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McKinney, Larry Lee

THE UNDERSTANDINGS OF THE NATURE OF SCIENCE, LEARNING IN SCIENCE AND SCIENCE TEACHING HELD BY OKLAHOMA PUBLIC SCHOOL ADMINISTRATORS

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THE UNDERSTANDINGS OF THE NATURE OF SCIENCE, LEARNING IN SCIENCE AND SCIENCE TEACHING HELD BY OKLAHOMA PUBLIC SCHOOL ADMINISTRATORS

A DISSERTATION

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LARRY L. McKINNEY

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THE UNDERSTANDINGS OF THE NATURE OF SCIENCE,
LEARNING IN SCIENCE AND SCIENCE TEACHING
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APPROVED BY

John D. Pulliam

Michael R. Alan

DISSERTATION COMMITTEE

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CHAPTER 1

CLASSROOM IMPLEMENTATION OF THE STRUCTURE OF SCIENCE

The responsibility of curriculum leadership in the school rests with those persons employed by the local Board of Education--the peoples' elected representatives--to implement its policies.[1] Those persons are employed as superintendents, principals, coordinators, department heads, and in other administrative-type roles.[2] Even if the curriculum responsibilities of the administration are passed on to an appointed committee of teachers, the administrator is still responsible to the Board of Education for the decisions and actions of that committee. The school administrator is the curriculum leader.

What types of understandings of curriculum do administrators need to enable them to make decisions which will provide students' classroom experiences which will lead those students to understand

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[1] _School Laws of Oklahoma_ (Oklahoma City: State Department of Education, 1978, Section 54), p. 44.

[2] _Annual Bulletin for Elementary and Secondary Schools_ (Oklahoma City: State Department of Education, 1978), p. 14.

the disciplines studied? That question should first be answered in terms applicable to any discipline. Because administrators are responsible for curriculum leadership, they must understand how each specific discipline is structured and how students learn. Only then can the foregoing question be answered for a specific discipline.

This researcher is interested in science. A specific response, therefore, will be developed to the foregoing question for the discipline of science. By definition, the administrator is responsible for the entire curriculum; that person must, therefore, understand how science is structured. Administrators must be able to inspect science curriculum guides and teaching materials and be able to decide if a teacher could teach from those items and lead students to understand science as that discipline is constructed. This research will provide data which will permit a decision to be made as to whether or not administrators have that competence.

<u>What is Science</u>?

How is science constructed? The best data resources to use in answering that question are scientists themselves. The nineteenth century French physicist and mathematician Jules Henri Poincare used an analogy in defining science. Poincare said, "Science is built up with facts, as a house is with stones, but a collection of facts is no more a science than a heap of stones is a house."[3] Science uses

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[3]Harry C. Kelly, <u>A Textbook in Electricity and Magnetism</u> (New York: John Wiley and Sons, Inc., 1941), p. 240.

facts, principles, laws, and generalizations that make up its content. But as Poincare said, that is not science. Science is something different. What is that "something different?"

Dr. Richard P. Feynman in an address delivered to the Fourteenth Annual Convention of the National Science Teachers Association spoke on "What is Science."[4] In his address he referred to the personal experiences that build his definition of science. As a young boy, Dr. Feynman's father would take him walking into the woods to learn about nature. As these trips were popular and fun, other children desired to go along, but the walks were kept private between Feynman and his father. The other children pressured their fathers to take them for walks. Later while playing, one boy, in some gesture to show what he had learned, commented,

> See the bird standing on the wheat there? What's the name of it? Dr. Feynman responded, "I haven't got the slightest idea." The boy said, "It's a brown-throated thrush. Your father doesn't teach you much about science." Dr. Feynman explained, "I smiled to myself, because my father had already taught me that that doesn't tell me anything about the bird. He taught me 'See that bird; it's a brown-throated thrush, but in Germany, it's called a Halzenflugel, and in Chinese they call it a Chung Ling--and if you know all those names for it, you still know nothing about the bird. You only know something about people; what they call that bird.'
>
> "Now that thrush sings, and teaches its young to fly, and flies so many miles away during the summer across the country, and nobody knows how it finds its way, and so forth. There is a difference between the name of the thing and what goes on."[5]

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[4]Dr. Richard P. Feynman, Professor of Physics, California Institute of Technology, Nobel Laureate, Physics, 1965. Address delivered to the Fourteenth Annual Convention, National Science Teachers Association, New York City, April 1-5, 1966.

[5]Ibid

Feynman points out that there is a difference between learning by memorizing names and learning by using the processes by which scientific knowledge is developed. He advocated an approach to learning that develops in students a spirit of inquisitiveness. Feynman would have allowed students to explore the things of the environment that were of interest to them and when guidance was sought by the students the accumulated values and knowledge of others would be interjected by such people as teachers or parents. In summary he said, "Science doesn't teach anything; experience teaches it."[6]

The Textbook

The one common major resource teachers use to teach a subject is the textbook. Traditionally the text is devoted primarily to giving information to be learned and sometimes it may read similar to an encyclopedia. The "experience" of the student is to read a question and to read the correct response often in the very next sentence. When activities are assigned, there may be no real reason for students to do activities because the text may have already explained the results. But there continues to be a reliance upon science textbooks for science investigations and knowledge. Dr. Albert Szent-Györgyi, Director of Research, Institute for Muscle Research, said, "Knowledge is a sacred cow, and my problem will be how we can milk her while keeping clear of her horns."[7] This research not only addresses the problems of

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[6] Ibid

[7] Albert Szent-Györgi, "Teaching and the Expanding Knowledge", Science, Volume 146, December 4, 1964, p. 1278.

science textbooks (where the milk for the "sacred cow" is stored) and the selection of the textbooks, but will also offer solutions to those problems.

In producing textbooks, publishers attempt to record information, facts, and ideas about a particular scientific concept. But those efforts can greatly confuse the readers about the nature of the discipline of science. Szent-Györgyi summarized that confusion like this.

> There is a widely spread misconception about the nature of books which contains knowledge. It is thought that such books are something the contents of which have to be crammed into our head. I think the opposite is closer to the truth. Books are there to keep the knowledge in while we use our heads for something better.[8]

The American Association for the Advancement of Sciences (AAAS) recently explained the relationship among facts, science, and books as follows:

> Although the facts . . . resulting from scientific studies can be learned from books, the processes and excitement inherent in science can be learned only through personal experiences so we know whereof we speak. Vicarious experiences are no substitute for sensing the phenomena of interest. Students . . . need direct satisfying experiences with phenomena which will often generate life-long interests. Science is an active endeavor in search of patterns and explanations.[9]

The AAAS makes it's position clear about the nature of science in the 1979 report by saying, "Without experience there is no science--especially for the novice."[10] Reading about science

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[8] Ibid

[9] Perspective on Science Education. Unpublished report of Section Q of the American Association for the Advancement of Science to the Board of Directors, April, 1979, p. 15.

[10] Ibid

and answering questions from a textbook do not teach the structure of science. Administrators must remember that without experience with the objects of the discipline, science is not being taught. The books purchased for use in science classes, therefore, must demand that experiences be had if those books are to be said to present science.

Science textbooks represent a wide range of emphases and knowledges and are justly criticized for limiting the students to being readers of science rather than "doers" of science. Frequently for students, science is reading about animals in the ocean, dinosaurs, and space. Those readings may have motivated students to make investigations, but many of those investigations are treated in textbooks as extra credit at the end of the chapter. There is little encouragement, therefore, for the student to make the investigation. Science textbooks in this sense have not been very affectively presenting the structure of science as explained by Feynman.

In the midst of textbooks and teaching is the scientist that desires to promote science as it should be. Dr. Duane Roller defined science as "a quest for knowledge, not the knowledge itself."[11] He is describing science as an act of searching to find or to obtain something, thereby implying that science is an activity that a person is engaged in. His "quest for knowledge" also implies that it is the

[11]Duane Roller, Has Science a Climate? (Oklahoma City: Sunday Oklahoman, February 22, 1970), p. 23.

processes one goes through to learn science and not the product that is important. The product of science, knowledge, is important, but it is cumulative and serves as the basis for further searching. Roller's statement is a summary of most explanations of the nature of science. That summary statement should influence science teaching and when it does, the current emphasis on reading about science and on the memorization of facts will be changed.

Pictures in the textbooks are more often used to institute for students doing experiments. Those pictures cannot provide the experience of what is meant by science. Traditional science courses are weak in providing the student a valid understanding of the "quest for knowledge." Since Roller, Feynman, and Szent-Györgyi have adequately defined the discipline of science around investigations, it is mandatory that administrators understand that aspect of the nature of science in order for them to select science learning materials including textbooks which reflect the nature of the discipline.

What is Learning?

At this point, administrators, textbooks, and the nature of science have been considered. Each different but each having a key role in the school curriculum. There is one unifying concept among people, materials, and philosophy as each is considered in relation to learning. Jerome Bruner has said that the single most characteristic thing about human beings is that they learn.[12]

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[12] Jerome S. Bruner, Toward a Theory of Instruction (New York: W. W. Norton & Co., Inc., 1966), p. 113.

What is learning? Because this research is interested in the discipline of science, a definition for learning science is provided.

Dr. Robert Karplus has described learning in three phases which he refers to as the learning cycle.[13] The phases, which are based on applied theories of how students learn, are exploration, invention, and discovery. In the exploration phase students explore materials provided them with guidance imposed in the form of instructions and specific questions. The materials are carefully chosen to provide the student experiences and background necessary for later questioning. After the student has explored the materials, the concepts associated with the experiences need to be introduced. That introduction, the second phase, conceptual invention by Karplus[14] and Piaget.[15] In most instances the student will be unfamiliar with the words or terms that describes the concept; therefore, the words must be provided for them. The third phase of the learning cycle, discovery, describes those activities in which a student broadens his understanding and/or applies the newly-experienced concept in a new situation. The student may also discover additional meanings associated with the concept or an alternative use for that concept.

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[13]Robert Karplus and Herbert D. Thier, A New Look at Elementary School Science (Chicago: Rand McNally & Co., 1967), p. 40.

[14]Ibid

[15]Jean Piaget, To Understand is to Invent (New York: Penguin Books, 1976)

The learning cycle applies to each learning situation. It is a methodology that involves students in their learning. As Roller indicated, it is a quest for knowledge, a search for information and understanding or more succintly--inquiry. The learning cycle is a procedure for searching--it is inquiry. The nature of science reflected by Roller and Feynman is that certain processes are used in developing concepts of science. This implies that if students are to understand science, they should learn science by using these processes.

In other words the concepts of science should be learned through inquiry. Research by Weber[16] and Schneider[17] suggest that the students gain a greater understanding of science concepts when presented through inquiry than when presented by traditional methods.

Inquiry will operate whenever students are in situations that arouses curiosity or excites them to continue to search for more information. It is a process similar to Feynman's walks into the woods where his father provided guided learning. His experiences were exploring the environment. As concepts were developed out of his explorations, he realized the importance of the things he experienced was secondary to what he knew about how things operated and to the processes he used.

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[16] M. C. Weber and John W. Renner, "How Effective is the SCIS Science Program?", School Science and Mathematics, Volume 72, Number 8, Whole 640, November, 1972, p. 729-734.

[17] Livingston Schneider and John W. Renner, "Concrete and Formal Teaching", Journal of Research in Science Teaching, in press.

CHAPTER 2

A COMPARISON OF WHAT WAS DONE

Saying that the textbook often dictates the school's curriculum is no exaggeration. When a school system adopts a text series, the publisher's scope and sequence charts usually become the course of study. But if science teaching is to reflect the nature of the discipline of science, the science textbook, therefore, should also reflects its nature. As we have previously seen from the scientists point of view, the nature of science is inquiry.

Role of OSTA in the Science Curriculum

In an effort to determine whether science textbooks do in fact reflect the nature of the discipline, the Educational Practices Committee of the Oklahoma Science Teachers Association (OSTA) identified and operationally defined educational practices to be used in textbook selection. That committee developed the following criteria to be used in evaluating textbooks:

1. Are the concepts in the textbook appropriate to developmental level of students?

2. Must the student use the processes of science? (Observing, measuring, interpreting, predicting, experimenting, model building)

3. Does the textbook require the student to use manipulative materials?

4. Are the student investigations designed to provide organized solutions to problems?

5. Does the textbook encourage answers to questions based on individual observations?

6. Is inquiry the predominant teaching method used in the textbook?

7. Can the student with a low reading ability be successful?

8. Do the materials appeal to the interest of the student?

9. Are adequate teaching aids available in the teacher's guide?[1]

Those criteria were first used to evaluate the textbooks offered to schools by publishers for adoption in 1973. Each of the foregoing nine criteria was to be scored with reference to a rating scale (+5, +4, +3, +2, +1, 0, -1, -2, -3, -4, -5) reflecting the extremes of complete inquiry and complete exposition. Inquiry[2] was defined as exploration, invention, and discovery (see Chapter One). Exposition[3] was defined as providing students information from various kinds of media--including the teacher--that was to be understood and remembered. From the rating scale, a score of +5 indicated complete inquiry and score of -5 indicated complete exposition. Each textbook received a score on each of the nine criteria and their scores were averaged to produce a mean score for each text. A score of +5 reflected complete inquiry on materials that will involve the student in inquiry and on particular components

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[1]Minutes of the meeting of the Educational Practices Committee, Oklahoma Science Teachers Association, Oklahoma City, Oklahoma, February 10, 1973.

[2]Ibid

[3]Ibid

such as reading level which teachers thought were important. The textbooks and their mean scores are listed in Tables 1 through 7 by subject matter area. The textbook which received the highest positive mean score using the OSTA criteria was ranked number one. The OSTA ranking of all the textbooks are given in Tables 1 through 7.

TABLE 1

TEXTBOOK RANKINGS BY OSTA-ELEMENTARY SCIENCE, GRADES K-6

Publisher	Mean	OSTA Rank
Houghton Mifflin Co.	4.3	1
Webster-McGraw Hill Co. (ESS)	3.6	2
Addison-Wesley	2.8	3
Webster-McGraw Hill Co. (PCP)	2.2	4
Rand McNally	1.5	5
American Book Co.	1.2	6
Silver Burdett and Co.	.42	7
Harcourt, Brace & Jovanovich	.26	8
Holt, Rinehart & Winston	.24	9
Harper and Row	- .27	10
Ginn and Co.	- .29	11
Laidlaw Brothers	- .91	12
Charles E. Merrill & Co.	-1.1	13
D. C. Heath	-1.6	14

TABLE 2

TEXTBOOK RANKINGS BY OSTA-LIFE SCIENCE, GRADES 7, 8, 9

Publisher	Mean	OSTA Rank
Prentice Hall & Co.	4.5	1
Rand McNally	3.9	2
Houghton Mifflin Co.	3.9	2
Pawnee	3.4	3

"TABLE 2 - Continued."

Publisher	Mean	OSTA Rank
Allyn & Bacon	2.3	4
Charles E. Merrill & Co.	1.9	5
Webster-McGraw Hill Co.	1.8	6
Ginn and Co.	1.7	7
Addison-Wesley	1.6	8
Harper and Row	.21	9
J. B. Lippincott	- .22	10
Harcourt, Brace & Jovanovich	- .41	11
American Book Co.	- .53	12
Laidlaw Brothers	-1.7	13
Holt, Rinehart & Winston	-2.4	14

TABLE 3

TEXTBOOK RANKINGS BY OSTA-EARTH SCIENCES, GRADES 7, 8, 9

Publisher	Mean	OSTA Rank
Prentice Hall & Co.	4.7	1
Rand McNally	3.0	2
Addison-Wesley	1.7	3
Allyn & Bacon	1.5	4
Ginn and Co.	1.3	5
Charles E. Merrill & Co.	1.1	6
J. B. Lippincott	.92	7
Harcourt, Brace & Jovanovich	.89	8
Webster-McGraw Hill Co.	.43	9
American Book Co.	.13	10
Harper and Row	- .12	11
Laidlaw Brothers	- .98	12
Holt, Rinehart & Winston	-1.7	13

TABLE 4

TEXTBOOK RANKINGS BY OSTA-PHYSICAL SCIENCE, GRADES 7, 8, 9

Publisher	Mean	OSTA Rank
Prentice Hall & Co.	4.7	1
Rand McNally	3.0	2
Addison-Wesley	1.7	3
Allyn & Bacon	1.5	4
Ginn and Co.	1.3	5
Charles E. Merrill & Co.	1.1	6
J. B. Lippincott	.92	7
Harcourt, Brace & Jovanovich	.89	8
Webster-McGraw Hill Co.	.43	9
American Book Co.	.13	10
Harper and Row	- .12	11
Laidlaw Brothers	- .98	12
Holt, Rinehart & Winston	-1.7	13

TABLE 5

TEXTBOOK RANKINGS BY OSTA-BIOLOGY 1, HIGH SCHOOL

Publisher	Mean	OSTA Rank
Rand McNally	3.7	1
Harcourt, Brace & Jovanovich	3.2	2
Houghton Mifflin Co.	2.5	3
Charles E. Merrill & Co.	2.1	4
American Book Co.	2.0	5
Prentice Hall & Co.	1.8	6
Holt, Rinehart & Winston	1.3	7
Allyn & Bacon	.52	8
Silver Burdett and Co.	.05	9
Addison-Wesley	- .53	10

TABLE 6

TEXTBOOK RANKINGS BY OSTA-CHEMISTRY I. HIGH SCHOOL

Publisher	Mean	OSTA Rank
Harcourt, Brace & Jovanovich	2.2	1
Addison-Wesley	2.1	2
Prentice Hall & Co.	2.1	2
D. C. Heath	1.7	3
Holt, Rinehart & Winston	1.0	4
Houghton Mifflin Co.	.78	5
Silver Burdett and Co.	.63	6
Charles E. Merrill & Co.	.42	7
Allyn & Bacon	- .1	8
American Book Co.	- .5	9

TABLE 7

TEXTBOOK RANKINGS BY OSTA-PHYSICS, HIGH SCHOOL

Publisher	Mean	OSTA Rank
Prentice Hall & Co.	2.9	1
D. C. Heath	2.7	2
Addison-Wesley	2.1	3
Silver Burdett and Co.	1.9	4
Charles E. Merrill & Co.	1.6	5
Holt, Rinehart & Winston	1.6	5
Lyons and Carnahan	1.6	5
American Book Co.	.87	6
Allyn & Bacon	.49	7
Benziger	- .83	8

Textbook Purchasing

In Oklahoma providing textbooks for students is a state responsibility. Textbooks are made available to schools through the State Textbook Commission. That Commission is served by a Governor-appointed board who selects the textbooks that are made available to the schools. The Commission, or its designated representatives, selects the textbooks for all content areas. Schools then receive a list of texts which can be purchased with state funds. If books other than those on the list are used by a school, state textbook funds may not be used to purchase them. The official textbook list of the State, therefore, is a potent curriculum-controlling force in the State of Oklahoma.

Science textbooks adopted in 1973 were purchased in 1974. Data for the 1974 purchases provided by the State Textbook Commission are in Tables 8 through 15. In addition to the total number of textbooks sold and the percentages of textbooks sold by each publisher in each subject area, the tables include the ranking provided by the OSTA of each textbook (refer to Tables 1 through 7).

TABLE 8

ELEMENTARY SCIENCE TOTAL NUMBER TEXTBOOKS SOLD 246,102

Publisher	% of Total Purchased	OSTA Rank
Addison-Wesley	33	3
Laidlaw Brothers	17	12
Harcourt, Brace & Jovanovich	14	8
Houghton Mifflin Co.	13	1
Silver Burdett and Co.	10	7
Harper and Row	7	10
American Book Co.	6	6

TABLE 9

LIFE SCIENCE, TOTAL NUMBER TEXTBOOKS SOLD 32,305

Publisher	% of Total Purchased	OSTA Rank
Charles E. Merrill and Co.	35	5
Harcourt, Brace & Jovanovich	31	11
Harper and Row	10	9
Prentice Hall & Co.	8	1
J. B. Lippincott	8	10
Webster-McGraw Hill Co.	6	6
Addison-Wesley	2	8

TABLE 10

EARTH SCIENCE, TOTAL NUMBER TEXTBOOKS SOLD 25,865

Publisher	% of Total Purchased	OSTA Rank
Charles E. Merrill and Co.	34	6
Harcourt, Brace & Jovanovich	26	8
Houghton Mifflin Co.	16	3
J. B. Lippincott	12	10
Harper and Row	9	9
American Book Co.	2	4
Addison-Wesley	1	7

TABLE 11

PHYSICAL SCIENCES, TOTAL NUMBER OF TEXTBOOKS SOLD 26,162

Publisher	% of Total Purchased	OSTA Rank
Charles E. Merrill & Co.	31	6
Holt, Rinehart & Winston	18	13
J. B. Lippincott	13	7

"TABLE 11, Continued."

Publisher	% of Total Purchased	OSTA Rank
Harcourt, Brace & Jovanovich	12	8
Laidlaw Brothers	11	12
Prentice Hall & Co.	9	1
Harper and Row	6	11

TABLE 12

BIOLOGY, TOTAL NUMBER TEXTBOOKS SOLD 45,583

Publisher	% of Total Purchased	OSTA Rank
Holt, Rinehart & Winston	48	7
Rand McNally	13	1
Charles E. Merrill & Co.	11	4
Harcourt, Brace & Jovanovich	9	2
Silver Burdett and Co.	8	9
Prentice Hall & Co.	6	6
Houghton Mifflin Co.	5	3

TABLE 13

PHYSICS, TOTAL NUMBER TEXTBOOKS SOLD 4,669

Publisher	% of Total Purchased	OSTA Rank
Holt, Rinehart & Winston	55	5
Charles E. Merrill & Co.	16	5
D. C. Heath	10	2
Silver Burdett and Co.	8	4
Addison-Wesley	5	3
Prentice Hall & Co.	3	1
Lyons & Carnahan	3	5

TABLE 14

CHEMISTRY, TOTAL NUMBER TEXTBOOKS SOLD 11,073

Publisher	% of Total Purchased	OSTA Rank
Holt, Rinehart & Winston	53	4
Houghton Mifflin Co.	17	5
Charles E. Merrill & Co.	16	7
D. C. Heath	5	3
Harcourt, Brace & Jovanovich	5	1
Addison-Wesley	4	2
Prentice Hall & Co.	1	2

Statement of the Problem

In several instances textbooks ranked in the top seven by OSTA did not make the official Oklahoma textbook list. When the top three ranked textbooks by OSTA are compared with the top three textbooks purchased by schools the percentage of OSTA recommended texts to adopted texts in Elementary Science was 43%; at the secondary science level, 27%; Biology; 18%, Physics, 16%, Earth Sciences; 15%, Chemistry; 9%, Physical Science; 8%, Life Science. These data indicated that those science textbooks most highly recommended by the Oklahoma Science Teachers Association were not those widely selected by the schools. The OSTA lists reflected what science is according to Roller, Feynman, and Szent-Györgyi. Observations of the purchasing patterns of science textbooks were not consistent with the OSTA recommended list.

There are several hypotheses which could account for the observed discrepancies. Administrators could be delegating their responsibilities for selecting science textbooks and those persons delegated did not understand the nature of science. Perhaps there were factors influencing the administrator that led to the purchasing of science textbooks that did not represent science. This study, however, investigated another possible reason for the discrepancies found between the books recommended by the OSTA and those purchased by schools. A hypothesis was formed that those administrators selecting the science textbooks did not know or were not sure what science is, how science is learned and how science should be taught to reflect the discipline of science.

Literature Review

A thorough review of the literature was essential to the development of the problem. ERIC type descriptors was compiled to communicate to the search procedure the information desired. The descriptors were the nature of science, learning science and science teaching, administrators, principals, superintendents, curriculum supervisors, science educators. The descriptors were fed into computers having several resources available such as the ERIC, Lockheed and Rockwell data banks. A total of three searches was implemented. No studies were located deemed relative to the descriptors. A review of the Dissertation abstracts also revealed that no studies have been done related to the present study. Using the same descriptors, a thorough search in the Education Index revealed no related research.

Quite apparently when the descriptors obtained from the problem statement are used, no completed research can be found which relates directly to the present study.

CHAPTER 3

THE 1977 EXAMINATION AND ADOPTION CYCLE

Science adoptions are made on a cyclical basis; they were adopted in 1973 and again in 1977. Between those two dates, one significant change was made in the adoption policies established by the Oklahoma State Textbook Commission. In 1977, a ten book adoption replaced the seven book adoption list of 1973. As in 1973, the Educational Practices Committee of the Oklahoma Science Teachers Association (OSTA) arranged a second textbook examination opportunity for science teachers; they were to examine and evaluate the science textbooks being considered for the 1977 adoption. The criteria, listed in Chapter 2 (pages 11 and 12) used to evaluate the textbooks during the 1973 examination, were reviewed and modified. Criterion eight was modified to read, "Do the concepts and materials appeal to the students' interest?" Criterion ten was added, "Is the text operationally independent of supportive printed materials?" The scoring procedure used by the examiners in 1977 was the same as that used in 1973, that is, the rating scale used--+5, +4, +3, +2, +1, 0, -1, -2, -3, -4, -5--reflected the extremes from complete inquiry to complete exposition. Each textbook received a score on each of the ten criterion used in the evaluation and the scores were averaged to produce a mean score for each text. The textbooks are listed by subject matter area and their mean scores in Tables 15 through 26.

TABLE 15

TEXTBOOK RANKINGS BY OSTA-ELEMENTARY SCIENCE, GRADES K-6

Publisher	Mean	OSTA Rank
MacMillan Publishing Co.	3.6	1
Addison-Wesley	3.6	1
Houghton Mifflin Co.	3.4	2
J. B. Lippincott	2.1	3
Harcourt, Brace & Jovanovich	1.0	4
Ginn and Co.	.4	5
Silver Burdett and Co.	.1	6
Laidlaw Brothers	- .4	7

TABLE 16

TEXTBOOK RANKINGS BY OSTA-LIFE SCIENCE, GRADES 7, 8, 9

Publisher	Mean	OSTA Rank
Prentice Hall & Co.	3.2	1
Laidlaw Brothers	2.9	2
John Wiley and Sons, Inc.	2.8	3
Steck Vaughn Co.	2.8	3
Rand McNally	2.7	4
Charles E. Merrill & Co.	2.5	5
Webster-McGraw Hill Co.	2.3	6
Ginn and Co.	2.3	6
J. B. Lippincott	2.0	6
Harcourt, Brace & Jovanovich	1.8	8
Allyn-Bacon	1.0	9

TABLE 17

TEXTBOOK RANKINGS BY OSTA-EARTH SCIENCE, GRADES 7, 8, 9

Publisher	Mean	OSTA Rank
Prentice Hall & Co.	4.0	1
Charles E. Merrill & Co.	2.8	2
Houghton Mifflin Co.	2.7	3
Rand McNally	2.3	4
Steck Vaughn Co.	2.0	5
J. B. Lippincott	.6	6
Harcourt, Brace & Jovanovich	.6	6
Laidlaw Brothers	.3	7
American Book Co.	-1.1	8

TABLE 18

TEXTBOOK RANKINGS BY OSTA-PHYSICAL SCIENCE, GRADES 7, 8, 9

Publisher	Mean	OSTA Rank
Prentice Hall & Co.	3.3	1
Steck Vaughn Co.	2.5	2
Laidlaw Brothers	2.4	3
Ginn and Co.	2.0	4
Rand McNally	1.9	5
Charles E. Merrill & Co.	1.8	6
Allyn-Bacon	1.7	7
Harcourt, Brace & Jovanovich	1.6	8
Houghton Mifflin Co.	1.6	8
J. B. Lippincott	.7	9

TABLE 19

TEXTBOOK RANKINGS BY OSTA-SCIENCE SERIES, GRADES 7-9

Publisher	Mean	OSTA Rank
Silver Burdett and Co.	4.1	1
Houghton Mifflin Co.	2.8	2
Rand McNally	2.4	3
Charles E. Merrill & Co.	1.6	4

TABLE 20

TEXTBOOK RANKINGS BY OSTA-GENERAL SCIENCE, HIGH SCHOOL

Publisher	Mean	OSTA Rank
Ginn and Co. (ISIS)	3.8	1
Prentice Hall & Co.(IIS - Biology)	2.7	2
Prentice Hall & Co.(Contours)	1.8	3

TABLE 21

TEXTBOOK RANKINGS BY OSTA-BIOLOGY, HIGH SCHOOL

Publisher	Mean	OSTA Rank
Harcourt, Brace & Jovanovich	3.1	1
Allyn-Bacon	3.1	1
Rand McNally	2.6	2
Charles E. Merrill & Co.	2.4	3
Allyn-Bacon	2.2	4
Prentice Hall & Co.	2.2	4
Silver Burdett and Co.	1.8	5
Holt, Rinehart & Winston	1.7	6
Ginn and Co.	1.2	7

TABLE 22

TEXTBOOK RANKINGS BY OSTA-BIOLOGY II, HIGH SCHOOL

Publisher	Mean	OSTA Rank
Harcourt, Brace & Jovanovich	2.6	1
Prentice Hall & Co.	2.5	2
John Wiley and Sons, Inc.	.5	3

TABLE 23

TEXTBOOK RANKINGS BY OSTA-CHEMISTRY I, HIGH SCHOOL

Publisher	Mean	OSTA Rank
Prentice Hall & Co.	3.5	1
Addison-Wesley	3.1	2
Houghton Mifflin Co.	3.2	3
Charles E. Merrill & Co.	1.8	4
Houghton Mifflin Co.	1.8	4
D. C. Heath	1.8	4
Prentice Hall & Co.	1.4	5
Allyn-Bacon	1.4	5

TABLE 24

TEXTBOOK RANKINGS BY OSTA-CHEMISTRY II, HIGH SCHOOL

Publisher	Mean	OSTA Rank
Harper and Row	1.5	1
Webster-McGraw Hill Co.	.8	2
John Wiley and Sons, Inc.	- .7	3
Holt, Rinehart & Winston	NA	NA *

*Not available for examination

TABLE 25

TEXTBOOK RANKINGS BY OSTA-PHYSIOLOGY, HIGH SCHOOL

Publisher	Mean	OSTA Rank
Holt, Rinehart & Winston	2.3	1
John Wiley and Sons, Inc.	.9	2
Webster-McGraw Hill, Gregg Division	- .1	3

TABLE 26

TEXTBOOK RANKINGS BY OSTA-PHYSICS, HIGH SCHOOL

Publisher	Mean	OSTA Rank
Charles E. Merrill & Co.	2.6	1
Holt, Rinehart & Winston	2.4	2
Addison-Wesley	2.3	3
Houghton Mifflin Co.	2.3	3
Holt, Rinehart & Winston	1.9	4
Prentice Hall & Co.	1.8	5
Allyn-Bacon	1.8	5
Silver Burdett and Co.	1.0	6

Textbook Purchasing Patterns

The science textbooks adopted in 1977 were available to schools for purchase beginning in 1978. Data showing the purchases of science textbooks through the State Textbook Commission are shown in Tables 28 through 38. The tables show the total number of textbooks sold and the percentages of textbooks sold in each subject area by publisher. They show the rankings of each textbook by OSTA. (Refer to Tables 15 through 27). Comparing the 1973 data of science textbooks purchased with the 1977 data, one outstanding difference was evident. (During that period the number of books which could appear on the approved list was raised from seven to ten.) Nearly all of those ranked by the OSTA in 1977 appear on the adopted list; that was not true in 1973. The top three textbooks ranked by OSTA were compared with the top three textbooks purchased by schools. The percentages of OSTA recommended textbooks to those purchased was: Elementary Science, 10%; at the secondary level, Life Science, 19.1%; Earth Science, 62.7%; Physical Science, 15.8%; Science Series, 29.5%; Junior High School General Science, 14.8%; Biology, 10.3%; Chemistry, 11.8%; Physics, 31.4%; High School General Science, 72.4%; Physiology, 100%.

TABLE 27

ELEMENTARY SCIENCE GRADES 1-6, TOTAL NUMBER OF TEXTBOOKS SOLD 150,938

Publisher	% of Total	OSTA Rank
Silver Burdett and Co.	43	7
Laidlaw Brothers	20	8
Harcourt, Brace & Jovanovich	18	5
Ginn and Co.	8	6
Addison-Wesley	5	2
MacMillan	4	1
Houghton Mifflin Co.	1	3
J. B. Lippincott	1	4

TABLE 28

LIFE SCIENCE GRADES 7, 8, 9, TOTAL NUMBER OF TEXTBOOKS SOLD 26,754

Publisher	% of Total	OSTA Rank
Charles E. Merrill & Co.	51	6
Laidlaw Brothers	15	2
Webster-McGraw Hill Co.	13	7
Harcourt, Brace & Jovanovich	7	10
Prentice Hall & Co.	4	1
J. B. Lippincott	3	9
Houghton Mifflin Co.	3	NA*
Ginn & Co.	2	8
Allyn-Bacon	1	11
Rand McNally	1	5

TABLE 29

EARTH SCIENCE GRADES 7, 8, 9, TOTAL NUMBER OF TEXTBOOKS SOLD 22,145

Publisher	% of Total	OSTA Rank
Charles E. Merrill & Co.		2
Laidlaw Brothers		8
Harcourt, Brace & Jovanovich		7
American Book Co.		9
Houghton Mifflin Co.		3
Allyn-Bacon		NA
J. B. Lippincott		6
Prentice Hall & Co.		1
Rand McNally		4
Steck Vaughn		5

*The textbook was not available for examination.

TABLE 30

PHYSICAL SCIENCE, GRADES 7, 8, 9, TOTAL NUMBER OF TEXTBOOKS SOLD 21,115

Publisher	% of Total	OSTA Rank
Charles E. Merrill & Co.		6
Holt, Rinehart & Winston		NA
Laidlaw Brothers		3
J. B. Lippincott		10
Harcourt, Brace & Jovanovich		8
Houghton Mifflin Co.		9
Prentice Hall & Co.		1
Allyn-Bacon		7
Ginn & Co.		4
Rand McNally		5

TABLE 31

SCIENCE SERIES, GRADES 7-9, TOTAL NUMBER OF TEXTBOOKS SOLD 14,223

Publisher	% of Total	OSTA Rank
Charles E. Merrill & Co.	70	4
Rand McNally	16	3
Silver Burdett and Co.	13	1
Houghton Mifflin	1	2

TABLE 32

GENERAL SCIENCE, HIGH SCHOOL, TOTAL NUMBER OF TEXTBOOKS SOLD 3,319

Publisher	% of Total	OSTA Rank
Scott Foresman	85	NA
Prentice Hall & Co. (115)	6	2
Prentice Hall & Co. (Contours)	6	3
Ginn & Co. (ISIS)	3	1

TABLE 33

BIOLOGY, HIGH SCHOOL, TOTAL NUMBER OF TEXTBOOKS SOLD 27,061

Publisher	% of Total	OSTA Rank
Holt, Rinehart & Winston		8
Charles E. Merrill & Co.		4
Rand McNally		3
Prentice Hall & Co.		6
Silver Burdett and Co.		7
Allyn-Bacon		5
Ginn & Co.		9
Harcourt, Brace & Jovanovich		1
Harcourt, Brace & Jovanovich		NA
Prentice Hall & Co.		NA
Allyn-Bacon		2

TABLE 34

CHEMISTRY, HIGH SCHOOL, TOTAL NUMBER OF TEXTBOOKS SOLD 8,211

Publisher	% of Total	OSTA Rank
Holt, Rinehart & Winston	49	NA
Silver Burdett and Co.	13	NA
Charles E. Merrill & Co.	9	4
Prentice Hall & Co.	7	7
Houghton Mifflin Co.	6	5
Houghton Mifflin Co.	5	3
Addison-Wesley	4	2
Allyn-Bacon	3	8
Prentice Hall & Co.	3	1
D. C. Heath	1	6

TABLE 35

CHEMISTRY II, HIGH SCHOOL, TOTAL NUMBER OF TEXTBOOKS SOLD 1,000

Publisher	% of Total	OSTA Rank
Holt, Rinehart & Winston	55	NA
Harper and Row	30	1
Webster-McGraw Hill Co.	15	2
John Wiley & Sons, Inc.	0	3

TABLE 36

PHYSICS, HIGH SCHOOL, TOTAL NUMBER OF TEXTBOOKS SOLD 2,682

Publisher	% of Total	OSTA Rank
Holt, Rinehart & Winston	54	4
Charles E. Merrill & Co.	27	1
Houghton Mifflin Co.	6	3
Allyn-Bacon	5	5
Prentice Hall & Co.	3	5
Addison-Wesley	3	3
Holt, Rinehart & Winston (P.P.)	1	2
Silver Burdett and Co.	1	6

TABLE 37

GENERAL SCIENCE, HIGH SCHOOL, TOTAL NUMBER OF TEXTBOOKS SOLD 2,081

Publisher	% of Total	OSTA Rank
Houghton Mifflin Co.	65.7	1
Addison-Wesley	15.9	4
Silver Burdett and Co.	9.5	5
Prentice Hall & Co.	6.7	2
Webster-McGraw Hill Co.	2.2	6

TABLE 38

PHYSIOLOGY, HIGH SCHOOL, TOTAL NUMBER OF TEXTBOOKS SOLD 2,361

Publisher	% of Total	OSTA Rank
Holt, Rinehart & Winston	77.9	1
John Wiley and Sons, Inc.	12.8	2
Gregg Division	9.4	3

Restating the Hypothesis

The 1978 data indicated that those science textbooks most highly recommended by OSTA were not those being purchased for adoption in the schools. The data of the 1977 OSTA examination and the purchasing patterns of science textbooks in 1978 compared closely with the data of the 1973 OSTA examination and the purchasing patterns of science textbooks in 1974. The similarity in the data reinforced the observation that there was a descrepancy in those science textbooks being purchased and in those being recommended by science educators. The data reflected that very little change occurred at the decision making level for the choice of science texts between 1973 and 1977. The hypothesis proposed earlier regarding the attitudes of school administrators is retained and the investigation of this problem begins in the following chapter.

CHAPTER 4

SAMPLE AND THE INSTRUMENT

Introduction

School administrators were chosen for this study because they have the responsibility for making decisions that effect the school's curriculum. As the schools' curriculum leader, the administrator must ensure the selection and purchase of textbooks that represent the academic disciplines that were offered to students. This was a study of the attitudes of administrators about the nature of science, the nature of learning science, and the nature of science teaching.

In order to secure data about the attitudes of administrators, two tasks were necessary. The first of which was to determine the size of the sample of school administrators necessary to make valid generalizations from the sample to the population; and secondly, it was necessary to develop and validate an instrument that would collect data on the attitudes of the administrators about the nature of science, the nature of learning science and the nature of science teaching.

The Sample

The sampling procedure used for this study reflected that used by the Oklahoma State Department of Education[1] in which the optimum sample level of school administrators had been set at 7 percent. To assure a 7 percent return for this study, more than 10 percent of the 2,239 school administrators were sampled. Because the numbers of administrators were different at the various grade levels, a stratified, proportional, random sampling was made of superintendents, high school principals, middle-junior high school principals and elementary school principals. The sample included: a) 46 superintendents; b) 48 high school principals; c) 36 middle-junior high school principals; and d) 110 elementary school principals, for a total of 240 administrators. The number of completed returns were: a) 34 superintendents; b) 40 high school principals; c) 20 middle-junior high school principals; and d) 60 elementary school principals, for a total of 154, or 64 percent of the total sampled and 6.9 percent of the total population of Oklahoma school administrators.

Construction and Validation of the Instrument

To ascertain the attitudes of the sample of administrators about the nature of science, the nature of learning science, and the nature of science teaching, an instrument--The Science Attitude Inventory (SAI)--was constructed. The purpose of the SAI was to

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[1] Oklahoma Educational Status Study, School Year 1978-79, State Department of Education, Oklahoma City, Oklahoma, 1979, p. 3.

gather data on the opinions of school administrators towards the nature of science, the type of science teaching needed to teach the nature of science, the nature of learning science and the relationships among science, science learning and science teaching. The foregoing universe of content was established from the publications The Improvement of Science Instruction in Oklahoma, Grades K/6, 1971[2] and The Improvement of Science Instruction, Grades 7/12, 1970[3]. Those publications were used to construct the SAI and to establish content validity of the SAI. The SAI was constructed from the content of the publications which were related to the different aspects of the constructs of the nature of science, the nature of learning science and the nature of science teaching. Twenty-six statements were compiled to become the first version of the SAI (Appendix A). The statements were numbered and columns of strongly agree, agree, neutral, disagree, strongly disagree were provided for the respondents to mark in. The construction of the SAI was similar to a Likert scale with the columns scored as follows: (strongly agree) 5; (agree) 4; (neutral) 3; (disagree) 2; and (strongly disagree) 1. The scale ascertains a degree of intensity

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[2] The Improvement of Science Instruction in Oklahoma, Grades K/6, State Department of Education, Oklahoma City, Oklahoma, 1971.

[3] The Improvement of Science Instruction in Oklahoma, Grades 7/12, State Department of Education, Oklahoma City, Oklahoma, 1970.

felt about a statement and enabled relationships between statements to be identified. To improve clarity and understanding of the statements, the inventory was given an experimental trial in three graduate level education administration classes at the University of Oklahoma, and it was mailed to 37 members of the National Association of Research in Science Teaching (NARST) for their comments. All comments, verbal and written from administrators in the education classes and from members of the NARST, were used to modify the statements and to eliminate any statements deemed unnecessary A representative of NARST suggested a change in the scale to include a column for those respondents who choose to mark a statement uncertain. The neutral column was retained because a respondent may have a neutral attitude about a statement that he/she understood The statements were revised and compiled into an Inventory of sixteen statements in a Likert-type scale with the scoring of: strongly agree, 5; agree, 4; neutral, 3; disagree, 2; strongly disagree, 1; uncertain, 0. Data on the sixteen statements were needed to see if the statements measured what they were intended to measure--that is did the statements reflect the nature of science, the nature of learning science and the nature of science teaching, and did the statements distinguish between the attributes of inquiry and exposition with relation to science education. A group of educators with known attitude characteristics (criterion group) was needed. Thirty-seven members of the NARST whose writings, public statements, and other professional activities had demonstrated that they understood the differences and similarities between the inquiry and exposition teaching models were selected as the criterion group. The thirty-seven science educators selected were judged to be a competent group to distinguish between the attributes of inquiry and exposition with relation to science, learning science and science teaching.

Two copies of the SAI containing sixteen statements (Appendices C & D) were mailed to the science educators on the first copy of the SAI they were asked to mark their attitude towards each statement and on the second copy of the SAI they were asked to rate each statement according to their opinion of whether the statement represented inquiry or exposition. The constructs of inquiry and exposition were defined for respondents (refer to to Appendix E). Defining inquiry and exposition was an essential procedure for establishing criterion validity.

From the first copy of the SAI, the responses of the science educators' attitudes were compiled into a frequency chart (Appendix F). Statement 15 showed a wide range of responses indicating that the question was ambiguous and did not allow the respondent a choice of distinguishing characteristics. Statement 15 was dropped from future analysis. Two statistical analyses were carried out. These were an intercorrelation analysis and a principal components analysis.

A. Intercorrelation Analysis

To determine whether or not a statement reflected the constructs of the nature of science, learning science, and science teaching, the degree of certainty of the science educators about how they felt about each statement was analyzed. Scoring the SAI required specific instructions. A high scale score was used to indicate inquiry statements whereas statements scored low were interpreted to indicate exposition statements.

Statements 1, 2, 3, 4, 7, 9, 11, 13, 14 were scored as the science educators had marked them, however, the scoring for statements 5, 6, 8, and 12 had to be reversed to show agreement with the concept of exposition. The science educators' scores were reversed before they were punched on the data cards.

To establish the criterion validity of the SAI, a point-biserial correlation was chosen. The correlations demonstrated whether the science educators were certain or uncertain in their attitudes about each statement. (The second copy of the SAI was completed by the NARST sample). To obtain a correlation, the statements were scored in the following way: all of the statements were scored "one" that received a rating whether strongly agree, agree, neutral, disagree, or strongly disagree and were put into the category of certain. A statement rated uncertain received a score of zero. The uncertain/certain scores for each statement were totalled for science educators and then correlated against the mean score from all of the science educators for that particular statement. The higher the correlation coefficient the more certain were the science educators about their answers for a particular statement. For example, if a science educator scored statement number one as strongly agree, then that statement was scored one. If the science educator scored statement number one uncertain, then that statement was scored zero. If all of the science educators scored statement number one as certain, then statement number one would have a mean of one. If all science educators scored all statements certain, the mean score for the fifteen statements of the SAI would be fifteen. However, this was not the case. Therefore, some variance occured from which correlation coefficients could be established. The correlation coefficients found are shown in Table 39.

TABLE 39

POINT-BISERIAL CORRELATION COEFFICIENTS BETWEEN STATEMENT SCORE AND CERTAIN/UNCERTAIN RESPONSE SCIENCE EDUCATORS N=25

Statement	Correlation Coefficient
1	.99
2	.69
3	.99
4	.99
5	.99
6	.99
7	.99
8	.99
9	.99
10	.06
11	.99
12	.69
13	.99
14	.99
15	Discarded by frequency distribution (Appendix F)
16	-.06

Statements one through nine and eleven through fourteen in Table 39 showed high coefficients indicating that the science educators were highly certain about their answers. Statements ten and sixteen showed low coefficients indicating that the science educators were highly uncertain about the information in the statements, that they had an unenthusiastic response about the statement or that it was ambiguous and were dropped from the SAI. Therefore, statements one through nine and eleven through fourteen constituted the SAI which was used to gather data from the school administrators which became the basis of the research. The criterion validity of the SAI was established through the foregoing procedures and, therefore, considered an adequate content measure of the nature of science, learning science and science teaching.

Data from the second copy of the SAI were needed to show whether a statement was oriented towards inquiry or exposition. The purpose of asking the science educators to rate the statements inquiry or exposition was to identify the specific constructs of inquiry and exposition science, inquiry and exposition learning science and inquiry and exposition science teaching. According to the data in Table 40, the science educators rated statements 1, 2, 3, 4, 7, 9, 11, 13 and 14 inquiry and statements 5, 6, 8 and 12 exposition.

TABLE 40

RATINGS RAW DATA: INQUIRY-EXPOSITION, N=25

Statement:	Raw Data Inquiry	Raw Data Exposition	Percent Inquiry	Percent Exposition
1	25	0	100	0
2	20	5	80	20
3	24	1	96	4
4	17	8	68	32
5	0	25	0	100
6	1	24	4	96
7	25	0	100	0
8	0	25	0	100
9	25	0	100	0
11	25	0	100	0
12	8	17	32	68
13	25	0	100	0
14	24	1	96	4

The data in Table 40 demonstrates that nine inquiry-rated statements represented attributes of inquiry science, inquiry learning science and inquiry science teaching and the four exposition-rated statements represented attributes of exposition science, exposition learning science and exposition science teaching.

The SAI consists of thirteen criterion validated statements rated inquiry or exposition (Appendix G). The SAI was also recognized to have face and content validity because the thirteen statements were compiled from information contained in the professional science education publications The Improvement of Science Instruction in Oklahoma, Grades K/6[4] and The Improvement of Science Instruction in Oklahoma, Grades 7/12[5].

B. Principal Components Analysis

The SAI of statements contained specific terms or components about the nature of science, the nature of learning and the nature of science teaching. These components represented constructs that defined the nature of science, learning science and science teaching. The principal components analysis is a statistical method used to reduce the number of components into a smaller number of factors and to produce composite scores which represent underlying constructs in a group of statements. Some components will have greater influence upon the derived factors than others, but basically the number of variables represented by the thirteen SAI statements can be reduced using the principal components analysis with little loss of information. The analysis produces a pattern of weights on the variables based upon the scores of the respondents to the statements. The weights

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[4] The Improvement of Science Instruction in Oklahoma, Grades K/6, State Department of Education, Oklahoma City, Oklahoma, 1971.

[5] The Improvement of Science Instruction in Oklahoma, Grades 7/12, State Department of Education, Oklahoma City, Oklahoma, 1970.

of the combined variables account for an amount of a variance combined into a single score or factor loading. A greater percentage of variance is captured where the factors are closely related to each other. Where little variance is captured, little relationship between the variables is exhibited. The data from the science educators' responses to the SAI were computer analyzed using the program entitled, "Principal Factoring Without Iteration."[6] The results of that analysis demonstrated that four factors with eigenvalues[7] greater than unity were found. The procedure of using only eigenvalues greater than unity to isolate the principal factors in data has been established by Kaiser.[8] According to Amick and Walberg[9], "Unless the first three of four components are sufficient to capture more than 70 percent of the variance, there is little reason for using principal components." Since the data in Table 41 show that the first four factors accounted for 73.8 percent of the variance, the principal components analysis can be interpreted to have established the construct

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[6]Norman H. Nie, et. al., Statistical Package for the Social Studies, Second Edition, New York, McGraw-Hill Book Co., 1975, p. 479-480.

[7]The term "eigenvalue" is essentially synonymous with the terms root, latent root or characteristic root commonly used in a branch of matrix algebra. Eigenvalues represents variances of the principal components.

[8]H. F. Kaiser, "The Application of Electronic Computers to Factor Analysis, Educational and Psychological Measurement, 1960, Vol. 20, p. 141-151.

[9]D. J. Amick and H. J. Walberg, Introductory Multivariate Analysis for Educational, Psychological and Social Research, Berkeley, California, McCutchan Publishing Corp., 1975, p. 119-130.

validity of the thirteen items of the SAI. The reversal of scoring of the Likert-type scale explained on page 36 was not used for the principal components analysis.

TABLE 41

SCIENCE EDUCATORS

PRINCIPAL COMPONENTS ANALYSIS, N=25

Factor	% Variance	Eigenvalue	Cumulative Percentage
1	31.2	4.0	31.2
2	18.8	2.4	49.9
3	13.3	1.7	63.3
4	10.6	1.4	73.8

In addition to isolating the four factors shown in Table 41, the principal components analysis also--through a statistical procedure called varimax rotation--identified the statements of the SAI that loaded on each of the four factors. In Table 42, for example, six statements are seen to load on Factor One. The loading of each statement on Factor One is shown as a correlation.[10] Statement three, for example, correlated with Factor One at 0.85. The negative correlations in Table 42 are an indication that those statements were correlated with Factor One opposite to the positive correlations.

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[10] A. A. Afifi and S. P. Azen, Statistical Analysis: A Computer Oriented Approach, New York: Academic Press, 1972, p. 264.

TABLE 42

SCIENCE EDUCATORS PRINCIPAL COMPONENTS ANALYSIS/VARIMAX ROTATED FACTOR MATRIX, N=25

Factor One		Factor Two		Factor Three		Factor Four	
Statement	Correlation	Statement	Correlation	Statement	Correlation	Statement	Correlation
3	0.85	9	0.71	1	0.76	2	0.89
5	-0.63	11	0.86	7	0.81	4	0.89
6	-0.75	12	-0.78				
8	-0.78						
13	0.79						
14	0.51						

The statements which correlate negatively with Factors one and two were evaluated as "exposition" by the science educators; all other statements were evaluated "inquiry" by that group. Thus, the principal components analysis was important to the validity development of the SAI because the factors and the correlation reflect a measure of the constructs of the nature of science, learning science and science teaching. This type of validity is referred to as construct validity.

An understanding of the constructs which comprise the SAI can be obtained by interpreting the data in Table 42. Those data show which statements loaded on a particular factor. Those groups of statements which load, either positively or negatively, in a particular factor will be listed below. Interpretations of these groups of statements will then be made. These interpretations or summary statements represent the underlying constructs of the SAI.

Factor 1

The following statements were positively loaded on factor one.

Statement # 3. Students should be engaged in science activities that provide data for solving problems.

Statement #13. Science teaching should include experiences from which students can make predictions.

Statement #14. Science teaching should include concrete experiences that will eventually help students build images and/or theoretical models.

Summary Statement:

The above three statements emphasized that students should engage in activities which represent the quest for knowledge, not the knowledge itself. These activities begin with first-hand experiences, which lead to developing theoretical models. Such a view indicates an inquiry-orientation towards science education.

The following statements were negatively loaded on factor one.

Statement # 5. Science teaching is most effectively accomplished by teachers giving lectures.

Statement # 6. Laboratory work in the schools should be used as a follow-up to the presentation of the text materials.

Statement # 8. The students' understanding of most science concepts should come from reading science textbooks.

Summary Statement:

In contrast with statements 3, 13 and 14, statements 5, 6 and 8 indicate an exposition-orientation towards science education.

Notice the dependence of the foregoing factors on language only. The latter statements focus on the teacher's role in science education as one of telling the students what they should know and how to obtain this knowledge from lectures, laboratories and reading textbooks. Most of the knowledge thereby obtained by students will be from second-hand experiences, not by directly interacting with concrete materials.

Factor 2

The following statements were positively loaded on factor two.

Statement # 9. The primary purpose of science teaching is to teach students to use and develop their abilities to think.

Statement #11. Science teaching should provide students the opportunity to interpret data.

Summary Statement:

Statements nine and eleven, reflecting an inquiry view, indicate that the development of the ability to think is one of the purposes of science education and that this purpose can be partly achieved by students interpreting data.

The following statement was negatively loaded on factor two.

Statement #12. Understanding science concepts is the most valuable learning students receive from studying science.

Summary Statement:

The foregoing statement represents a goal supported by an exposition view of science education. In other words, learning

<u>science concepts is the most important goal of science education</u>.

<u>Factor 3</u>

The statements below were positively loaded on factor three.

Statement # 1. In science courses, students should do experiments as the vehicle for most learning.

Statement # 7. Science teaching should include the development of students' observational abilities.

Summary Statement:

<u>Because of the positive loadings of statements one and seven, these statements represent an inquiry view of science which supports students learning by carrying out experiments and developing their observational abilities.</u>

<u>Factor 4</u>

The statements below were positively loaded on factor four.

Statement # 2. The concepts taught in science courses should be matched to the intellectual development levels of students.

Statement # 4. Science textbooks should require that concrete materials be used with most topics.

Summary Statement:

The foregoing statements reflect an inquiry-orientation towards science education--that science concepts should be compatible with the intellectual levels of students and that concrete materials must be used to achieve this goal.

In conclusion, the above interpretations of the results of the principal components analysis of the SAI clearly indicated that science educators support an inquiry view of science education and that science is not learned by exposition.

Having validated the SAI, data were needed to determine what school administrators believed to be the nature of science, learning science and science teaching.

CHAPTER 5

THE DATA AND INTERPRETATION

Data presented in Chapters Two and Three demonstrated that the science textbooks purchased for schools were exposition-oriented and the science textbooks that rated as inquiry-oriented by the science teachers were not being purchased. Therefore, exposition-oriented science textbooks were being placed in the schools' classrooms. School administrators are responsible for the selection and purchase of science textbooks so it appears that they view the nature of science, the nature of learning science and the nature of science teaching differently than the science teachers rating the textbooks. The major objective of this investigation was to answer the question: What are school administrators attitudes towards the nature of science, learning science and science teaching? The data in Chapter 4 show that a valid instrument had been developed which would enable data to be collected to answer the foregoing question.

Treatment of the Data

The data obtained from 154 school administrators on thirteen statements were analyzed to determine the administrator's attitudes toward the nature of science, learning science and science teaching. Demographic data on the administrators appear in Appendix H. The sampling procedure used to obtain data from the administrators was discussed in Chapter 4, page 39. The school administrators responded to the sixteen statements, but because of the findings during the validation of the instrument three statements--numbers 10, 15, and 16--were discarded. Statements one through nine and eleven through fourteen furnished the data from the school administrators to be analyzed to test the hypothesis of the present study.

Five statistical analyses were carried out on the data. These were the intercorrelation analysis, t-test, analysis of variance, Behrens-Fisher statistic, and principal components analysis.

A. Intercorrelation Analysis

The school administrators' data from the SAI were first analyzed using the point-biserial correlation coefficient to determine whether or not the administrators were certain about their responses to the statements. Table 43 shows item by item point-biserial correlation coefficients for the administrators and the science educators from Table 39.

TABLE 43

POINT-BISERIAL CORRELATION COEFFICIENTS BETWEEN STATEMENT SCORE AND CERTAIN/UNCERTAIN RESPONSES SCIENCE EDUCATORS N=25 ADMINISTRATORS N=154

Statement	r Value	r Value
1	.99	.56
2	.69	.29
3	.99	.99
4	.99	.59
5	.99	.20
6	.99	.42
7	.99	.09
8	.99	.17
9	.99	.23
10	.06	Discarded statement (See Table 39)
11	.99	.99
12	.69	.29
13	.99	.99
14	.99	.22
15	Discarded by frequency distribution (See Appendix F)	
16	-.06	Discarded statement (See Table 39)

First consider the data from the administrators shown in Table 43. The data showed a high level of certainty among administrators on three, or 23 percent, of the statements--numbers 3, 11, and 13. Those data indicated that administrators were certain about their responses to the statements. Such results can be interpreted to mean that administrators were certain that science is a course that is problem solving oriented and produces data from which predictions can be made. Low correlations existed for the remaining ten, or 77 percent, of the statements--numbers 1, 2, 4, 5, 6, 7, 8, 9, 12 and 14--in Table 43, p. 52. These low "r" values indicated that the administrators were either uncertain in their attitudes towards the statements, or they lack adequate knowledge about the content of the statements or they have a poor attitude about the content of the statements. There are considerable differences with respect to the manner in which the administrators responded to the SAI when compared to the science educators, the criterion group.

Consider now the data from the science educators. The high correlation found in the science educator group indicated that they are certain of their answers. They have an attitude toward each statement and they are certain of that attitude. Science educators are certain that science concepts should be learned by students being actively involved with concrete materials in investigations that provide problem solving experiences. The experiences should be matched to the students' intellectual level of development to appropriately build thinking processes from which images or theoretical models could emerge.

Science teaching should include developing the students' ability to observe, interpret, and predict from data. The science educators agreed that science teaching is not effectively accomplished by teachers giving lectures but that lectures should be used as a follow-up to the laboratory work. When asked if laboratory work should come after the presentation of text material, they strongly disagreed, implying that science teaching should begin with the introduction of laboratory work. Science educators believed that the understanding of most science concepts does not come from reading about science. They also believed that concepts are not the most important thing to learn from science. They were certain that understanding science concepts come from science teaching that provides students the opportunity to observe, manipulate and investigate data; they are certain that understanding and using the processes of science leads to conceptual understanding. The foregoing can be interpreted to mean that students developing understanding of the processes of science is at least as important as students developing conceptual understandings. They also recognize that there are other important factors that lead students to the understanding of science concepts, such as the students using concrete materials and building mental images.

The science educators were asked to decide whether each of the statements was oriented towards inquiry or exposition. The definitions of these variables--inquiry and exposition--were provided to the science educators on the Inventory (Appendix E). In Table 40, page 41, the point-biserial correlation data indicate nine statements rated inquiry and four statements exposition. The nine statements identified inquiry were rated strongly agree and the four statements identified exposition were rated strongly disagree. Therefore, the science educators were certain that nine statements represented science, learning science, and science teaching as inquiry and four statements represented science, learning science and science teaching as exposition. To further analyze the discrepancies between the administrators and science educators responses to the SAI, a t-test was used to compare the means of the two groups - science educators and administrators. Before interpreting the results of the t-test, the types of errors involved in the study will be discussed.

Error Type

Avoiding the Type I error was critical to the present study. In other words, the researcher wanted to avoid rejecting the null hypothesis when it was true. The implication of making that error and stating that a difference existed when there was no difference between the means of the different groups, leads to the false conclusion that the administrators' attitudes toward science, learning science and science teaching differed from the science educators even though no real difference existed. Making a Type I error would lead to the drawing of an incorrect conclusion and the probability of making that error should, therefore, be minimized.

Avoiding the Type II error is less important in this study. That error would be accepting the null hypothesis when it was false. The implication of making the error and stating that there was no difference when really there was a difference between the means of the different groups, lead to the false conclusion that administrators and science educators had similar attitudes towards science, learning science and science teaching.

There was no desire by the researcher to make either a Type I or Type II error. But in this study the researcher has minimized making the Type I error because of the reason given above and the reputations of administrators which could be damaged. It is common practice in research of this type to minimize the Type I error and to set the level of confidence at five percent.

B. t-Test

The difference in attitudes of the science educators and administrators to the SAI were measured by comparing the mean scores of the science educators with the mean scores of the administrators. The scoring procedure for the Likert-type scale was discussed on page 35.

To test the null hypothesis--there is no significant difference between the mean score of the science educators and the school administrators on the SAI--the t-test was used. Because of the unequal sample sizes the Welch and Aspen[1] correction

[1]G. A. Ferguson, Statistical Analysis in Psychology and Education, McGraw-Hill Book Co., New York, N.Y., 1966, p. 173.

for the degrees of freedom (df) was used. Use of this correction for the degrees of freedom insured that the homogeneity-of-variance assumption of the t-test was not violated. The results of the analysis are given in Table 44.

TABLE 44

t-TEST, CORRECTED FOR UNEQUAL SAMPLE SIZES

Group	N	Mean Score	DF	t
Science Educators	25	48.8	53	2.237
Administrators	154	46.76		

With df equal to 53, the value of t required for significance at the 5 percent level is 2.006 in a nondirectional test. The computed value of t, 2.237, exceeded the value required for significance at the 5 percent level. Therefore, the difference between means was significant. This result indicated that there is a significant difference between the mean score of science educators and school administrators on the SAI. Apparently, administrators did not respond to the statements in the same way as the science educators. Therefore, the attitudes of science educators and administrators differed about the constructs of the nature of science, learning science and science teaching.

C. Analysis of Variance

From the data of the five groups--science educators and four different groups of school administrators--the significance of the differences between the means was tested using the analysis of variance. Table 45 shows the result of the F-star[2] test with the obtained ratio of 3.28. That result was significant at the .05 level of confidence. The F-star test was additional evidence that there were significant differences in the attitudes between science educators and each of the groups of administrators on the way they responded to the SAI.

TABLE 45

F-STAR - UNEQUAL CELL SIZES

Group	N	Mean Score	Sums of Squares
Science Educators	25	48.8	59649
Superintendents	34	47.8	78201
High School Principals	40	46.6	87407
Middle-Junior High School Principals	20	46.65	44206
Elementary School Principals	60	46.3	129721

df between = 4
df within = 70
F-star = 3.28 significant at the .05 level of confidence

[2] B. L. Welch, Biometrika, 1951, Volume 38, p. 330-336.

D. Behrens-Fisher Statistic

An extension of the t-test and analysis of variance--which compared the mean scores of all administrators and the mean score of the science educators--was an analysis of pairs of means shown in Table 45.

Four sub-hypothesis were formed:

1. There is no significant difference in the mean scores on the SAI between the science educators and the superintendents.

2. There is no significant difference in the mean scores on the SAI between the science educators and the high school principals.

3. There is no significant difference in the mean scores on the SAI between the science educators and the middle-junior high school principals.

4. There is no significant difference in the mean scores on the SAI between the science educators and the elementary school principals.

The data contained both unequal variances and means. Therefore, the Behrens-Fisher (BF) statistic,[3] v, with the Welch[4] correction for degrees of freedom (df) was used. Table 46 lists the four possible combinations of pairs, the v statistic for each pair, the value of df of administrators and the science educators and whether or not the null hypothesis was rejected. The null hypothesis

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[3]Paul A. Games and John F. Howell, Pairwise Multiple Comparison Procedures with Unequal n's and/or variances, Journal of Educational Statistics, Summer 1976, Volumes 1 and 2, p. 113-125.

[4]B. L. Welch, Further note on Mrs. Aspins' tables and on certain approximations to tabled functions, Biometrika, 1949, Volume 36, p. 293-296.

was rejected when the BF statistic v was greater than the critical value at the (0.05) level of confidence. When using the BF statistic to compare the means of the scores on the SAI by the science educators and the administrator groups, a significant difference was found between the science educators and the high school principals, and the science educators and the elementary school principals at the .05 level of confidence. There was no significant difference between the science educators and superintendents, and the science educators and the middle-junior high school principals.

TABLE 46

PAIRWISE MULTIPLE COMPARISONS USING BEHRENS-FISHER (BF) STATISTIC FOR UNEQUAL VARIANCES AND N'S

Group	N	Mean Score	Comparisons	BF Statistic v	df	$\frac{q(.105,\ 5,\ (df)}{2}$ Critical Value	Pairwise Comparison
1. Science Educator	25	48.8					
2. Superintendent	34	47.8	1 & 2	1.2256	52.87	2.83	Not Reject Ho
3. High School Principal	40	46.6	1 & 3	3.0011	62.75	2.814	Reject Ho
4. Middle-Junior High School Principal	20	46.7	1 & 4	1.3495	22.99	4.17	Not Reject Ho
5. Elementary School Principal	60	46.3	1 & 5	3.635	77.87	2.8001	Reject Ho

E. Principal Components Analysis

Previously in this study principal components analysis was used to establish the construct validity of the SAI. The principal components analysis will now be used as a measuring instrument to compare responses of administrators with the responses of science educators and thereby determine the understanding of the constructs of science, learning science and science teaching held by administrators. The science educator data presented in Table 41 showed that in the SAI 73 percent of the variance was captured by four factors. Now compare those data with those obtained from the administrators.

TABLE 47

PRINCIPLE COMPONENTS ANALYSIS FROM ADMINISTRATORS

Peer Group	N	Number of Factors	Percentage of Variance Accounted for
All Administrators	154	5	58.2
Superintendents	34	5	70.6
High School Principals	40	3	69.6
Middle-Junior High School Principals	20	5	86.0
Elementary Principals	60	4	53.0

Table 47 displays the results of the principal components analysis of the data which resulted from one hundred and fifty-four administrators completing the SAI. A statement by Amick and Walberg[5]

[5] D. J. Amick and H. J. Walberg, Introductory Multivariate Analysis for Educational, Psychological and Social Research, Berkeley, California, McCutchan Publishing Corp., 1975, p. 128.

relative to interpreting the results of a principal components analysis needs to be understood before the data in Table 47 are analyzed. Those researchers said, "The more closely related the variables, the greater the percentage of the variance may be expected in relatively few components."[6] Notice that in Table 47 the high school principals group accounted for 69.6 percent of the variance (almost exactly the 70 percent level referred to in Chapter 4) in three factors. Obviously the variables account for the principal's understandings of science, science learning and science teaching were closely related. Five factors were necessary to account for 70.6 and 86.0 percent of the variance for the superintendents, and middle-junior high principals, respectively. Only 53 percent of the variance--a statistically unacceptable amount--is accounted for with four factors for the elementary principal group.

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[6] Ibid

TABLE 48

PRINCIPAL COMPONENTS ANALYSIS VARIMAX ROTATED FACTOR MATRIX

Group	Factor One		Factor Two		Factor Three		Factor Four		Factor Five	
	Statement	Correlation	Statement	Correlation	Statement	Correlation	Statement	Correlation	Statement	Correlation
All	2	50	1	76	5	75	4	59	8	45
Administrators	7	67	3	60	14	67	6	76	12	72
N = 154	11	77	9	54						
	13	76								
Super-	3	60	11	86	5	84	1	66	9	89
intendents	12	82	13	88	8	69	4	68	7	48
N = 34			2	55	14	48	6	78		
Middle-	2	88	1	87	9	91	12	93	4	93
Junior	5	63	3	82						
	7	86	6	67						
High School	8	28								
Principals	11	74								
N = 20	13	67								
	14	88								

"TABLE 48 - Continued."

Group	Factor One Statement	Factor One Correlation	Factor Two Statement	Factor Two Correlation	Factor Three Statement	Factor Three Correlation	Factor Four Statement	Factor Four Correlation	Factor Five Statement	Factor Five Correlation
HIGH	1	55	4	67	8	55	0	0	0	0
SCHOOL	2	56	5	55	9	45	0	0		
PRINCIPALS	3	71	6	69	12	41				
N = 40	7	73	14	36						
	11	71								
	13	66								
ELEMENTARY	3	78	2	46	5	48	1	43	0	
SCHOOL	7	62	4	71	9	81	6	65		
PRINCIPALS	11	56	8	58	14	55				
N = 60	13	59	12	66						

The data in Table 48 suggested that the understandings of science, learning science and science teaching held by administrators may be different from those understandings held by science educators. To obtain an analytical perspective of how the administrators and science educators understandings differed, a principal components analysis (varimax rotated factor matrix) was made of the administrators' responses on the SAI. That analysis provided a definitive listing of those statements in the SAI which loaded on particular factors isolated for each administrator group (See Table 48). Examining those loadings allowed general statements to be made about the beliefs of each administrator group regarding science, learning science and science teaching. First of all, examination of Table 48 shows that there are no negative loadings as were found with the science educator data (See Table 42). This can be interpreted to mean that no administrator group differentiated between inquiry and exposition. Now the particular statements which load on each of the factors from each administrator group will be examined. Generalizations will then be made regarding the understandings each administrator group has about science, learning science and science teaching.

1. <u>High School Principals</u>

Listed below are the statements which loaded on the three factors which accounted for 69.6 percent of the variance in the data from the SAI for the administrator group.

Factor 1

Statement # 1. In science courses, students should do experiments as the vehicle for most learning.

Statement # 2. The concepts taught in science courses should be matched to the intellectual development levels of students.

Statement # 3. Students should be engaged in science activities that provide data for solving problems.

Statement # 7. Science teaching should include the development of students' observational abilities.

Statement #11. Science teaching should provide students the opportunity to interpret data.

Statement #13. Science teaching should include experiences from which students can make predictions.

Summary Statement: Students should be engaged in science activities at their own intellectual level which provide data for problem solving.

Factor 2

Statement # 4. Science textbooks should require that concrete materials be used with most topics.

Statement # 5. Science teaching is most effectively accomplished by teachers giving lectures.

Statement # 6. Laboratory work in the schools should be used as a follow-up to the presentation of the text material.

Statement #14. Science teaching should include concrete experiences that will eventually help students build images and/or theoretical models.

Summary Statement: Science teaching should use concrete materials and experiences, but only after the students have been told what to do.

Factor 3

Statement # 8. The student's understanding of most science concepts should come from science textbooks.

Statement # 9. The primary purpose of science teaching is to teach students to use and develop their abilities to think.

Statement #12. Understanding science concepts is the most valuable learning students receive from studying science.

Summary Statement: Students must develop the ability to think using concepts they have been given by a textbook.

2. Elementary School Principals

The statistical analysis isolated five factors for this group but those factors only accounted for 53.0 percent of the variance. A wide diversity of what science, learning science, and science teaching are exists within this group. The wide diversity of statements loading on each factor is evident here. The factors and statements from the SAI that load on each follows.

Factor 1

Statement # 3. Students should be engaged in science activities that provide data for solving problems.

Statement # 7. Science teaching should include the development of students' observational abilities.

Statement #11. Science teaching should provide students the opportunity to interpret data.

Statement #13. Science teaching should include experiences from which students can make predictions.

Summary Statement: Science should provide students with experiences that will teach them to solve problems.

Factor 2

Statement # 2. The concepts taught in science courses should be matched to the intellectual development levels of students.

Statement # 4. Science textbooks should require that concrete materials be used with most topics.

Statement # 8. The students' understanding of most science concepts should come from reading textbooks.

Statement #12. Understanding science concepts is the most valuable learning students receive from studying science textbooks.

Summary Statement: Students should learn concepts of science which are at their intellectual level but which they should have found in a textbook.

Factor 3

Statement # 5. Science teaching is most effectively accomplished by teachers giving lectures.

Statement # 9. The primary purpose of science teaching is to teach students to use and develop their abilities to think.

Statement #14. Science teaching should include concrete experiences that will eventually help students build images and/or theoretical models.

Summary Statement: Students should develop the ability to think and build images and models and do it with information they have been given by an adult.

Factor 4

Statement # 1. In science courses, students should do experiments as the vehicle for most learning.

Statement # 6. Laboratory work in the schools should be used as a follow-up to the presentation of the text material.

Summary Statement: Students should have experiences with ideas they have been told about.

3. Superintendents

The data analysis identified five factors that accounted for 70.6 percent of the variance. That amount of variance is quite acceptable but the fact that five factors, each with eigenvalues greater than one, were identified, suggests a diversity in the attitudes of the superintendents participating in the study.

Factor 1

Statement # 3. Students should be engaged in science activities that provide data for solving problems.

Statement #12. Understanding science concepts is the most valuable learning students receive from studying science.

Summary Statement: Science learning is activities that lead to conceptual understanding.

Factor 2

Statement # 2. The concepts taught in science courses should be matched to the intellectual development levels of students.

Statement #11. Science teaching should provide students the opportunity to interpret data.

Statement #13. Science teaching should include experiences from which students can make predictions.

Summary Statement: Science teaching should match the intellectual level of the student with the concepts to be taught and students should learn through experience.

<u>Factor 3</u>

Statement # 5. Science teaching is most effectively accomplished by teachers giving lectures.

Statement # 8. The students' understanding of most science concepts should come from reading science textbooks.

Statement #14. Science teaching should include concrete experiences that will eventually help students build images and/or theoretical models.

Summary Statement: <u>Students should learn science with concrete activities but only those they have been informed about</u>.

<u>Factor 4</u>

Statement # 1. In science courses, students should do experiments as the vehicle for most learning.

Statement # 4. Science textbooks should require that concrete materials be used with most topics.

Statement # 6. Laboratory work in the schools should be used as a follow-up to the presentation of the text material.

Summary Statement: <u>Students should learn through laboratory experience with actual materials but only with ideas they have been informed about</u>.

<u>Factor 5</u>

Statement # 7. Science teaching should include the development of students' observational abilities.

Statement # 9. The primary purpose of science teaching is to teach students to use and develop their abilities to think.

Summary Statement: <u>Science experiences should lead students to develop the ability to think</u>.

4. <u>Middle-Junior High School Principals</u>

The statistical technique used in this research identified five factors in the data from this administrator group. Those five factors accounted for 86.0 percent of the variance, which is a great deal of the variance to have identified. The fact that five factors, each with eigenvalues greater than one, were identified shows a greater than would be expected diversity among the participants, but the high percentage of variance accounted for with those five factors also shows that the beliefs of the group were nearly confined to those five factors.

<u>Factor 1</u>

Statement # 2. The concepts taught in science courses should be matched to the intellectual development levels of students.

Statement # 5. Science teaching is most effectively accomplished by teachers giving lectures.

Statement # 7. Science teaching should include the development of students' observational abilities.

Statement # 8. The students' understanding of most science concepts should come from reading science textbooks.

Statement #11. Science teaching should provide students the opportunity to interpret data.

Statement #13. Science teaching should include experiences from which students can make predictions.

Statement #14. Science teaching should include concrete experiences that will eventually help students build images and/or theoretical models.

Summary Statement: Students should learn science concepts through experience but only with those concepts which textbooks and teachers have informed them about.

Factor 2

Statement # 1. In science courses, students should do experiments as the vehicle for most learning.

Statement # 3. Students should be engaged in science activities that provide data for solving problems.

Statement # 6. Laboratory work in the schools should be used as a follow-up to the presentation of the text material.

Summary Statement: Students should do experiments, gather data and solve problems but only after the text has explained the material to them.

Factor 3

Statement # 9. The primary purpose of science teaching is to teach students to use and develop their abilities to think.

Factor 4

Statement #12. Understanding science concepts is the most valuable learning students receive from studying science.

Factor 5

Statement # 4. Science textbooks should require that concrete materials be used with most topics.

In Chapter 4 the summary statements explaining the four factors which were found in the science educator were specific about the content of each factor. The factors dealt with inquiry or exposition and there was no ambivalence evident. If the summary statements for the administrator groups are examined, it will be observed that most of those statements bridged both inquiry and exposition. That "bridging effect" was further evidence of the interpretation made earlier in this chapter that administrators were not certain about what is science, learning science, and science teaching. The manner in which some of the statements were identified with some factors suggested that lack of knowledge as well as confusion may exist.

CHAPTER 6

CONCLUSIONS AND IMPLICATIONS

The purpose of this investigation was to test the null hypothesis that there were no significant differences in attitudes about the nature of science, the nature of learning science and the nature of science teaching between science educators, the criterion group, and administrators. In order to collect data to test the hypothesis, a Science Attitude Inventory (SAI) was constructed and validated. A sample population of school administrators was identified and they responded to the SAI. The data collected from the administrators' responses were analyzed and that analysis was compared with similar data from science educators through an intercorrelation analysis, a t-test, and analysis of variance, the F-star test which led to a Behrens-Fishers' pairwise comparison statistic test, and a principal components analysis. Those analyses lead to the following conclusions.

Conclusions

The intercorrelation analysis indicated that science educators were certain about the nature of science, learning science and science teaching. They were certain in their knowledge and attitude about all statements on the SAI. Whereas, the administrators were certain in their knowledge and attitude about the SAI on 23 percent of the statements. Those results could mean that the administrators had an indifferent attitude towards science, or they lacked sufficient knowledge about the nature of science, learning science and science teaching. Three statistical treatments, the t-test, analysis of variance and the Behrens-Fisher (BF) were implemented comparing the mean scores of science educators and administrators. These treatments were different in that the t-test compared the means of two groups - science educators and administrators. Administrators were then divided into the categories of superintendents, high school principals, middle-junior high school principals and elementary school principals. The analysis of variance compared the means among the five groups - science educators, superintendents, high school principals, middle-junior high school principals and elementary school principals. The Behrens-Fisher test compared the means of the 5 groups (science educators, superintendents, high school principals, middle-junior high school principals and elementary school principals) taken two at a time.

The t-test indicated a significant difference between the mean scores of the science educators and the administrators on the way each group responded to the SAI. The t-test confirmed the hypothesis that school administrators hold different views about the nature of science, learning science and science teaching from the science educators.

The analysis of variance provided additional evidence that there was a significant difference in the attitudes of each of the groups of administrators and science educators about the constructs of science.

The BF statistic indicated that superintendents and middle-junior high school principals have more similar attitudes and knowledge about the nature of science, learning science and science teaching, when compared with science educators than did high school and elementary principals. The principal components analysis indicated that the administrators did not recognize the same inquiry and exposition constructs of the nature of science, learning science and science teaching as recognized by the science educators. Therefore, the administrators were reflecting confusion, insufficient information and/or knowledge about the theoretical structures that make up the discipline of science.

Implications

The implications following this study are intended for the improvement of science education. School administrators' should view themselves as instruments of change and experimentation. Today's technological age demands a continuous search for improvement. As the schools' curriculum leaders, administrators should influence changes that reflect new scientific and technological advances in the curriculum and most assuredly any innovation which includes an understanding of the nature of science, the nature of learning science and the nature of science teaching. This is the role of administrators whether they want to recognize it or not because of expectations which have grown out of staff, curriculum, community and national conditions.

The period of the National Science Foundation - type (NSF) curriculum development was one of innovation; the years following innovation should have been one of implementation of innovative programs. From this study, there is little evidence of administrative leadership towards implementation of NSF - type curriculum programs. Science textbook adoptions and purchasing patterns have provided data indicating only a small percentage of NSF - type developed textbooks going to the schools. Administrators should be aware that if science education is to reflect the nature of the discipline of science, they must provide the necessary leadership to insure the adoption of science textbooks that reflects the structure of the discipline of science. Administrators concerned with improving their schools' science curriculum should consider the constructs of the SAI as objectives through which improvement in the science curriculum can be made. The following actions and research are recommended:

1. Administrators should work cooperatively with science teachers in the examination and adoption of science textbooks.

2. The Oklahoma Science Teachers Association criteria developed for the examination of science textbooks should be made available to all administrators.

3. Pre-service education of administrators should include experiences in the nature of science, the nature of learning science and the nature of science teaching.

4. Administrators and science teachers should respond to the SAI to ascertain the presence or absence of the constructs that make up the nature of science, learning science and science teaching.

5. The SAI should be given to science teachers immediately after completing their teacher-education programs to determine whether they have undergone pre-service teacher preparation which led them to develop the understandings of constructs of science, learning science and science teaching. A more complete profile of science teachers' attitudes towards science, learning science and science teaching could be developed if the SAI were implemented with experienced science teachers.

6. As a result of the findings of this study, the researcher recommends that a study be implemented to determine who--administrators or science teachers--selects the science textbooks for the school's classrooms.

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APPENDIXES

APPENDIX A

CORRESPONDENCE MAILED WITH THE SCIENCE ATTITUDE INVENTORY

J. D. GIDDENS
ASST SUPERINTENDENT
INSTRUCTION

JACK STRAHORN
ASST SUPERINTENDENT
STATE-FEDERAL

S. H. MC DONALD
ASST SUPERINTENDENT
FINANCE

State Department of Education

LESLIE FISHER, Superintendent
LLOYD GRAHAM, Deputy Superintendent
TOM CAMPBELL, Associate Deputy Superintendent

2500 North Lincoln Boulevard
Oklahoma City, Oklahoma 73105

MEMORANDUM

DATE: February 20, 1979

TO: School Administrators

FROM: Larry McKinney, Science Specialist

SUBJECT: Science Attitude Inventory

My role in the State Department of Education is to strive to improve science education instruction. Improvement can be accomplished when base line information is sufficiently compiled.

During the next year, I plan to obtain relevant information about Oklahoma Science Education. This effort combines information relevant to my job and significant to completing my dissertation. The survey enclosed will assist me in establishing the status of science education among administrators. A minimum number of administrators were randomly chosen to respond to this survey. Your contribution to this effort will be greatly appreciated.

The data collected will go into a pool of data ensuring individual anonymity. I anticipate using the information for articles to be published in the <u>Oklahoma Educator</u>. If you would like a summary of the research, I will be pleased to send it to you.

Thank you for your anticipated cooperation.

Note:

Due to the lack of validity of the first inventory, the data from the sample were discarded. The inventory was corrected as explained in the validation process and another sample was identified.

The University of Oklahoma 820 Van Vleet Oval Norman, Oklahoma 73019

College of Education

February 13, 1979

We at the Science Education Center, University of Oklahoma, have had several years of experience assisting schools introduce science curriculum innovations with classrooms. There have been instances where often the initial enthusiasm for the program dies for lack of administrative support. In some cases, the introduction of programs is resisted by administrators.

Our hypothesis is that many administrators and teachers do not know that science has a process element. We believe that many persons making budgetary decisions believe science is a collection of facts that can be learned with no more expenditure than the cost of a book.

We are going to test our hypothesis. We need, however, to get some feeling for the validity and reliability of our questionnaire. We are, therefore, asking you to complete the enclosed questionnaire and return it in the enclosed self-addressed, stamped envelope. We shall be happy to share our results with you if you will let us know of your interest.

Thank you for your anticipated cooperation.

Sincerely yours,

John Renner
Professor of Science Education

Note:

Due to the lack of validity of the first inventory, the data from the sample were discarded. The inventory was corrected as explained in the validation process and another sample was identified.

J. D. GIDDENS
ASST SUPERINTENDENT
INSTRUCTION

JACK STRAHORN
ASST SUPERINTENDENT
STATE-FEDERAL

S. H. MC DONALD
ASST SUPERINTENDENT
FINANCE

State Department of Education

LESLIE FISHER, Superintendent
LLOYD GRAHAM, Deputy Superintendent
TOM CAMPBELL, Associate Deputy Superintendent

2500 North Lincoln Boulevard
Oklahoma City, Oklahoma 73105

MEMORANDUM

DATE: April 9, 1979

TO: School Administrators

FROM: Larry McKinney, Science Specialist

SUBJECT: Science Attitude Inventory

My role in the State Department of Education is to strive to improve science education instruction. Improvement is possible only when basic information is accurately collected and interpreted.

Administrators have an important function in science education. Information from you is necessary if a comprehensive picture of science education is to be obtained.

As part of gathering this information, a survey which was sent to school administrators in February helped provide validity for that survey. Over 80 percent of the surveys mailed were returned. I would now like you to respond to the survey. The enclosed survey will assist me in establishing the status of science education among administrators. A minimum number of administrators was randomly chosen to respond to this survey. Your contribution to this study by responding to the survey will provide me with additional information relevant to my job and significant to completing my dissertation. Your contribution to this effort will be greatly appreciated.

The data collected will go into a pool of data ensuring individual anonymity. I anticipate using the information for articles to be published in the Oklahoma Educator. If you would like a summary of the research, I will be pleased to send it to you.

Thank you for your anticipated cooperation.

The
University of Oklahoma 820 Van Vleet Oval Norman, Oklahoma 73019

College of Education

April 9, 1979

Thank you for responding to and returning the survey instrument we sent you earlier. Over 200 science educators, principals, and superintendents responded to the first version of the survey instrument. All of those data helped us increase the face validity of the survey instrument.

Our objective now is to establish the survey instrument's criterion and construct validities. You will find two copies of the survey instrument enclosed. Please refer to the copy marked "Copy 1". Your responses on that copy will help us establish the response pattern of persons who have a contruct of what science instruction should be. That is, of course, construct validity. That response pattern can then be used as comparison to ascertain whether or not school administrators hold similar attitudes toward science teaching.

You will find a second copy, "Copy 2", of the survey instrument enclosed. That instrument has the words INQUIRY and EXPOSITION written on the right. Please encircle the term that best explains the type of science instruction each item reflects. Our definitions of INQUIRY and EXPOSITION are provided on "Copy 2". Please refer to those definitions when making your judgments. Your judgment will establish the criterion validity of each item, and consequently, the entire survey instrument.

Please complete the two tasks independently. No attempt will be made to correlate your responses to the survey instrument and the INQUIRY-EXPOSITION judgments you make about each item. If you have any comments or questions regarding the study or its procedures, please enclose them with the instruments.

Thank you for your cooperation. We know the quality of the research done with the survey instrument will reflect your efforts and we appreciate those efforts.

Sincerely,

John Renner
Professor of Science Education

APPENDIX B

SCIENCE ATTITUDE INVENTORY
FIRST VERSION

SCIENCE ATTITUDE INVENTORY

Here are some statements about science and science teaching. Some statements are about the nature of science and some are about the nature of teaching and learning. Some of these statements describe how you feel about science. You are asked to indicate your attitude towards science by agreeing or disagreeing with the statements.

Please read each statement carefully and decide whether or not you agree with it. You may agree strongly or you may disagree strongly or you may be uncertain about your decision on the statement. After you have made your choice about a particular statement, place a check in the appropriate column on the right.

STATEMENT	ATTITUDE				
	STRONGLY AGREE	AGREE	UNCERTAIN	DIS-AGREE	STRONGLY DISAGREE
1. Science teaching should use students performing experiments as the vehicle for learning.					
2. The concepts in science, which make up the courses taught, should be matched to the intellectual development levels of students.					
3. A student should be engaged in science activities that provides data to use in solving problems.					
4. Science textbooks should demand that concrete materials be used with most topics.					
5. Science processes should be emphasized as facts to be learned.					
6. Science teaching is most effectively accomplished by teachers giving lectures.					
7. Laboratory work in the schools should be used as a follow-up after text materials has been introduced.					
8. Science textbooks should dominate the student's experience in a classroom.					
9. Discoveries of great scienctists should be the basis of science courses.					
10. Science teaching should include the development of observational abilities in students.					
11. Students should gain understandings of scientific achievements by reading science textbooks.					
12. The primary purpose of science teaching is to teach students to use and develop their abilities to think.					

STATEMENT ATTITUDE

STATEMENT	STRONGLY AGREE	AGREE	UNCERTAIN	DIS-AGREE	STRONGLY DISAGREE
13. The teacher should require students to use manipulative materials.					
14. Science should be represented as a systematic collection of principles.					
15. Science teaching should provide students the opportunity to interpret data.					
16. Among the experiences a student has in science, the most valuable is an understanding of scientific conclusions.					
17. Science teaching should have necessary materials available that enables students to develop understandings of science principles.					
18. Science teaching should include experiences from which students can make predictions.					
19. Science experiences should lead students to develop a set of basic facts.					
20. Science teaching should include concrete experiences that will eventually help students build theoretical models or images.					
21. Science teaching should stress facts and concepts that applies to common scientific principles.					
22. Science textbooks are designed to bring about commitment to a set of basic finished scientific achievements.					
23. For science teaching to be most successful, the learning activities should take place in the science classroom.					
24. Science teaching materials should focus upon the investigative processes.					
25. When teaching science content, the conceptual structure of that discipline should be followed regardless to whom it is taught.					
26. Science textbooks should present past scientific achievements in their original historical context.					

APPENDIX C

SCIENCE ATTITUDE INVENTORY
SECOND VERSION

APPENDIX C

SCIENCE ATTITUDE INVENTORY

Here are some statements about science and science teaching. Some statements are about the nature of science and some are about the nature of teaching and learning. Please read each statement carefully. You are asked to indicate your attitude towards science and/or science teaching by placing a check in the appropriate column on the right.

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Uncertain
1. In science courses, students should do experiments as the vehicle for most learning.						
2. The concepts taught in science courses should be matched to the intellectual development levels of students.						
3. Students should be engaged in science activities that provide data for solving problems.						
4. Science textbooks should require that concrete materials be used with most topics.						
5. Science teaching is most effectively accomplished by teachers giving lectures.						
6. Laboratory work in the schools should be used as a follow-up to the presentation of the text material.						

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Uncertain
7. Science teaching should include the development of students' observational abilities.						
8. The students' understanding of most science concepts should come from reading science textbooks.						
9. The primary purpose of science teaching is to teach students to use and develop their abilities to think.						
10. The teacher should require the student to use laboratory materials in most activities.						
11. Science teaching should provide students the opportunity to interpret data.						
12. Understanding science concepts is the most valuable learning students receive from studying science.						
13. Science teaching should include experiences from which students can make predictions.						

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Uncertain
14. Science teaching should include concrete experiences that will eventually help students build images and/or theoretical models.						
15. The primary purpose of science textbooks should be to provide students information about basic science concepts.						
16. All science teaching materials in the classroom should lead students to make investigations.						

Note:

On the original copy, this page was on the back side of the SAI. The statements of the first version of the SAI ran parallel to the short length of the paper. From a respondent's suggestion, the statements of the second version of the SAI ran parallel to the long side of the paper.

APPENDIX D

SCIENCE ATTITUDE INVENTORY
INQUIRY-EXPOSITION

APPENDIX D

Statement	Inquiry	Exposition
1. In science courses, students should do experiments as the vehicle for most learning.		
2. The concepts taught in science courses should be matched to the intellectual development levels of students.		
3. Students should be engaged in science activities that provide data for solving problems.		
4. Science textbooks should require that concrete materials be used with most topics.		
5. Science teaching is most effectively accomplished by teachers giving lectures.		
6. Laboratory work in the schools should be used as a follow-up to the presentation of the text material.		
7. Science teaching should include the development of students' observational abilities.		
8. The students' understanding of most science concepts should come from reading science textbooks.		

Statement	Inquiry	Exposition
9. The primary purpose of science teaching is to teach students to use and develop their abilities to think.		
10. The teacher should require the student to use laboratory materials in most activities.		
11. Science teaching should provide students the opportunity to interpret data.		
12. Understanding science concepts is the most valuable learning students receive from studying science.		
13. Science teaching should include experiences from which students can make predictions.		
14. Science teaching should include concrete experiences that will eventually help students build images and/or theoretical models.		
15. The primary purpose of science textbooks should be to provide students information about basic science concepts.		
16. All science teaching materials in the classroom should lead students to make investigations.		

APPENDIX E

SCIENCE ATTITUDE INVENTORY
DEFINITIONS OF INQUIRY AND EXPOSITION

APPENDIX E

SCIENCE ATTITUDE INVENTORY

Here are some statements about science and science teaching. Some statements are about the nature of science and some are about the nature of teaching and learning. Please read each statement and respond whether you think the statement is oriented toward INQUIRY or toward EXPOSITION. Our definitions of INQUIRY and EXPOSITION are provided.

INQUIRY science instruction is leading students to find information, using the materials of the appropriate discipline, and interpreting the meaning of that information.

EXPOSITION science instruction is providing students information from various kinds of media--including the teacher--that is to be understood and remembered.

Note:

On the original copy, this page was on the back side of the SAI.

APPENDIX F

SCIENCE ATTITUDE INVENTORY
FREQUENCY DISTRIBUTION OF SCIENCE EDUCATOR DATA

APPENDIX F

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Uncertain
1. In science courses, students should do experiments as the vehicle for most learning.	卌 卌 卌 ||||	卌		|		
2. The concepts taught in science courses should be matched to the intellectual development levels of students.	卌 卌 卌 ||||	卌				|
3. Students should be engaged in science activities that provide data for solving problems.	卌 卌 卌 卌 ||	|||				
4. Science textbooks should require that concrete materials be used with most topics.	卌 卌 卌 ||	卌 ||		|		
5. Science teaching is most effectively accomplished by teachers giving lectures.				卌 |	卌 卌 卌 ||||	
6. Laboratory work in the schools should be used as a follow-up to the presentation of the text material.	|	|	|	卌 ||||	卌 卌 |||	

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Uncertain
7. Science teaching should include the development of students' observational abilities.	𝍸 𝍸 𝍸 III	𝍸 I	I			
8. The students' understanding of most science concepts should come from reading science textbooks.		I		𝍸 𝍸 I	𝍸 𝍸 III	
9. The primary purpose of science teaching is to teach students to use and develop their abilities to think.	𝍸 𝍸 𝍸 III	𝍸 I	I			
10. The teacher should require the student to use laboratory materials in most activities.	𝍸 𝍸 II	𝍸 IIII	III			I
11. Science teaching should provide students the opportunity to interpret data.	𝍸 𝍸 𝍸 𝍸	𝍸				
12. Understanding science concepts is the most valuable learning students receive from studying science.	I	𝍸	I	𝍸 𝍸 𝍸 I	I	I

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Uncertain
13. Science teaching should include experiences from which students can make predictions.	𝍸 𝍸 𝍸 ||||	𝍸 |				
14. Science teaching should include concrete experiences that will eventually help students build images and/or theoretical models.	𝍸 𝍸 𝍸	𝍸 𝍸				
15. The primary purpose of science textbooks should be to provide students information about basic science concepts.	|||	𝍸 ||	|||	𝍸 ||	|||	||
16. All science teaching materials in the classroom should lead students to make investigations.	𝍸 ||||	𝍸 ||	|	𝍸	||	|

Note:

Second version of SAI.

APPENDIX G

FINAL VERSION OF SAI

APPENDIX G

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Uncertain
1. In science courses, students should do experiments as the vehicle for most learning.						
2. The concepts taught in science courses should be matched to the intellectual development levels of students.						
3. Students should be engaged in science activities that provide data for solving problems.						
4. Science textbooks should require that concrete materials be used with most topics.						
5. Science teaching is most effectively accomplished by teachers giving lectures.						
6. Laboratory work in the schools should be used as a follow-up to the presentation of the text materials.						

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Uncertain
7. Science teaching should include the development of students' observational abilities.						
8. The students' understanding of most science concepts should come from reading science text-books.						
9. The primary purpose of science teaching is to teach students to use and develop their abilities to think.						
10. Science teaching should provide students the opportunity to interpret data.						
11. Understanding science concepts is the most valuable learning students receive from studying science.						
12. Science teaching should include experiences from which students can make predictions.						
13. Science teaching should include concrete experiences that will eventually help students build images and/or theoretical models.						

APPENDIX H

ADMINISTRATORS DEMOGRAPHIC DATA

APPENDIX H

ADMINISTRATORS DEMOGRAPHIC DATA, N=154 VARIABLES COMPARED WITH THE ADMINISTRATORS MEAN SCORES ON THE SAI

Variable	Pearson Correlation Coefficient
Number of college hours in science	.07
Size of student population at their school	$<.01$
Subject matter area in which they taught	.07
The degree attained	.02
The number of years they taught in the classroom before becoming an administrator	.23
The grade level at which they taught	.03
The number of years of service at their current location	-.06
The administrators' age level	-.03