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AUTHOR Blood, David; Zalewski, Leon J.
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ABSTRACT

Research studies have indicated the role curriculum plays in the crisis confronting science education. Many states have begun to reorganize and evaluate their science curricula for a more coherent and improved educational program. Curricular changes have traditionally included teacher input through a local school district committee. Information gathered for this paper originated from such committees. One problem encountered by most school districts in Illinois is that of developing science objectives from goals which can be assessed with local or standardized instruments. Sample objectives provided by the state board are organized into four goals: (1) knowledge and vocabulary; (2) science, technology, society; (3) scientific enterprise; and (4) science processes. From these goals local science objectives were developed and in each case more objectives were written for goal 1 than any other goal. Additional analyses and implications are cited. (RT)

DEVELOPING SCIENCE CURRICULA

David Blood
Professor of Education
Governors State University
University Park, Illinois 60466

and

Leon J. Zalewski
Professor of Education
Governors State University
University Park, Illinois 60466

Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (62nd, San Francisco, CA, March 30-April 1, 1989).

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by

Drs. David Blood and Leon J. Zalewski

Introduction

Science education is receiving a lot of attention recently. Many states such as Illinois and Texas have legislated educational improvement through curriculum development. A review of ERIC (Educational Resources Information Center) documents reveals the publication of several curriculum guides for science by state Departments of Education within the past few years. Seven subject matter areas including science are scheduled for reorganization and evaluation in Illinois. The reorganization and evaluation have forced many school districts to develop coherent science curricula not only within school districts but among school districts as well. The purpose of this article is to analyze efforts by some school districts reorganizing science curricula.

Studies have emphasized the crisis confronting science education and the role curriculum plays in this crisis. For example, Harms and Yager (1981) through Project Synthesis, indicated that there exists a great discrepancy between science curricula in schools and what students need. Most of the recent efforts have been in writing science textbooks but no new thrusts have been made toward developing science curricula (Brandwein, 1981). Evidence gathered and synthesized by Project Synthesis led to four broad goals for science curricula (Harms and Yager, 1981). These include:

1. Personal Needs. School science should be applicable to daily living in a technological society.
2. Societal Needs. School science should help prepare informed citizens to deal with societal problems.
3. Career Education/Awareness. Students with varying abilities and interests should be made aware of the variety of science and technology-related careers.
4. Academic Preparation. School science should prepare students to go beyond high school as well as consider careers in science.

Many states, including Illinois, have legislated changes in curricula. Curricular changes have historically included teacher input through local school district committees. The information gathered for this article came from work with science committees given the task to reorganize science curricula around goals established by legislated mandates. The problem, faced by most school districts in Illinois and

other states with legislated mandates for change, is to develop science objectives from goals which can be assessed with local or standardized instruments.

Goals established by Project Synthesis influenced the Sample Learning Objectives in Biological and Physical Science developed by the Illinois State Board of Education. Educational reform legislation amended the School Code of Illinois in 1985 to include, for the first time in the state's history, a definition of schooling and a requirement that objectives be identified and assessed. Sample goals and objectives were established by the Illinois State Board of Education in six areas of learning including Language Arts, Mathematics, Biological and Physical Sciences, Social Sciences, Fine Arts, and Physical Development and Health. Legislative requirements include that local, independent school districts establish student learning objectives in the six areas which meet or exceed goals established by the State Board. Elementary school districts were also mandated by the legislation to coordinate efforts with high school districts and to assess the degree students meet local goals and objectives at grades 3, 6, 8 and 11.

The Sample Learning Objectives developed by the State Board of Education, were organized to provide assistance to districts. School districts had to meet or exceed the sample objectives. Many school districts called upon university consultants to help teacher committees develop local science objectives and assessment plans. The educational reform legislation provided a very unique opportunity for local school districts to work cooperatively to improve science curricula in Illinois.

Illinois State Learning Goals and Objectives

Beginning in 1987, school districts were required to submit objectives for student learning to the State Board of Education. Science objectives were to be sent to the Board of Education for approval and had to be matched with goals developed by the Board.

The State Goals for Learning and the Sample Learning Objectives for Biological and Physical Sciences are broadly stated expressions of what the State Board wants and expects its students to know and be able to do as a consequence of elementary and secondary schooling. Local elementary school districts were to cooperate with neighboring districts and the high school district in developing science objectives. School districts were to use the Sample Objectives as a guide to assist local

efforts. The Sample Objectives provided by the State Board are organized into four goals. These goals are:

1. Knowledge and Vocabulary. Concepts and basic vocabulary of biological, physical and environmental sciences and their application to life work in contemporary, technological society;
2. Science-Technology-Society. The social and environmental implications and limitations of technological development;
3. Scientific Enterprise. The principles of scientific research including ethical questions and the application of the principles in simple research projects;
4. Science Process. The processes, techniques, methods, equipment and available technology of science.

A booklet containing the Goals and Sample Objectives was sent to every school district in Illinois. Sample Objectives were listed for all four Goals. Listed below are several Sample Objectives teacher committees used for developing local objectives (Illinois State Board of Education, 1986).

Goal 1: Grade 3

Compare solids liquids and gases.

Observe the force due to gravity.

Goal 1: Grade 6

Identify the components of atoms.

Understand frictional forces.

Goal 2: Grade 3

No Sample Objectives provided by the State.

Goal 2: Grade 8

Compare and contrast the differences between science and technology.

Goal 3: Grade 6

Recognize conflicting data resulting from an investigation.

Goal 3: Grade 11

Relate alternatives to using animals in scientific research.

Goal 4: Grade 3

Recognize that data is collected through use of the senses.

Goal 4: Grade 11

Distinguish between precision and accuracy.

Procedures

Basic curriculum development processes were followed during the development of local science goals and objectives. Teachers and administrators were chosen from different schools within districts, representing each grade level K-12. The whole group met to discuss the current status of science curricula and instruction as well as philosophical ideas. Science instructional ideas were debated and associated with the Sample Objectives developed by the State Board. Most importantly, the role of the Illinois Educational Reform legislation, including State Goals and Sample Objectives, were examined in regards to development of local science objectives.

With the above activities as a common base, energies were then directed toward developing local science objectives. The large group of K-12 teachers was divided into smaller groups with each group having at least one teacher representing primary, intermediate, junior and senior high school. Teachers were also given opportunities to communicate with other grade level teachers throughout the entire process. In all cases objectives were typed on the AppleWorks data base. Using the data base was invaluable because objectives could be exchanged and discussed during subsequent large or small group meetings. Teachers also seemed more willing to let the list of objectives evolve knowing that it could be easily edited through use of the AppleWorks data base. The end result of all curricular development efforts was a data bank of objectives labeled according to the State Goals and Sample Objectives in Biological and Physical Science. Objectives contained in the data base program of AppleWorks were then scrutinized to determine the number of objectives fitting into each of the four State Goals.

The tables below indicate the number of objectives developed by four different teacher committees and submitted to the State Board of Education. Only the number objectives for grades 3, 6, 8 and 11 are listed despite the fact that all districts completed objectives for the other grade levels. Grades 3, 6, 8 and 11 were chosen because these are the grades at which mastery of objectives will be assessed.

NUMBER OF OBJECTIVES FOR GRADES 3, 6, 8 AND 11 BY GOALS

CASE I-B

GRADES	3	6	8	11
	Number of Objectives			
GOAL 1. Knowledge & Vocabulary	10	9	34	21
GOAL 2. Science, Tech, Society	2	0	1	8
GOAL 3. Scientific Enterprise	1	1	2	8
GOAL 4. Science Processes	3	2	13	7

CASE II-R

GRADES	3	6	8	11
	Number of Objectives			
GOAL 1. Knowledge & Vocabulary	4	15	13	13
GOAL 2. Science, Tech, Society	1	5	4	4
GOAL 3. Scientific Enterprise	0	5	4	4
GOAL 4. Science Processes	0	13	7	9

CASE III-TH

GRADES	3	6	8	11
	Number of Objectives			
GOAL 1. Knowledge & Vocabulary	7	9	10	8
GOAL 2. Science, Tech, Society	0	11	3	3
GOAL 3. Scientific Enterprise	3	4	2	2
GOAL 4. Science Processes	6	14	2	2

CASE IV-M

GRADES	3	6	8	11
	Number of Objectives			
GOAL 1. Knowledge & Vocabulary	5	6	36	14
GOAL 2. Science, Tech, Society	0	2	4	4
GOAL 3. Scientific Enterprise	0	2	2	2
GOAL 4. Science Processes	2	2	21	9

Analyses and Implications

In each case and for all grade levels, more objectives were written for Goal 1 than any other Goal. The number of Sample Objectives listed by the Illinois State Board of Education also places more emphasis across the grade levels on Goal 1-Knowledge and Vocabulary. Science curriculum committees in Illinois obviously believe that concepts and vocabulary are very important to the science curriculum. Local development of the objectives has followed the State's implied suggestion. Other information may have influenced the science committees. Standardized science tests assess knowledge through verbal and mathematical skills (Yager, 1987). Science committees are influenced by state guidelines and possibly by standardized achievement tests while reorganizing the curriculum.

The number of Knowledge and Vocabulary objectives increases from grade 3 to grade 8 in most of the cases. However, the number of objectives declines when making the transition from Junior(grade 8) to the Senior(grade 11) high school. Since these objectives are to serve all students in elementary and secondary school districts, perhaps the committees felt that less Knowledge and Vocabulary should be taught in high school than in junior high. Future research into developing science curricula for schools might take note of this fact to determine if this is a trend between junior and senior high school science programs.

At a time when more science educators are suggesting a move toward teaching science for application to everyday life, Illinois teachers and administrators are paying very little attention to this very important goal. No Sample Objectives were provided for Goal 2-Science, Technology, Society(S-T-S) for grade 3 in the booklet published by the State to help teachers develop the local science curriculum. Grade 6, however, contains 21 Sample Objectives for Goal 2. Grade 8 has 28 and grade 11 has 64 Sample Objectives for Goal 2 in the State manual. The State's progression toward a larger number of objectives for grades 6, 8 and 11 for the S-T-S theme is not reflected in the number developed by the science committees. However, Linn (1987), for example, demands that science curricula "reflect new knowledge, technological advances, and societal needs" (pg. 201). Furthermore, Linn reports quite a bit of agreement on this goal among Science Educators so that the voting public can act knowledgeably on science issues. Yager and Penick (1987) also support this contention and indicate that preparation of an informed citizenry to live in an age of science and technology and for coping with associated problems can be productive to attracting the most capable students to become scientists and engineers. If the evidence from Illinois science committees is indicative of the thinking exhibited by others around the country, science educators have an awesome task before them. Namely, how can we convince school personnel of the need for increasing emphasis upon applying science to personal, local and societal problems? School personnel must change their views of science curriculum and instruction for the elite going beyond high school to science for all students to use in their daily lives (Fensham, 1986).

According to the number of objectives developed by the science committees, Goal 3-Scientific Enterprise-has implications for grade 6 and beyond. Apparently the committees, reorganizing science curricula, do not believe that Scientific Enterprise should be a part of the

curriculum or science instruction for the Primary Grades. This concept follows direction provided by the State which also placed very little emphasis upon the principles of scientific research and the application of these principles in science experiments. More will be said about Goal 3 objectives in association with Goal 4 because the two are interrelated.

Science committees indicated that Goal 4-Science Processes-is important for grades 6 and 8 but somewhat less important for grade 11. Science processes seem to diminish in importance as indicated by the number of objectives. Goal 3-Scientific Enterprise-logically involves the integration of several science processes and may be more suited for upper grade science students. However, the elementary science curricula from the 1960's such as Science-A Process Approach placed a great deal of emphasis upon science processes. James and Hord (1988) pointed out that the authors of the elementary programs which included scientists, learning theorists, science educators and teachers, included "discovery learning and skills of inquiry" or processes to insure quality elementary science programs. In addition, Fensham (1986) observed that while elementary science programs of the 1960's emphasized processes, secondary programs paid very little attention to this focus of science. In light of the above observations from the authors, two conclusions can be made from the number of objectives science committees developed for State Goals 3 and 4-Scientific Enterprise and Science Processes, respectively. One, the committees did not believe in the importance of Scientific Enterprise which deals with the methods and ethics of obtaining knowledge. Two, the committees place very little importance on Science Processes for the primary(K-3) grades and follow the old pattern of placing little emphasis upon process at the secondary(grade 11) level.

Implications

Teachers and administrators will continually be asked to reorganize science curricula. The evidence gathered in this study suggests that science committees given the task of curriculum reorganization along the lines of the state mandates, are accepting some of the state guidelines. Not all goals developed by the State such as the S-T-S theme receive equal attention by science committees. The committees reorganizing the science curricula are NOT aware of recent thrusts in the subject area. Science education is making great strides in knowledge about what to teach and how to teach at all grade levels. Sadly, curricula organized

by committees reflects only minimal knowledge about what science education should be in our schools.

To place the S-T-S theme in science curricula, committees could become aware of some the recent findings in science education. Bybee and Bonstetter (1987) surveyed teachers to determine how to implement the S-T-S theme and indicated that science teachers rely on journals, newspapers and other print media for information. The authors believe that in-service programs, special summer workshops and courses could be used to provide the "grass-roots" reform necessary for implementation of the S-T-S theme into science teaching and curricula. Bybee and Bonstetter also indicate that pre-service teacher education should contain S-T-S materials to help future teachers. James and Hord (1988) have suggested mechanisms for school personnel to follow when implementing changes in science programs. They provide practical suggestions which are useful for altering current practices of elementary teachers including "....1. arranging for the materials, equipment, space and other logistics; 2. training; 3. monitoring efforts, and 4. follow-up consulting and reinforcing" (pg. 331). These are important steps to follow if teachers are going to change current practices and curricula. More importantly these practical steps could be followed when implementing science curricula containing new ideas and updated concepts.

Committees reorganizing curricula should also be aware of the definition/description of science. Science is viewed by some to include exploration, explanation and testing of explanations. Barrantine (1987) includes the above and adds that science must involve the application of knowledge and processes to benefit society and self. The teaching of science at any grade level, guided by the curriculum, must include opportunities for students to explore natural phenomena, develop explanations based upon experiences and test their explanations. In addition, the processes and knowledge organized in the curriculum and used during science teaching, should be in the realm of application and association with societal problems and individual questions. To summarize then, science curricula should guide the teaching with objectives which provide opportunities for students to use processes and knowledge applied to and associated with societal and individual problems. Any science curriculum should contain objectives addressing Scientific Enterprise-Goal 3, Science Processes-Goal 4 and Science-Technology and Society-Goal 2. Furthermore, there should be an increase

in the number of these objectives as students progress from elementary through secondary grades.

Teachers and administrators are influenced by textbooks, journals and other print media and can use these to define science curricula. Science educators must work to use these means as well as in-service, workshops and courses to influence teachers to consider new ideas and thrusts in science education. With the recent legislated curriculum changes in Illinois and other states, teachers should welcome the opportunity to reorganize science and other subject curricula to include worthwhile trends. Let us not waste this opportunity re-establishing old dogma.

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