REPORT RESUNES

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REVIEW OF RESEARCH STUDIES IN SCIENCE EDUCATION.

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MICHIGAN ST. UNIV., EAST LANSING

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SECONDARY SCHOOL SCIENCE EDUCATION RESEARCH STUDIES conducted during 1963-65 are reviewed and compared with those reviewed during 1961-63. Titles of 195 research reports were obtained from periodicals, serial and nonserial bulletins, and indexes. Abstracts of 125 documents were obtained and reviewed by a committee. The studies were classified as (1) survey and status, (2) analytical and survey, (3) experimental, or (4) curriculum. During the 2-year period the number of survey and status and curriculum studies increased while the number of analytical survey and experimental studies decreased. Reviews include a short description of the study and results obtained. A bibliography of the studies included in the review is presented. (AG)
Members of the staff of the Science and Mathematics Teaching Center at Michigan State University, as a cooperative service with the United States Office of Health, Education, and Welfare and the National Association for Research in Science Teaching, assumed the responsibility for the review of research in secondary school science for the 1963-65 biennium. It has been an interesting and challenging activity, and we trust that our compilation and analysis may be useful to the science education community.

Review of Sources of Science Education Research

Fifty-seven periodicals, one serial and one non-serial bulletin, and three index sources (Appendix A) were systematically searched to obtain the titles, names, and the addresses of the authors of published research. One hundred and ninety-five titles (Appendix B) resulted from this literature search. The titles were transmitted to Dr. Lloyd Johnson of the U.S.O.E. staff for his use in securing abstracts of the studies. From these and other sources, Dr. Johnson forwarded to the committee one hundred and twenty-five abstracts for review.

Review of Abstracts

Table I summarizes the categories and final disposition of the studies received. By agreement of the committee under the chairmanship of Dr. Lloyd Johnson, categories of previous biennial surveys were replaced by a classification system recommended by Novak. The committee recognizes that the grouping used in this report is somewhat arbitrary and that other reviewers might have arrived at different categorizations. The subsets intersect particularly between "Survey and Status" and "Analytic Survey," and many of the "Experimental" and "Curriculum" studies might well fall into both categories.


Chairman - Wayne Taylor

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TABLE I
CATEGORIES OF ABSTRACTS RECEIVED

<table>
<thead>
<tr>
<th>CLASSIFICATION</th>
<th>REPORTED</th>
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<tr>
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<td>18</td>
<td>37</td>
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<tr>
<td>ANALYTIC SURVEY</td>
<td>18</td>
<td>5</td>
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<tr>
<td>EXPERIMENTAL</td>
<td>7</td>
<td>11</td>
<td>18</td>
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<tr>
<td>CURRICULUM</td>
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<td>34</td>
<td>47</td>
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<td><strong>57</strong></td>
<td><strong>68</strong></td>
<td><strong>125</strong></td>
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Sources of Studies

Abstracts of sixty-three doctoral and twenty-nine masters' theses were received by the committee. In addition, thirty-three miscellaneous abstracts were received. The committee disposition of the studies is shown in Table II.

Each of the one hundred and twenty-five abstracts was independently reviewed by three members of the committee and the committee chairman. Basic criteria for inclusion in the final report were the suggestions included in the committee manual and in Novak's article. It should be noted that the determinations were made from the abstracts submitted, and the committee fully recognize the limitations involved in not working from the original study. There were, not unexpectedly, differences of opinion on some of the studies. In these cases a majority opinion was used as the basis for the final decision. Every effort was made to produce consistent and unbiased reports. A bibliography of the abstracts of the studies examined is shown as Appendix C.

General Comments on the Abstracts Submitted

Unfortunately time and personnel limitations prevented the committee from reading all the original studies, and our comments must necessarily be interpreted as stemming from the abstracts themselves. Many of the abstracts were poorly prepared; as a result, the reviewers feel that many of the studies may appear to lack lucidity, direction, and purpose.

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Serious questions might be raised about some of the research designs. Since 92, or 74 per cent, of the studies were masters' and doctors' theses, it seems appropriate to point out that better supervision of the research design and reporting should be a more active responsibility of the major professors involved.

**TABLE II**

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<thead>
<tr>
<th>SOURCES OF ABSTRACTS RECEIVED</th>
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<tr>
<td>Doctoral</td>
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<tr>
<td>Survey and Status</td>
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<td>Analytical Survey</td>
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<tr>
<td>Experimental</td>
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<tr>
<td>Curriculum</td>
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<tr>
<td>TOTAL</td>
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</table>

1Recommended for Abstract Inclusion by Secondary Level Committee.
2Recommended for Bibliography Inclusion by Secondary Level Committee.
3Total R + B.

The use of questionnaires and, to some degree, jury techniques, again seem to predominate, particularly in the survey and status and analytic survey classifications. Serious questions might be raised about the depth of many of the studies and about the validity of instruments used. There certainly is little indication that concentrated attention has been given to the nine categories of issues and problems discussed at the 1960 and following meetings of the National Association for Research in Science Teaching. In our report two years ago we postulated that studies for this biennium might begin to reflect this emphasis, but the change is not apparent.

There was, however, an interesting shift in emphasis as well as committee assessment of quality. The data are shown in Table III.
<table>
<thead>
<tr>
<th>Year</th>
<th>Doctoral</th>
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<td>1963-65</td>
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By Category and Committee Recommendation

Table III. Comparison of 1961-63 and 1963-65 Studies
In Category I, Survey and Status Studies, there was a large increase in the percentage of studies, both in number received and number reported. Conversely, the category Analytical Survey experienced a small drop and Experimental suffered a very large drop. Curriculum studies had the same trend as Survey studies. As one reads the abstracts the charges leveled by Dr. Benjamin Bloom in his presidential review for the *Educational Researcher* begin to take an added meaning. He says:

"In the past, much of educational research has been fragmentary, redundant, and trivial. Educational research must be more systematic, and the investigations must be more crucial. Each piece of research must have a place in a larger conceptual framework. No longer can the same studies be done over and over again without taking into consideration what went on before or the advances which have taken place in theory and method. We must all learn how to do more crucial and significant research; redundant and poorly done research must be discouraged or, at least, questioned."

The increased funds available for educational research and recognition of the need for sound research activity should be an incentive for the National Association for Research in Science Teaching to re-evaluate the scope and usefulness of reports such as this one. Better abstracting (by independent evaluators) and collection and dissemination of educational research data will undoubtedly result from the efforts of the Educational Research Information Center (ERIC) of the U.S.O.E. Bureau of Research, which has now become operational. Perhaps NARST should explore possibilities of joining forces with the American Educational Research Association and Phi Delta Kappa both to broaden the scope and intensify the coverage of extant studies. Undoubtedly our present efforts, valuable though they may be, are but at best a sampling technique beset by inadequate resources and ineffectual and tardy dissemination techniques. In short, we need a much more businesslike approach to the issue of making immediately and widely known to the science education community current science education research. This problem has been discussed many times. Now is the time for action.

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February, 1966, p. 5.
There were few studies submitted in the areas of public policy, facilities and equipment, administration and supervision, teacher education, and evaluation. There were many curriculum studies and methods studies, but the committee felt that in many cases the samples were small or poorly selected, the studies were uniquely local in nature, or that inadequate or inappropriate evaluation instruments were used. Conclusions frequently represented the subjective judgment of the investigator and were not supported by adequate treatment of the data. The above criticism is not a blanket indictment of all of the abstracts examined. There were many fine studies that had ample data adequately treated. The committee, in general, would support the views of various contributors to the *Journal of Research in Science Teaching*, that much progress remains to be made in science education research, that science educators need to become more familiar with other educational, psychological, and sociological research, and that we have much farther to go before we can confidently say, "Science Education research says. . . . . . . ."
Survey and Status Studies

Woodard (S-122) collected data through the State Department of Education in New York, and from a subsequent questionnaire through Cornell University to investigate science offerings, enrollments, and aspects of facilities and characteristics of science teachers of the State. He found that all academically able students in the schools studied had access to biology, chemistry, and physics courses, and that these courses usually integrally included laboratory work. Earth science was being added to junior high schools and greatest curriculum change was occurring at this level. Teachers were best prepared in biology, next chemistry, then physics. Earth science background was limited and more than fifty per cent of the teachers had three years or less tenure in their current positions. Morris (S-85) compared a total of 209 science and non-science teachers at elementary, junior high, and senior high levels on a number of characteristics. Among his conclusions were: The need for deference, for affiliation, and for conformity seemed to increase in science teachers with experience and age, science teachers at higher grade levels exhibited greater need for achievement, and both male and female teachers, regardless of their subject matter area, tend to exhibit striking similarity in their needs, values, and motives. In another study of teacher characteristics, Tubbs (S-112) attempted to determine differences in effective and less effective teachers. Questionnaire responses from 404 replies to a distribution of 994 teachers were analyzed. Each teacher was rated on an effectiveness scale by one class of pupils, the principal, and a group of fellow teachers. From the responses fifty-three teachers were designated as effective and forty-three were designated less effective. Seven characteristics were judged significantly different at the .01 level, eight at the .05 level, and five at the .10 level of confidence.

Bogen (S-11) appraised the effectiveness of the Oregon Traveling Science Teacher program as an agent for in-service training. He concluded that the program reached its objectives in that it stimulated interest and spread the influence of competent teachers of science, it encouraged the building of simple laboratory apparatus in smaller and poorly-equipped high schools, and it provided secondary school students with a deeper appreciation of science and helped motivate competent young people to enter scientific careers.

Etten (S-34) questioned 3000 teachers in 50 states. He concluded that while science studies, projects, surveys, and programs have been multiplying rapidly the average secondary school teacher seems to be maintaining the
status quo, that there is a gap in the communications between science teachers, and that many teachers are making an effort to keep up with the fast pace of science. Van Houten (S-113) assembled and submitted a checklist to experienced chemistry and physics teachers. The 46 respondees rated the degrees of necessity for various skills and from an analysis of the responses recommendations for teacher training programs were made. Fisk (S-17) analyzed 1047 application forms submitted by teachers to academic year institute programs. He concluded that all applicants were deficient in some phase of their preparation, that, in general, they did not indicate that they recognized their deficiencies and thus did not indicate that they were interested in correcting them, and that the academic year institute programs in question did not meet the needs of applicants.

Ward (S-118) studied questionnaires from academic year institute directors and teachers of special institute courses. The data indicated that major objectives of the courses were to provide for basic review and to bring participants' knowledge up to date. Instructors were aware of the special needs of the teachers and felt that courses should carry graduate credit. Instructors generally felt that rigor of treatment was frequently sacrificed. Fisk (S-36) studied documents dealing with the historical development of educational activities of the National Science Foundation. He concludes that although the NSF science education programs were started as emergency measures, they now appear to be permanent and NSF is indeed becoming a Federal Educational Agency.

Bennett (S-6) surveyed current teaching practices in Texas junior high schools. He found that over half the schools used school time to encourage science fair work, that controversial issues are treated, and that only half of the school buildings have been designed specifically for that age group. A description of a typical junior high school is formulated, and the typical teacher is described. Johnson (S-62) studied the effect of radiation science institutes on secondary science programs of California. He concludes that teachers lack textbooks and laboratory manuals, that there is no formal provision in the course of study for such work, and that maintenance and calibration of equipment are teacher problems. The typical participant teaches four sections of biology and one of mathematics, and after institute training typically uses three periods of instruction per year per class of biology.
Parasugo (S-90) surveyed instructional programs in science for slow learners in ten junior high schools. He found that although homogeneous grouping was widely employed, there were few other modifications made in the ten academically-oriented junior high school studied. Fowler (S-38) studied the advanced biology course in Pennsylvania secondary schools. He found that of the 134 schools described, the course was more common in larger schools and has a prerequisite of biology, usually tenth grade. Almost without exception the course is considered a special course for college preparatory, terminal, or given a general education objective. Rarely is it considered advanced placement, and it commonly uses a "modern biology" approach. The taxonomy-structure approach was noticeably lacking.

Voss (S-116) evaluated the chemistry topics in BSCS Blue Version biology. A questionnaire listing 104 chemistry topics was submitted to 58 Blue Version teachers, and respondents indicated that biochemistry topics should be taught as part of the program; they were about equally divided on inclusion of basic chemistry topics. Fakier (S-35) determined the extent of the use of tests and other measurement techniques by high school biology teachers. A sample of 410 teachers was used and eleven conclusions were listed. No trend or pattern in regard to measurement practices or techniques could be established.

Morgan (S-83) did a thirty year longitudinal study of chemistry texts and popular literature of principles, vocabulary, and objectives. He found that little change has occurred, that methods of presentation differ primarily in emphasis placed on laboratory data and theoretical and mathematical considerations. Words and terms in the popular literature were contained to a greater extent in the traditional texts.

Weisberg (S-120) analyzed a 65 per cent return of 260 opinionnaires distributed to teachers and administrators to find attitudes toward the value and control of science projects in New Jersey secondary schools. He concluded that science projects were widely used despite the fact that the majority of principals and teachers believed that the projects were not valuable experiences for all students, that teacher structuring of projects was slight or non-existent in many cases (although this is not in keeping with what is suggested in the literature as good science project technique), and that science project work, in the main, was not truly experimental and therefore, at variance with what is generally accepted as most valuable and worthwhile for the acquisition of scientific knowledge and attitudes.
Matthews (S-80) sent questionnaires to 590 educational institutions to find the current status of earth science in secondary schools. He found that the interdisciplinary study is becoming increasingly common and is being taught as a separate course to almost 200,000 students in 50 states. The subject is usually offered in the 9th grade, but it is also taught in the 8th and 10th grades. Two major obstacles in teaching the course are (1) lack of suitable teaching materials, and (2) a scarcity of properly prepared teachers. In another study of earth science Kozak (S-69) found that the course is on the increase in New York state. The fundamentals have been taught for many years, and the basic material has remained similar since 1900.
Analytic Survey Studies

Hedges, MacDougall and Lochhead (S-51) analyzed teacher-made science tests to determine the teachers' educational goals. They found that the majority of the items reflected objectives classifiable among the lowest orders of Bloom's Taxonomy, and that the items were inadequately constructed. They conclude that science education in Virginia high schools is of a fragmentary and elementary nature, that science teachers are not giving sufficient consideration to the consolidation of broad understandings, and that science teachers appear to be insufficiently prepared in the construction of teacher-made tests. Kleinman (S-66) studied the relationship between teacher questions and pupil and teacher behaviors, and attempted to determine whether the kinds of questions general science teachers ask influence pupils' understanding of science. The study involved classroom observation in the seventh and eighth grades. Teachers were classified into two groups and the 767 pupils of 23 teachers were tested by the TOUS test. She found that there were significant differences at the .01 level of confidence on neutral, rhetorical, factual, clarifying, associative, and critical thinking question categories, that teachers who asked critical thinking questions rated higher on pupil and teacher behaviors than teachers who did not, that the 23 teachers demonstrated many similarities as well as differences in behavior, and that there were significant differences between pupils of both groups of teachers on six of eight comparisons of test scores.

Blankenship (S-10) studied the relationship of reactions to the BSCS program to selected teacher characteristics. He found that teachers who ranked higher on measures of capacity for independent thought and action and who had taught high school biology for three years or less reacted favorably to the BSCS program while those science teachers who ranked lower on measures of capacity for independent thought and action and who had been teaching high school biology for more than three years reacted unfavorably to the program. Howe (S-56) studied selected teacher factors and teaching methods in 51 Oregon tenth grade high school biology classes. He concluded, among others, that teachers rated high in personal adjustment by principals taught classes with higher adjusted gains on four of five learning outcomes, that teachers with less than forty quarter hours of preparation in all science areas and less than thirty quarter hours in biology, with one exception, did not teach classes with positive mean gains among the highest third on any of the learning outcomes, that pupil-centric methods emphasizing problem-solving laboratory procedures with
analyses of experimentation were characteristic of a majority of the classes
with a high composite success, and that several teachers in the study were
not previously cognizant of broad objectives or were not including them
in their teaching.

Matthews (S-79) investigated the changes in classroom verbal behavior
of student teachers and the relation of the classroom verbal behavior of
the cooperating teacher to these changes. He concludes that verbal be-
haviors of the student teachers exhibit significant change during the
period of student teaching. Certain variations in verbal behavior may
be related to the verbal behaviors of the cooperating teachers; in some
aspects, student teachers become more similar to their cooperating teachers
and in other aspects they become less similar to their cooperating teachers
during the period of student teaching.

Zaki (S-124) found that there was a highly significant negative
correlation between the attitude of Pakistani science teachers toward
religion and their attitude toward science. He found that high school
students in the United States understood that nature of the scientific
enterprise significantly better than did the science teachers of West
Pakistan, and that science teachers with a background in the biological
sciences understood the nature of the scientific enterprise significantly
better than did those who had studied only physical science.

Stokes (S-107), from a study of the proposals of the Woods Hole
Conference concludes that the basic assumptions about the nature of
knowledge and the nature of learning germane to the position of the Woods
Hole Conference have not been carefully investigated, that the advantages
claimed for teaching the structure of a discipline have not been subjected
to research even though such research is repeatedly called for by the
report of the Conference, that the research on the effectiveness of the
curriculum projects based on disciplinary structure is largely ambiguous,
making it impossible to determine at present how effective the new
programs are, and that the research on the effectiveness of learning by
discovery as compared to nondiscovery methods was inconclusive for the
six criteria used.

McFarland (S-81) examined teacher perceptions and reactions to
system-wide adoption and implementation of Chemical Education Material
Study materials of teachers who were involved in in-service workshops.
Indications were that the amount of time spent in various instructional activities did not change perceptibly, that special techniques for expediting equipment orders and instructional aids had to be developed, and that CHEMS experienced teachers assisted considerably in the implementations. The existence of distinct patterns of teacher response, he concluded, indicates a need for specifically tailored approaches to curriculum change within a given school system. Further, analysis of the student data indicates that new dimensions were added to the prediction of student achievement.

Nahrstedt (S-87) analyzed junior high school science programs which served as the basis of the development of twenty-five guides to aid in the revision of the junior high science curriculum.

Gomez (S-48) gave pre and post-tests to 814 students in 13 junior high schools in a study of sequential and non-sequential general science programs. He found, among others, that students in a general science program scored significantly higher than students in a sequential program, although there was no difference if the quality of instruction is high. There were differences in socio-economic level student scores, and in instruction using demonstrations.

Riggsby (S-92) studied the writing of scientists and content of textbooks in an investigation of scientific method. He concluded that the textbook approach is considerably more rigid and "objective" than scientists say it is in their actual practice, that many of the facets of the scientific method are of a personal nature to the scientist, and that many textbook writers confuse the logic the discovered with the logic of discovery.

Dessel (S-29) used a selected set of criteria to attempt to predict success in physics for high-ability students. He concludes that the letter grade is grossly inadequate but that certain standardized instruments have potential for use. In another study of factors operative in success in physics Brakken (S-12) analyzed intellectual factors of conventional and PSSC students. He found that differences exist between the two types of courses, that the conventional course is more verbally oriented, that achievement was dependent on verbal ability, and that the importance of this factor increased for conventional physics as instruction progressed, but that the trend did not appear for PSSC students.

Hamilton (S-50) compared the scientific literacy of urban, suburban, and rural high school seniors in Kentucky and concluded that scientific literacy depends upon mental ability, no conclusions can be drawn relative
to scientific literacy of students from different areas, there is a positive relationship between the number of science courses completed and scientific literacy, boys are not more literate scientifically than girls, and the size of the graduating class is not a contributing factor. In another study of achievement Giddings (S-46) studied disadvantaged students from junior high schools in New York. He found that high achievers had the active interest and strong encouragement of parents, they had a place that was conducive to study, there were more books, and magazines, in the homes, they showed much greater interest in science and careers in science, had a higher self-estimate of ability, and achieved better in other areas.

Braund and Heath (S-15) did a pilot study of a cognitive restructuring paradigm with four PSSC physics classes and concluded that devices such as the Kit of Reference Tests for Cognitive Factors and the Cognitive Preference Test can be useful in the analysis of curricular effects.

Vitrogen (S-115) developed a scale to measure a generalized attitude of secondary school students toward science. He concluded that a generalized attitude toward science can be identified among secondary school students 13 to 15 years of age, and that his instrument differentiated between high and low science oriented students in the study. In a study of interest Wynn (S-123) used the Kuder Preference Record to assess the change in scientific interest of high school students. Twenty-one percent of the sample underwent significant change, although no significant relationships were established between Scientific Interest and Language IQ, Non-language IQ, Total IQ, academic achievement, science achievement, and biology achievement. The scientific interest scores of five successive classes did not indicate a trend of increasing interest in science.
Experimental Studies

Supplementary programmed instruction material used in conjunction with regular and team taught physical science classes was reported by Benson and Schorow (S-7). They conclude that sequentially paced materials using immediate reinforcement can be a valuable supplementary aid for the teacher, and that there is some evidence to indicate that programmed materials can be used to overcome deficiencies which teachers may possess either in the areas of academic preparation or interest. Lindbeck (S-75) also used programmed material to teach chemistry classes. She concludes that for a program teaching specific, detailed concepts, an overt response would seem to be most effective. For general concepts the covert response mode might be as effective.

Mahan (S-77) compared lecture-discussion and problem-solving methods of teaching ninth grade science. Two classes were used for each method and seven of the eight conclusions listed favored the problem-solving approach. No differences were found in the development of scientific attitudes.

Gallagher (S-42) sought to determine modifications in children's judgments after instruction in relevant physical principles. He concludes that children evaluate explanations on the basis of (a) logical structure, (b) physical principles, and (c) comprehensibility. The first generally results in the rejection of incomplete and logically inadequate explanations. Instruction in the logical structure of explanations appears to effect considerable change in children's views of acceptable explanations.

Coulters (S-25) compared the amount of learning in terms of inductive laboratory, inductive demonstration, and deductive laboratory instruction in biology. He concludes that the inductive treatments produced significantly greater attainment of attitudes of science. In no outcome was there a significant difference in favor of the deductive laboratory treatment. Gennaro (S-44) also did a comparative study of teaching biology using the BSCS Yellow Version and BSCS Laboratory Blocks with collateral reading. He found no significant differences between control and experimental classes except subject matter achievement for Block tests. Brosius (S-14) also used tenth-grade biology to compare two methods of laboratory instruction. He compared the use of films to actual dissections. He concludes on the basis of his self-constructed instruments that the films used could be substituted for conventional dissections in tenth-grade beginning biology without loss in the learning process and with more efficient use of time, space, and materials.
Curriculum Studies

A televised general science course was the basis for Jerkins (S-61) investigation of learning and retention. He found that the telecasts were most effective in teaching objectives at the lower extreme in the cognitive domain, that pre and post-test interest were stable, and that overall pupil and teacher reactions were favorable. Hunt (S-59), in another junior high school study investigated team teaching in science and social studies. He found that staff organizational patterns did not significantly affect academic or achievement or personality development, and there was some indication that team teaching was more successful at lower ability levels than higher ability levels.

Hubbard (S-57) used general science classes as a source of eighth graders to investigate junior high school students' perceptions of science and scientists by using an experimental and control group. The experimental group was taught a unit concerning scientists. Although no significant differences existed the experimental group scored slightly higher on the post-test.

George (S-45) compared conventional with BSCS biology in a study of their effects on critical thinking ability. He concluded that teachers must teach specifically for critical thinking, and that pupil achievement was significantly higher in Blue Version than Yellow Version and Yellow Version in turn was better than Green Version. There were no significant differences between Green and Yellow Versions and conventional.

In still another study involving biology, Morholt (S-84) used a resource unit as a means of teaching conceptual schemes by investigative approaches using a single organism.

Lisonbee (S-76) also compared BSCS biology with conventional biology. Experimental and control groups did not differ significantly on the Nelson Biology Test, but subgroups of middle and high ability tested higher on the BSCS Achievement Test.

Robinson (S-94) used instructional tests to determine understandings of BSCS biology students. Ten high school biology teachers met twice monthly during the school year to develop the series of classroom tests. The tests were in turn administered and evaluated. Standard techniques were used to check readability, reliability, and discrimination.

Hill (S-54) developed a syllabus for a course in biology for the non-academic high school student. He gathered data from non-academic students and their teachers and community adults who supervised out-of-school activities for the students.
In another study involving new curricula Herron (S-53) compared CHEM study with conventional chemistry in terms of their development of cognitive abilities. He used factor analysis to treat pre and post-test data and found that conventional low and average ability students scored significantly higher on the Watson-Glaser subtest, Recognition of Assumptions, than did the comparable CHEM study group. No other significant differences were found.

Day (S-28) compared PSSC physics and traditional physics in six areas of critical thinking. He concluded that students who take PSSC physics exhibit a greater ability to solve critical thinking problems and that non-PSSC students had a more positive attitude toward their physics courses.

Crumb (S-26) also used high school physics students and their teachers to study gains in scores on the Test on Understanding Science. He compared teachers of PSSC physics, both with and without formal PSSC training, and teachers of non-PSSC physics, both with and without formal PSSC training. Data were treated by analysis of variance and significant gains in understanding science were made by the entire study population over a period of a school year. Differences were found between PSSC and non-PSSC students.

Sawyer (S-97) also studied the effectiveness of the PSSC course. A test was developed by four physics teachers, two PSSC and two non-PSSC, to be used with four physics classes as both pre-test and post-test. He concluded that the classes differed on the pre-test, the PSSC program does not fulfill non-PSSC objectives and vice versa, and that the tendency for students taking such a combination examination would favor higher scores for non-PSSC students. Rather (S-91) also used PSSC as the basis for a study to determine generalizations desirable as prerequisites to PSSC. He identified 223 generalizations and submitted them to a panel of teachers. He concluded that college and high school teachers disagreed as to (a) the ability of certain science terms to convey accurate scientific meaning, and (b) how accurately quantitative relationships should be expressed for pre-PSSC science courses.
APPENDIX A

Sources Examined for Research in Secondary Science Education

1. American Biology Teacher.
10. California Schools.
11. Education.
12. Educational Administration and Supervision.
15. Educational and Psychological Measurement.
19. Improving College and University Teaching.
21. Journal of Chemical Education.
22. Journal of Educational Psychology.
25. Journal of Experimental Education.
27. Journal of Higher Education.
29. Journal of Secondary Education.
31. Liberal Education.
32. Metropolitan Detroit Science Review.
34. National Education Association Journal.
37. Phi Delta Kappan.
38. Physics Today.
41. Safety Education.
42. School and Society.
43. School Life.
44. School Science and Mathematics.
45. Science.
46. Science Course Improvement Projects (NSF Bulletin)
47. Science Education.
48. Scientific American.
49. Science Teacher.
50. Teaching Tools.
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51. Today's Health.
52. The Catholic Education Review.
53. The Clearing House.
54. The Education Index.
55. The Educational Record.
56. The Physics Teacher.
58. The Readers' Guide.
60. The School Review.
61. The Teachers College Journal.
62. The Teachers College Record.
APPENDIX B
AUTHORS AND TITLES FROM 1963-65 LITERATURE SEARCH


13. BERGER, Joel J. "A Determination of the Relative Effectiveness of Two Specific Teaching Methods on the Ability of High School Chemistry Students to Write Chemical Formulas and to Apply This Knowledge to a New Problem-solving Situation." Dissertation Abstracts, Vol. XXIV, No. 7, 2806, Order No. 64-236.


52. EVEN, Robert L. "An Experimental Study of the Comparative Effect of Selected Art Experiences on the Creative Performance and Attitudes of Academically Superior Students." Dissertation Abstracts, Vol. XXIV, No. 11, 4470, Order No. 64-4062.


63. GAVERICK, Charles M. "Retention of School Learning as Influenced by Selected Affective Tone Variables." Journal of Educational Psychology, 1964, Vol. 55, No. 1, pp. 31-34.


75. HELLER, Robert L. "The Earth Science Curriculum Project."
    pp. 272-275.

76. HILL, Casper W. "A Syllabus of a Course in General Biology for the
    Non-Academic Student in High School." Dissertation Abstracts,
    Vol. XXIV, No. 7, 2811, Order No. 64-283.

77. HILL, Russel Norman. "An Analytic Survey of Curricular Changes in
    Minnesota Schools, 1951-1962." Dissertation Abstracts, Vol. XXIV,
    No. 11, 4471, Order No. 64-4065.

78. HOFFMASTER, Edmund, LATHAM, James, and WILSON, Elizabeth. "Design for
    pp. 15-17.

79. HONNEN S. S. J., James F. "The History of Chemistry Teaching in Catholic
    High Schools of the New York Archdiocese." Dissertation Abstracts,
    Vol. 25, No. 5, 2884, Order No. 64-11299.

80. HOWE, Robert W. "The Relationship of Learning Outcomes to Selected
    Teacher Factors and Teaching Methods in Tenth Grade Biology Classes

81. HUBBARD, Howard Newton. "Junior High School Students' Preceptions of

82. HUNT, Edward George. "Team Teaching in Junior High School Science and

83. HUTTO, Thomas A. "A Need for Coordination of Science Youth Activities."

84. JACKSON, Harold F. "The Effectiveness of Using Filmed Courses in Physics
    and Chemistry in Addition to the Traditional Lecture-Laboratory

85. JACOBElli, Anthony. "A Special Honors Three in One Biology Course."


87. JONES, George L. "An Enrichment Program in Chemistry for the Advanced
    p. 605.
88. JONES, James W. "The Physical Science Programs in the Senior High Schools of Arkansas."

89. JONES, Kenneth. "Interest, Motivation, and Achievement in Science."
   pp. 41-53.

90. JONES, Kenneth J. "Predicting Achievement in Chemistry: A Model."
   pp. 226-231.

91. KAPLAN, Eugene H. "Empiricism as a Function of Training in the Scientific Method."

   pp. 341-50.

93. KEFFER, Eugene R. "The Use of Expert Judgments in the Development of a Science Methods Course."
   pp. 55-59.

94. KLAUSMEIER, Herbert J. and WIERSMA, William. "Effects of Condensing Content in Mathematics and Science in the Junior and Senior High School."
   pp. 4-11.

95. KLOPFER, Leopold. "The Use of Case Histories in Science Teaching."
   pp. 660-66.

96. KOELSCH, Charles L. "Science Education Programs in the Developing Countries of South and Southwest Asia."

97. KUETHE, James L. "Science Concepts: A Study of Sophisticated Errors."

98. LANCE, Mary L. "A Comparison of Gains in Achievement Made by Students of BSCS High School Biology and Students of a Conventional Course in Biology."
   Dissertation Abstracts, Vol. 25, No. 5, 2814, Order No. 64-11708.

100. LISONBEE, Lorenzo K. "The Comparative Effect of BSCS and Traditional Biology Upon Student Success." Dissertation Abstracts, Vol. XXIV, No. 8, 3153, Order No. 64-2186.


112. MERRILL, Reed M., and JEX, Frank B. "Role Conflict in Successful Science Teachers."

113. MILLER, Phillip E. "Do the Low Achievers Fit In?"


115. MONTAGUE, Earl J. "An Attempt to Appraise Whether Problem-Solving Abilities Can Be Developed in a General Chemistry Laboratory."

116. MORHOLT, Evelyn. "The Use of Chorella to Teach Conceptual Schemes and Experimental Approaches in Biology. A Resource Unit to Illustrate the Use of an Organism as a Focus for the Development of Ideas Central to a Course of Study."
Dissertation Abstracts, Vol. 25, Part 1, 45, Order No. 64-4330.

117. MORIARTY, Barry M. "Science for the Intelligent Adult of the Future."

118. MORRISSEY, Sister M. Chrysoston. "A Study of the Predictive Value of High School Science Grades as Indicators of Success in Anatomy and Physiology in Selective Schools of Nursing."


120. NEWTON, David E. "The Role of Science in General High School Education."

121. NICHOLS, Robert. "Career Decisions of Very Able Students."

122. NOHRSTEDT, Gary W. "An Analysis of the Junior High School Science Program with Proposed Guides for Curriculum Revision."
Dissertation Abstracts, Vol. XXIV, No. 8, 3233, Order No. 64-1539.

123. OLSTAD, Roger G. "Secondary School Biology Achievement Related to Class Period Length and Teaching Method."

124. O'REILLY, Lawrence. "Let's Get the Health Out of Science."


165. SPIETH, Phillip E. "Intelligence As It Relates to Three Creativity Categories: Science, Art, and Literature." Dissertation Abstracts, Vol. 25, No. 3, 1759, Order No. 64-8212.


Dissertation abstracts, Vol. XXIV, No. 11, 4491, Order No. 64-4460.

194. YAGER, Robert E. "A Junior High School Sequence in Science."
pp. 719-25.

195. YAGER, Robert E. "Science Curriculum Revision."
National Association of Secondary School Principals, Vol. 47,
APPENDIX C
Abstracts Examined for the 1963 - 1965
Review of Research in Science Education
Secondary School Level


* Recommended for inclusion in the U.S.O.E. Report.
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S43. GAWE, Roger Barry. "The Number, Content, and Objectives of Outdoor Education Programs Sponsored by the Science Departments Among 113 Northern New Jersey Junior and Senior High Schools, Fall, 1963." Research reports, Montclair State College, 1964.

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S70. KUEBBELER, Ann E. "A Bibliography of Supplementary Reading for the Biological Sciences Curriculum Study Text: Biological Sciences: Molecules to Man (Blue Version)." M.A. Thesis, University of Toledo, June, 1964.


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