and it doesn't appear that there will be a science teacher shortage because of mass retirements or "burnout" as is sometimes suggested. One finding in the demographics section stands out: The extraordinarily high percentage of men in the science teaching force. This could be a self-perpetuating problem with young women not choosing to be science teachers or to go on in science because there are no observable role models. Continuation in science is a complex social issue and these data do not allow us to speculate on the causes of the high percentage of male science teachers or on what might facilitate young women's continuation in science. It would seem only reasonable, however, to try and hire more women science teachers. A positive indication from these data pertaining to the gender-in-science issue is the finding that, except for physics classes, Minnesota girls are taking science classes; one of the first steps toward continuing in science.

A reasonable mix of activities is available for science students. Laboratory or hands-on activities are common, and a variety of other teaching techniques are reported as being used. Student learning is assessed in a variety of ways, and independent homework plays a prominent role. There is a fairly heavy reliance on textbooks, but it is impossible to say from these data how this reliance translates into classroom practice. Textbooks may be used in either a deductive or inductive fashion.

Minnesota teachers are much more likely than science teachers nationally to use hands-on activities. This pervasive use of hands-on activities is a real strength of Minnesota science teachers. Even though it is likely that much of the hands-on work reported by these surveyed teachers would be in verification-oriented activities, at least some would be more inquiry-oriented and promote the development of higher order thinking skills and problem-solving.

Although there were some problems reported, at most only a third of the science teachers reported them as serious. As might be expected, the teachers considered the factors involved in delivering science education as more serious problems than their principals. Perhaps principals are not as aware of the actual instructional situation as they might be. The problems reported as most serious were too many students and not enough funds to purchase equipment and supplies. The "too many student" problem may be related to a spread of ability and interest within classes since lack of materials for individualized instruction was also rated as a problem by many. Since principals generally control funding, the "lack of funds" problem may be related to the discrepancies in the teacher and principal perceptions of problems. Inadequate student skills in mathematics and reading were seen as at least somewhat of a problem by 82 percent of the teachers. Clearly, improvement in these basic skills should be a high priority. Computers appear to be available to Minnesota teachers, but they are perhaps not as accessible as they might be and this lack of accessibility may be the cause of the low reported use of computer-assisted instruction in science classes.

In summary, the state of the State of Minnesota in science education is healthy with room for growth in inquiry-oriented activities designed to promote critical thinking skills, in emphasizing the relationships among science, technology, and society issues, in improving students' reading and mathematics skills, and in integrating computers into science instruction.

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