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SCIENCE ACHIVEMENT AS IT RELATES TO SCIENCE CURRICULA AND PROGRAMS AT THE SIXTH GRADE LEVEL IN MONTANA PUBLIC SCHOOLS.

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DESCRIPTORS- *LEARNING, *ACADEMIC ACHIEVEMENT, *ELEMENTARY SCHOOL SCIENCE, *EVALUATION, *PROGRAM EVALUATION, CURRICULUM DEVELOPMENT, *GRADE 6, MONTANA

THE RESEARCH WAS DESIGNED TO COLLECT INFORMATION ABOUT CURRICULAR CONTENT, TO MEASURE COGNITIVE AND AFFECTIVE ACHIEVEMENT OF STUDENTS, AND TO DETECT RELATIONSHIPS BETWEEN CERTAIN SCIENCE PROGRAM FACTORS AND ACADEMIC ACHIEVEMENT. THE SAMPLE CONSISTED OF 3,060 CHILDREN AND THEIR TEACHERS AND PRINCIPALS. THROUGH A QUESTIONNAIRE, INFORMATION WAS COLLECTED FROM THE TEACHERS AND PRINCIPALS ON (1) SCHOOL FACILITIES, (2) SCIENCE BACKGROUND OF THE STUDENTS, (3) TEACHER CHARACTERISTICS, AND (4) OTHER SELECTED FACTORS. EACH RESPONSE WAS ASSIGNED A SCORE. STUDENT COGNITIVE ACHIEVEMENT WAS MEASURED USING THE METROPOLITAN ADVANCED SCIENCE TEST. AFFECTIVE LEARNING WAS MEASURED BY AN AUTHOR-CONSTRUCTED INVENTORY OF SCIENCE ATTITUDES, INTERESTS, AND APPRECIATIONS. COGNITIVE ACHIEVEMENT AND AFFECTIVE ACHIEVEMENT WERE BOTH SIGNIFICANTLY RELATED TO SEVERAL PROGRAM FACTORS AT THE .05 LEVEL. AN EXTENSIVE DISCUSSION OF IMPLICATIONS OF THE FINDINGS AND RECOMMENDATIONS FOR THE IMPROVEMENT OF PROGRAMS IS INCLUDED. THIS ARTICLE IS PUBLISHED IN THE "JOURNAL OF RESEARCH IN SCIENCE TEACHING," VOLUME 4, ISSUE 2, 1966. (RS)

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This study deals primarily with the relationship between pupil achievement in science and factors in the science program. An inventory of science attitudes, interests, and appreciations was constructed and administered in connection with an advanced science test to a large sample of sixth graders. Their teachers completed science teaching questionnaires. The results of the study are significant and are a contribution to the field.

Science Achievement as It Relates to Science Curricula and Programs at the Sixth Grade Level in Montana Public Schools

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Increased competition by all subject matter areas for every portion of the school day point out the need for factual information about the effectiveness of instruction. Such data should be foundational for the instructional program at all grade levels, but are not always available. The problem is acute in elementary school science for programs have blossomed in recent years despite the lack of such foundational studies. Smith and Anderson, Navarra, Fitzpatrick, and other writers deplore this situation.[1] Watson calls the lack of research on the relations between the behavior of science teachers and other variables such as behaviors of their pupils especially unfortunate.[2]

The Problem

Answers to questions such as these were sought in this study:

1. Can relationships be identified in Montana sixth grades between instructional factors (such as amount of time devoted to science, teacher preparation, facilities, instructional methods, etc.) and pupil achievement in science?

2. Is the science achievement of all categories of pupils similar?

3. Are Montana sixth-grade science programs like those idealized in the literature, and to what extent are their components related?

The study was expected to reveal:

1. Ways in which science is taught in Montana sixth grades.

2. Information about the science achievement of some groups and categories of children.

3. Relationships among some science program factors and some forms of science achievement.

4. Relationships among some science program factors.

Procedures

This problem was attacked by (*1*) submitting a science program or teaching questionnaire to a sample of Montana teachers of sixth-grade science; (*2*) measuring the science achievement of the children in these teachers' classes; (*3*) analyzing these data for differences and relationships.

The Participants

The population for this study was the sixth grades and their teachers in Montana public school districts with more than 100 pupils in grades 1–8. A random sample of 135 of these sixth-grade classes (27% of the population) was drawn. One hundred eighteen of the classes in this sample containing 3060 children participated. Thirty-seven were from districts enrolling 100–499 pupils in grades 1–8, 23 from districts enrolling 500–1499 pupils, and 58 from those enrolling 1500

or more pupils. The testing was done in May 1964, with the percentage of classes cooperating in each school size category ranging from 22.3 in the medium-school group to 24.5 in the large-school group.

In every case, the person teaching science completed a questionnaire about the science program provided these pupils.

The Questionnaire

The "Science Teaching Questionnaire," designed and used in this study to obtain information about the cooperating science programs, contains three major sections. The first, or Program section, contains items about the scheduling of science, textbooks, library and laboratory facilities, and previous science backgrounds of the pupils. The second, or Instruction section, deals with teaching methods, experimentation, pupil evaluation, use of materials, etc. The third section deals with teacher factors such as experience, training, interests, attitudes, sex, and age.

A scoring system was constructed whereby each factor or reply was assigned a "score" according to how closely it approached that which is idealized in the literature. This made it possible to rank the 118 classes on each of the instructional or program factors.

Interviews were conducted with a substantial portion of the cooperating teachers and their principals to gain additional insight into the Montana science programs.

The Achievement Instruments

Pupil achievement must be measured in terms of the instructional objectives. Those of science teaching extend beyond cognitive achievement or the acquisition of factual information and knowledge. Consensus exists among science educators that affective outcomes such as interests, attitudes, appreciations, habits, and skills are of equal or greater importance. In fact, much of the criticism of science teaching research is focused on the measurement of achievement solely by tests that tend to be limited to cognitive outcomes.[3] An attempt was made in this study, therefore, to measure both the cognitive and affective science achievement of the pupils in the cooperating classes.

The available elementary school science tests were examined, and the Metropolitan Advanced Science Test was selected as the test of cognitive achievement in this study.[4] This instrument was selected as it seemed to most closely mesh in content with the *Montana Science Study Guide 1–6*,[5] could be administered within the time limits thought to exist, and best met the other criteria used in the selection of a test. Another factor of considerable importance was that this instrument was designed for use in grades 7–9; therefore, few or none of the pupils or teachers would have had previous exposure to it. This test contains 55 multiple choice items dealing with life, earth, and physical sciences, and with conservation and health. Norms were available for children in the first month of the seventh grade. Pupils in this study were in the ninth month of the sixth grade.

No instrument could be found that seemed satisfactory for use in measuring affective aspects of science achievement at the sixth grade level. A major undertaking in this study, therefore, was to construct the Inventory of Science Attitudes, Interests, and Appreciations (ISAIA). This provided a way to measure affective outcomes of science teaching such as scientific attitude, appreciations, interests, and skills. The form used in this study contains 50 "Agree or Disagree" statements and 21 science experiences. Seventeen of the statements deal with the scientific attitude, 18 with appreciations, and 15 with interests. They are based upon and are similar to items used by Noll, Reed, and other writers.[6]

These are representative of the Agree–Disagree statements of the ISAIA:

1. I think it is very interesting to study live animals and specimens in science.

2. Most of the important things that scientists discover are more the result of lucky accidents than hard work.

3. By the time a person has graduated from col-

lege, he has learned almost everything worth knowing.

4. Scientists have discovered and named all the plants and animals.

5. When we think about how large the universe is, I feel real small.

6. I just hate mice, bugs, and other small crawling things.

7. It is very difficult for scientists to find new problems to work on.

8. I usually get lower grades than I deserve.

9. Science has done much good for man, but this is probably outweighed by the harm he has caused.

10. When doing a very short experiment, it isn't necessary to take notes because one can remember until he is finished to write down what happened.

The remainder of the ISAIA consists of 21 experiences selected from science textbooks and the Montana guide. Pupils responded by indicating which items they had experienced or done. These were called "Skills" achievement.

The statements and experiences of the ISAIA survived an analysis in which 134 children participated. A list of more than 200 items was reduced by discarding those with negative discriminating power, biserial "*r*" less than 0.21, and those with corrected difficulty indexes more than 0.79 or less than 0.21.[7]

To facilitate analysis, pupils indicated their sex, place of residence, and if they liked or disliked science on their answer sheets.

Analysis and Handling of Data

Pupil Achievement

Seven achievement scores or subscores were recorded for each pupil. The Metropolitan Advanced Science Test score was designated as cognitive achievement, the ISAIA score as affective achievement, and their sum as total science achievement. Scientific attitudes, appreciations, interests, and skills subscores were also obtained from the inventory.

Twenty-seven pupil categories were identified from pupils' responses to questions about their sex, place of residence, and attitude toward science (see Table I). Frequency distributions of scores were tabulated and from these, the means and standard deviations were calculated for each of the pupil categories. The difference between each mean and every other mean was subjected to the *t* test.[8]

A two-by-two chi square analysis was also made to determine the relationship between each aspect of achievement and all other aspects. Class rank was used as the basis for division in this analysis.

Questionnaire Data

A coding system provided a way to tabulate each teacher's questionnaire responses on a single column of ledger paper. Number and percentage tables were computed to determine the prevalence of a particular condition or practice.

As mentioned earlier, some program and teaching factors were assigned scores or values according to how closely they approached situations "idealized" in the literature. Two-by-two cell chi-square analyses were made by dividing the classes into two or three groups according to how closely they approached the ideal in one respect, and each of these into two or three groups on the basis of a second variant. Among the teaching factors included in this scoring system were: (*1*) time for science, (*2*) library facilities, (*3*) textbooks, (*4*) laboratory facilities, (*5*) total program—the sum of 1 to 4, (*6*) methods and presentation, (*7*) experimentation, (*8*) text and reference use, (*9*) pupil evaluation, (*10*) total instruction—the sum of 6 to 9, and (*11*) total program and instruction—the sum of 5 and 10. Hence, classes receiving the highest total program and instruction scores most closely approached situations idealized in the literature in all respects, and those receiving the highest Textbooks, Laboratory, or Methods scores more closely approached the "ideal" in these respects.

Chi square was also used to test relationships between pupil achievement and these and other facets of the science program. In this analysis, the classes were divided into two groups according to class rank on an aspect of achievement, and these each into

TABLE I

Performance of the Pupil Categories on the Metropolitan Advanced Science Test and the Inventory of Science Attitudes, Interests, and Appreciations

Pupil category[a]	Number of pupils	Metro. mean score	ISAIA mean score	Mean ISAIA subscores			
				Sci attitude	Appre-ciations	Inter-ests	Skills
All Pupils	3062	31.03	41.69	12.67	13.00	8.98	7.03
Boys	1575	32.32	42.42	12.33	12.88	9.63	7.54
Girls	1488	29.66	40.90	13.03	13.12	8.31	6.46
Country Pupils	719	31.18	41.21	12.57	12.67	8.93	7.02
Town Pupils	2178	31.07	41.87	12.75	13.15	8.94	7.03
Pupils Liking Science	2237	31.61	43.06	12.88	13.24	9.64	7.30
Pupils Disliking Science	555	29.34	35.95	11.90	12.21	6.01	5.68
Country Boys	390	32.04	41.70	12.19	12.60	9.46	7.44
Town Boys	1145	32.40	42.87	12.47	13.03	9.73	7.64
Boys Liking Science	1212	33.01	43.79	12.50	13.21	10.25	7.84
Boys Disliking Science	218	30.29	35.46	11.45	11.38	6.51	6.07
Country Boys Liking Science	314	33.02	43.62	12.32	12.96	10.25	7.65
Country Boys Disliking Science	73	28.22	34.10	10.74	11.56	6.12	5.68
Town Boys Liking Science	898	33.00	43.72	12.51	13.17	10.25	7.82
Town Boys Disliking Science	145	31.28	36.84	11.86	12.17	6.62	6.23
Country Girls	329	30.15	40.63	13.02	12.75	8.31	6.53
Town Girls	1033	29.50	40.76	13.06	13.28	8.05	6.36
Girls Liking Science	1025	30.06	42.20	13.34	13.20	8.92	6.67
Girls Disliking Science	337	28.72	36.27	12.19	12.61	5.69	5.43
Country Girls Liking Science	245	30.34	41.72	13.37	12.79	9.05	6.91
Country Girls Disliking Science	84	29.61	37.44	12.00	12.64	6.17	5.42
Town Girls Liking Science	780	29.84	42.34	13.31	13.45	8.87	6.66
Town Girls Disliking Science	253	28.42	35.88	12.26	12.77	5.53	5.44
Country Pupils Liking Science	559	31.85	42.76	12.78	12.89	9.72	7.33
Country Pupils Disliking Science	157	28.96	35.86	11.43	12.14	6.15	5.54
Town Pupils Liking Science	1678	31.53	43.08	12.88	13.30	9.61	7.28
Town Pupils Disliking Science	398	29.46	36.23	12.11	12.55	5.93	5.73

[a] Not all children indicated their attitude toward their science class or where they lived. It was therefore necessary to omit them from the subgroups for which this information was required.

two or three groups according to score on the particular program factor.

Results

Pupil Achievement in Science

Table I shows the seven achievement scores of the 27 categories of pupils. The mean of 31.03 scored by the Montana pupils on the Metropolitan was somewhat above the national norms for pupils in the first month of the seventh grade.

In most cases, boys scored higher then comparable groups of girls. Pupils who like science had much higher mean scores than those disliking it. In cases, differences equaled a standard deviation. Particularly noticeable are the differences between the scores of pupil groups on the Interest items of the inventory.

The difference between each mean and all other means was subjected to the t test. Many of these were significant at the 0.001 level of confidence.

This study provided no indication that children living in the country scored differently from those living in town or that achievement in the small or medium sized schools differed from that in larger districts.

Table II deals with the relative rank of each pupil category on the seven aspects of achievement. Note the consistencies in rank

TABLE II
Relative Rank of Pupil Categories on the Metropolitan Advanced Science Test, ISAIA, Total Score, and ISAIA Subscores

Pupil category[a]	Pupils	Metro. rank	ISAIA rank	Total rank	ISAIA subscores: S.A. rank	Apprec. rank	Interests rank	Skills rank
All Pupils	3062	13	14	11	11	10	11	10
Boys	1574	5	8	6	16	13	7	5
Girls	1488	19	16	17	5	7	16	17
Country Pupils	719	11	15	12	12	18	13	12
Town Pupils	2178	12	11	10	10	9	12	10
Pupils Liking Science	2237	8	5	5	7	4	6	8
Pupils Disliking Science	555	23	23	23	23	23	24	22
Country Boys	390	6	13	9	19	21	9	6
Town Boys	1145	4	6	4	15	9	4	4
Boys Liking Science	1212	2	1	1	13	5	1	1
Boys Disliking Science	218	15	26	21	25	27	20	20
Country Boys Liking Science	314	1	3	3	17	11	1	3
Country Boys Disliking Science	73	27	27	27	[illegible]	26	23	22
Town Boys Liking Science	898	3	2	2	14	8	1	2
Town Boys Disliking Science	145	19	20	19	24	24	19	19
Country Girls	329	16	18	16	6	16	17	16
Town Girls	1033	21	17	18	4	3	18	18
Girls Liking Science	1025	17	10	14	2	6	14	14
Girls Disliking Science	337	25	21	25	18	20	26	26
Country Girls Liking Science	245	14	12	15	1	14	10	13
Country Girls Disliking Science	84	20	19	20	22	19	21	27
Town Girls Liking Science	780	18	9	13	3	1	15	15
Town Girls Disliking Science	253	26	24	26	18	15	27	25
Country Pupils Liking Science	559	7	7	7	9	12	5	7
Country Pupils Disliking Science	157	24	25	24	26	25	22	24
Town Pupils Liking Science	1678	9	4	8	7	2	8	9
Town Pupils Disliking Science	398	22	22	22	21	22	25	21

[a] Not all children indicated their attitude toward their science class or where they lived. Therefore, it was necessary to omit them from some categories.

on all aspects of measured achievement. The All Pupil group ranked between 10th and 14th on all scores. Children Disliking Science ranked between 22nd and 24th, and Country Boys Disliking Science were near the bottom on all seven areas.

Inconsistencies also exist. Boys Liking Science scored 13th in Scientific Attitudes but near the top in the other scores. Several groups consisting entirely of boys were low on this subscore but high in the other areas. Although the categories of pupils containing only girls were lower than the boy categories in most aspects of achievement, they scored above comparable boys groups in Scientific Attitudes.

Extremely close relationships exist in the ranking of the pupil groups on the Interests and Skills areas. A similar relationship exists between Scientific Attitudes and Appreciations. The chi square analysis further indicated that a high degree of confidence

TABLE III
Number and Percentage Tabulation of Some Science Program and Instruction Practices in Montana Sixth-Grade Classes

Science teaching practice	Number	%	Science teaching practice	Number	%
Ability group for science	13	11	Use of small interest groups		
Departmentalize for science	16	14	Frequently	26	22
			Occasionally	51	44
Time for science (weekly)			Seldom	39	34
Less than 60 min.	2	2			
60–120 min.	41	35	Pupil experimentation		
121 to 180 min.	58	49	Weekly or more often	34	29
More than 180 min.	17	14	Less frequently	84	71
Textbooks for science	112	95	Pupil demonstrations		
Use a single basic textbook	5	4	Weekly or more often	24	20
Use several textbooks	1	1	Occasionally done	79	67
Use no science textbook			Infrequent	15	13
Textbook published before 1957	19	17			
Text published 1957–1959	49	42	Teacher demonstrations		
Text published after 1959	48	41	Weekly or more often	13	11
			Occasionally done	87	74
Library			Infrequent	18	15
Have a central school library	67	57			
Under 10% of books science	42	36	Use of textbooks		
More recent encyclopedia than 1959	101	86	Regular assignments	65	55
Possessed a science encyclopedia	57	48	Irregular assignments	53	45
			Use of outside references		
Laboratory facilities			Frequently used	54	46
Use classroom for science	116	98	Infrequently used	64	54
Possessed less than half the listed equipment items	56	47	Test item selection		
Possessed less than half the listed apparatus items	55	47	Pupils sometimes assist	61	52
			Pupils never participate	57	48
Most used teaching methods			Disposal of scored tests		
Problem solving and experimentation	11	9	Returned without comment	6	5
Class discussion	84	72	Pupils required to correct missed items	39	33
Lecture	21	18	Class discussion of test	99	84
Science integrated into non-science units			Determinants of pupil grades (one of the two most important factors)		
Frequently done	19	16	Test scores	92	78
Occasionally done	54	46	Written work	76	64
Seldom done	45	38	Experiments and demonstrations	21	18
Use of science-oriented units			Interest in science	9	8
Frequently done	23	19	Teacher's appraisal	31	26
Occasionally done	45	38			
Seldom done	50	42			

(0.001) could be placed in the relationship found between the rank order of classes on most aspects of achievement. Exceptions, however, were the Interest and Skills subscores that were more independent of the other scores.

A rank difference correlation coefficient of 0.33 was obtained when the 118 classes were ranked by mean class scores on the Metropolitan Advanced Science Test and the ISAIA. A Pearson product moment correlation coefficient of 0.38 was obtained by

TABLE IV
Number and Percentage Tabulation of Teacher Opinions and Characteristics Pertaining to Montana Sixth-Grade Science

Teacher opinion	Number	%
Need for science teaching and specialists		
Believe that special teachers are needed for math. and science	73	62
Believe that specialists are not needed	44	38
Need for additional training		
Feel a definite need	49	42
Might be of value	55	47
Feel preparation sufficient	13	11
Rating given state science guide		
Much value	14	12
Some value	53	45
Little value or did not use	51	43
Preference for textbook organization		
Prefer developmental series	71	62
Prefer one divided by science discipline	43	38
Rating given basic textbook		
Very good	24	20
Acceptable	69	58
Poor	25	21
Rating given library		
Very adequate for science	33	28
Adequate for science	60	51
Inadequate for science	25	21
Room space		
Have enough space for science teaching	58	49
Lack enough room for science	60	51
Facilities and equipment		
Have adequate facilities	64	54
Facilities are inadequate	54	46

Teacher characteristic	Number	%
Age of teachers, yr.		
Less than 30 yr.	30	25
30–49 yr.	53	46
50 yr. and over	33	28
Sex		
Male	54	46
Female	64	54
Years of teaching experience		
0–5	45	39
6–15	56	48
16 and over	17	14
College education		
Nondegree	40	34
Bachelor's degree	66	56
Master's degree	12	10
College science, quarter hr.		
8 or less	12	10
9–21	70	60
22 and over	34	29
Favorite teaching subjects		
Ranked science as one of two favorites	39	34
Ranked math. as one of two favorites	81	71
Least liked subjects		
Ranked science one of their two least liked subjects	26	23
Ranked math. one of their two least liked subjects	8	7
Relative subject preferences		
Prefer to teach math. to science	91	81
Prefer to teach reading to science	42	39

using individual pupil scores on these two instruments.

Montana Sixth-Grade Science Programs

Characteristics

This phase of the study revealed that only a small percentage of Montana sixth-grade classes were departmentalized or ability-grouped for science (see Table III). About half of the teachers scheduled science daily and provided it more than two hours per week. Rarely was science taught less than three times weekly or less than 50 minutes per week.

A "single textbook" dominated Montana science programs, and in most cases this was more than four years old. About half of the teachers made regular reading assignments in their text, and most had recent general and science encyclopedias available.

All but two of the teachers held science in the regular classroom. Few of these classrooms contained "essentials" such as water, ample space, tables, electrical outlets, etc. Only about half had as many as 50% of the "listed" apparatus and equipment items. A few teachers reported requiring weekly pupil experimentation or demonstrations, but most said that such activity was infrequent.

Science was mostly a "reading and talking" subject, and class discussion appeared to characterize the teaching. Teachers said that class discussion occupied the bulk of the time not used in science reading and writing. Most said this approach was used more than half the time, and that it was the most used method of instruction.

"Lecture" seemed to be used more in teaching science in these schools than "problem solving" and "experimentation." Only a few teachers reported frequent efforts to integrate science with other curriculum areas.

Test scores and written work determine pupil grades (Table III). Factors such as interest, demonstrations, and subjective appraisal were less important. Although many of the interviewed teachers saw "interest" as a primary objective of science teaching, only a few reported it to be important in grading.

Teachers are insecure in science for 62% said they believed it should be taught by specially trained teachers (see Table IV). Only a few felt their preparation was sufficient or called science a favorite teaching subject. About one-third of the respondents lacked a college degree and almost one-half had completed less than 15 quarter hours in science.

When the data in Table IV were segregated by school size category, there was no indication that teacher biographical factors were related to school size. Although more teachers in the larger districts had degrees, the difference was not significant.

Relationship between Teaching Factors

This analysis revealed that many program or teaching factors were related in Montana schools. Rather than a random distribution, classes assigned high scores or having optimum conditions in one respect tended to receive high scores or have optimum conditions in several respects. For instance, those assigned high scores because of adequate time provisions for science received higher (*1*) textbooks, (*2*) methods and presentation, and (*3*) experimentation scores.

Several of these correlations included teachers' opinions and biographical factors. An example is that younger teachers, those with more college science, and those liking to teach science gave it more time in their schedules.

Clusters were found in which several variants were significantly related to each other. Among these was a facilities cluster and another that included several of the assigned scores. One cluster included the biographical factors of sex and college education. Men (*1*) had more years of college, (*2*) were more satisfied with their classrooms, (*3*) were able to obtain more apparatus, and (*4*) were assigned higher total program scores. Each of these five variants was significantly related to each of the other four.

Pupil Achievement and Program Factors

Cognitive achievement was significantly 0.05 level (of confidence) related to (*1*) text and reference use, (*2*) teachers' preference for a "field" textbook, and (*3*) teachers' college credits in science (see Table IV).

Affective achievement was related (0.05 level or greater) to (*1*) experimentation, (*2*) total program and instruction, (*3*) pupils' previous science education, and (*4*) teachers' years of college.

Total achievement was related (0.05 level) to (*1*) pupil evaluation, (*2*) teachers' rating of the library, (*3*) pupils' previous science, and (*4*) teachers' college credits in science.

TABLE V

Direction and Levels of Significance between Forms of Science Achievement and Science Program Factors

	Total science achievement	Metropolitan (cognitive achievement)	ISAIA (affective achievement)	S.A.	Affective subscores		
					Apprec.	Interest	Skills
Assigned scores							
Time allotment score	—	—	—	—	—	—	0.05
Library score	—	—	—	—	—	—	—
Textbook score	−0.05	—	—	—	—	—	—
Lab. facilities score	—	—	—	—	—	—	0.05
Methods and presentation score	—	—	—	—	—	—	—
Experimentation score	—	—	0.05	—	—	0.05	0.05
Text and reference use score	—	0.05	—	—	—	—	—
Pupil evaluation score	0.05	—	—	—	—	0.05	0.05
Total program score	—	—	—	—	—	0.05	—
Total instruction score	—	—	—	−0.05	—	—	0.001
Total program and instruction score	—	—	0.05	—	—	—	0.01
Miscellaneous program factors							
Departmentalization	—	—	—	—	—	—	—
Ability grouping	—	—	—	—	—	—	—
Years of previous science	0.05	—	0.05	0.05	—	—	0.05
Possession of listed apparatus items	—	—	—	—	—	0.05	—
Possession of listed equipment items	—	—	—	—	—	—	—
Year of textbooks	—	—	—	—	—	—	—
Teacher ratings or opinions							
Value of state study guide	—	—	—	—	—	—	—
Preference of science discipline textbook	—	−0.05	—	—	—	—	0.05
Rating given facilities	—	—	—	0.05	—	—	—
Rating given classroom	—	—	—	—	—	0.05	—
Rating given library	0.05	—	—	—	—	—	—
Rating given textbook	—	—	—	—	—	—	—
Need for special science teachers	—	—	—	—	—	—	—
Teacher biographical factors							
Age	—	—	—	—	—	—	—
Sex	—	—	—	—	—	—	—
Years of experience	—	—	—	—	—	—	—
Years of college	—	—	0.01	0.05	0.01	0.05	—
College credits in science	0.05	0.05	—	—	0.01	—	—
Felt need for additional college science	−0.05	—	—	—	—	−0.05	—
Preference for science teaching	—	—	—	—	—	—	0.001

There were inverse relationships between total achievement and the textbooks score and between total achievement and teachers' feeling a need for additional work in college science courses.

Several program factors were related to the affective subscores (see Table V). Skills were significantly related to six of the assigned scores, for instance, and interest was related to three of them. Although teachers' years of college and pupils' previous science exposure were related to several aspects of affective achievement, they were not significantly related to cognitive achievement.

Implications and Recommendations

Implications

Pupil Achievement

Teachers have difficulty when evaluating pupil achievement in science. This exploration into affective aspects of science achievement that are not usually tested resulted in the Inventory of Science Attitudes, Interests, and Appreciations. Although this study dealt with groups of pupils, additional work could likely result in an instrument for individual use.

The program analysis and achievement scores indicated that equivalent science programs were provided in all school size categories. Since influences outside the school affect pupil achievement, the similarity of pupils' scores in the country and in town is interesting and deserves additional study. Either influences in these two environments were similar or else affected achievement in ways not distinguished by the instruments. Possibly out-of-school factors compensated for differences in the school science programs.

Reports by Brown, Herman, and Tyler[9] that boys usually score higher than girls on science achievement tests were verified in this study.

Knowing the reasons for some pupils liking science and others disliking it seems very important. In view of the large differences in the mean scores of pupils grouped by this variant, this should be studied. Although some pupils may like science because they do well, in other cases liking science probably contributed to achievement. Knowing why groups of girls scored higher than groups of boys on two aspects of affective achievement but lower on the other aspects might also be of importance.

The analysis revealed some positive correlation between pupils' scores on the two measuring instruments. Since this was not high, and if the tests are valid for their objectives, both types appear necessary to measure pupil achievement and to assign grades. Both kinds of instruments are also necessary in researching the effects of specific instructional variants.

Science Programs

Since, in most schools, the science programs little resembled those advocated in the literature and since some objectives of science teaching are not thought attainable except through a "discovery" or "experimental" approach, the emphasis placed on class discussion, lecture, and textbook reading has important implications. This may account for Tisher's finding that pupil interest decreases through the grades.[10]

The interviewed teachers seemed aware of the elements of a "good" program, but many said they were limited by space, materials, and time. Lack of preparation and training was also mentioned by teachers and principals as reasons for deviations from the recommended practice. Several principals pointed to both "good" and "mediocre" programs in their schools as reflections of teacher training and interest in science teaching.

The cluster in which five assigned program scores were related to each other indicated a tendency by some to move in several ways toward a program like those advocated by science educators. The relationship between the facilities items and a marked tendency for programs to be superior in several respects may illustrate the importance attached to science by the community or the individual teacher.

There may also be implications in the correlation between the time provisions for science and other aspects of the program such as experimentation, methods and presentation, and total instruction. Did better programs result when ample time was provided, or did teachers wishing to use favored methods and instructional techniques make time in their schedule for them?

The relationships between the assigned scores and teacher biographical items have implications for the training and selection of teachers. Also of interest is that young teachers provided more time for science and obtained better facilities, but scored lower on methods and presentation and on textbook and reference use than older teachers. Longitudinal studies might reveal shifts in teaching patterns as teachers grow older. It may also be helpful to know the reasons for teacher attitudes toward teaching this subject, why they feel inadequate, and why almost two-thirds of them indicated they believed it should be taught by specially trained teachers.

Relationships between Teaching and Achievement

Although cognitive and affective achievement were related to different program items, they are not necessarily in conflict, being obtained at the expense of each other. Pupils must be provided with the time, facilities, and opportunity to learn science by "doing and observing" if affective outcomes such as interests and skills are to be emphasized. If the cognitive outcomes are considered most important, there should be regular and extensive use of science textbooks and reference reading materials. These should be supplementary.

Biographical factors correlated to one or most aspects of pupil achievement were years of college, college credit in science, a felt need for additional work in science, and a liking for science teaching. If confirmed, these are important in the selection and training of teachers.

Recommendations

Since a wide gap seems to exist between that which is advocated and practiced, administrators and teachers in public schools may wish to reassess their science programs. They should consider (*1*) both cognitive and affective outcomes, (*2*) providing a planned sequential program throughout all elementary grades, and (*3*) providing a "discovery" or "experimental" program that includes frequent use of library and reference materials and frequent pupil–teacher demonstrations and experimentation. They should also consider a program of supervision and inservice training to (*1*) improve teacher competence in science, (*2*) erase fears of science teaching, and (*3*) create favorable attitudes toward science teaching.

Colleges and universities should attend to (*1*) erasing prospective teachers' feelings of inadequacy in science teaching, (*2*) improving their competency, and (*3*) providing them experience handling the kinds of materials they need to use.

This study was expected to reveal areas for further and more intensive study. Some have already been mentioned. Others deemed worthy of further consideration are:

1. Construction of more adequate methods for measuring pupil achievement in science.

2. Study of relationships between aspects of cognitive and affective science achievement in other groups and categories of pupils.

3. More status studies of science teaching dealing with other grade levels and other instructional variants.

4. Additional testing of relationships between science achievement and pupil or instructional variants.

References

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