Notes

I. Science and Why We Teach It to Young Children
   a. Science is often viewed as an encyclopedia of discoveries and technological achievements
      i. Formal training in science classes often promotes this view by requiring memorization of seemingly endless science concepts
      ii. Science has been compiling literally millions of discoveries, facts, and data over thousands of years
      iii. We are now living in the age that is sometimes described as the “Knowledge Explosion”
         1. Some scientists estimate that the total amount of scientific information produced now doubles every two to five years
      iv. Simply impossible to learn everything
         1. Far too many teachers still approach the task of teaching children science as if it were a body of information that anyone can memorize
      v. Entirely possible that today’s body of science knowledge will change before a child graduates from high school
         1. Cannot be predicted with any certainty which facts will be the most important for students to learn for life in the coming century
         2. What is known is that people in the coming century will have to face new problems that they will attempt to solve
   b. Science in preschool through college should be viewed more as a verb than a noun
      i. It is more like a way of thinking and acting than it is a body of knowledge
         1. It is a way of trying to discover the nature of things
         2. Attitudes and thinking skills that have moved science forward through the centuries are the same attitudes and skills that enable individuals to solve the problems that they encounter in everyday life
      ii. An approach to science teaching that emphasizes the development of thinking and the open-minded attitudes of science would seem to be most appropriate to the instruction of young children
      iii. Also important for the exploration of science topics to be enjoyable
         1. Supports a lifelong learning of science
   c. In 1996 the National Research Council published the *National Science Education Standards*
      i. Were designed to support the development of a scientific literate society
      ii. Help identify what children at different ages and stages should know and be able to do in the area of science
      iii. Describe appropriate content for children in kindergarten through the fourth grade
iv. Identify the processes, skills, and attitudes needed to successfully understand science

II. Science as Inquiry
   a. *National Science Education Standards* emphasize Science as Inquiry, which is divided into:
      i. Abilities children need in order to do scientific inquiry
      ii. Understandings children should have about scientific inquiry
   b. Inquiry is presented as a step beyond process learning
      i. Process skills are required, but students also must combine these skills with scientific knowledge as they use scientific reasoning and critical thinking to develop understanding
   c. According to standards, engaging students in inquiry serves five essential functions:
      i. It assists in the development of understanding of scientific concepts
      ii. It helps students “know how we know” in science
      iii. It develops an understanding of the nature of science
      iv. It develops the skills necessary to become independent inquirers about the natural world
      v. It develops the dispositions to use the skills, abilities, and habits of mind associated with science
   d. Inquiry-oriented instruction reflects the constructivist model of learning and is often referred to as active learning
      i. Osborne and Freyberg describe the constructivist model of learning as the result of ongoing changes in our mental frameworks as we attempt to make meaning out of our experiences
      ii. To develop scientific inquiry skills, kindergarten and primary age children should be able to do the following skills:
         1. Plan and conduct a simple investigation
         2. Employ simple equipment and tools to gather data
         3. Use data to construct reasonable explanations
         4. Communicate the results of the investigations and give explanations

III. Teaching the Process of Inquiry
   a. *National Science Education Standards* emphasize that as a result of scientific investigations in the primary grades, all students should begin to develop the abilities necessary to do even more advanced scientific inquiry in later years
      i. Children discover the content of science by using the processes of science inquiry
         1. Can be done through:
            a. Science investigations
            b. Class discussions
            c. Reading and writing
            d. Variety of other teaching strategies
   b. Science process skills are those that allow students to process new information through concrete experiences
      i. Are also progressive, each building on and overlapping with one
ii. Skills most appropriate for preschool and primary students are the basic skills of:
   1. Observing
   2. Comparing
   3. Classifying
   4. Measuring
   5. Communicating

iii. As students move through the primary grades, mastery of these skills will enable them to perform intermediate process skills that include:
   1. Gathering and organizing information
   2. Inferring
   3. Predicting

iv. If students have a strong base of primary and intermediate process skills, they will be prepared by the time they reach the intermediate grades to apply those skills to the more sophisticated and abstract skills

IV. Science Process Skills Used in Inquiry

a. Observing
   i. Most fundamental of the scientific thinking process skills
      1. Senses of sight, smell, sound, touch, and taste are the means by which our brains receive information and give us the ability to describe something
   ii. Teaching strategies that reinforce observation skills require children to observe carefully to not specific phenomena that they might ordinarily overlook
   iii. Observation is the first step in gathering information to solve a problem
      1. Students will need opportunities to observe size, shape, color, texture, and other observable properties in objects
      2. Teacher statements and questions facilitate the use of this process:
         a. “Tell me what you see”
         b. “What do you hear?”
         c. “What does this feel like?”
         d. “How would you describe the object?”

b. Comparing
   i. Comparing process is the first step towards classifying
   ii. Teachers can encourage children to find likenesses and differences throughout the school day
   iii. The comparing process builds upon the process of observing
      1. In addition to observing the characteristics of an object such as a leaf, children learn more about the leaf by comparing it to other leaves
      2. Statements and questions that facilitate the comparing process include:
         a. “How are these alike?”
b. “How are these different?”
c. “Which of these is bigger, wetter, etc.?”
d. “Compare similarities and differences between these two animals”

3. Begin by having children tell you about the characteristics of the objects
   a. Next, have the children compare objects and discuss how and why they feel the objects are similar or different

c. Classifying
   i. Begins when children group and sort real objects
   1. Grouping and sorting are done based on the observations they make about the objects’ characteristics
      a. To group, children need to compare objects and develop subsets
         i. A subset is a group that shares a common characteristic unique to that group
   ii. Children initially group by one property, such as sorting a collection of leaves by color, size, shape, and so on
      1. As children grow older and advance in the classification process, objects or ideas are put together on the basis of two or more characteristics that are inherent in the items
      2. Scientists from all disciplines use organization processes to group and classify their work whether that work involves leaves, flowers, animals, rocks, liquids, or rockets
   3. Statements and questions that facilitate this process include:
      a. “Put together all of the animals that belong together”
      b. “Can you group them in another way?”
      c. “How are these animals organized?”
      d. “Identify several ways that you used to classify these animals”

d. Measuring
   i. Skill of quantifying observations
      1. Can involve:
         a. Numbers
         b. Distances
         c. Time
         d. Volumes
         e. Temperature
      2. May or may not be quantified with standard units
         a. Children can invent units of measure

e. Communicating
   i. It is through communication that scientists share their findings with the rest of the world
   ii. In early childhood science explorations, communicating refers to the skill of describing a phenomenon
      1. A child communicates ideas, directions, and descriptions orally
or in written form, such as in pictures, dioramas, maps, graphs, journals, and reports.

2. Communication requires that information be collected, arranged, and presented in a way that helps others understand your meaning.

iii. Teachers encourage communication when they ask children to keep logs, draw diagrams or graphs, or otherwise record an experience they have observed.

1. Children respond well to tasks such as recording daily weather by writing down the date, time of day, and drawing pictures of the weather that day.

2. They will enjoy answering questions about their observations.

f. Inferring

i. When children infer, they:

1. Make a series of observations
2. Categorize their observations
3. Try to give their observations some meaning

ii. An inference is arrived at indirectly (not directly, like a simple observation)

iii. The process skill of inferring requires that a reasonable assumption of prior knowledge be present.

1. Requires that children infer something that they have not yet seen because it has not happened or because it cannot be observed directly.

2. For this reason, the inferring process is most appropriate for middle-level grades and the science content associated with those grades.

3. However, science content and inferences associated with past experiences such as inferring what animals made a set of tracks, or the loss of water from plants, or the vapor in air can be appropriate for older primary children.

g. Predicting

i. When you predict, you are making a statement about what you expect to happen in the future.

1. You make a reasonable guess or estimation based on observations of data.
   a. More than a simple guess
   b. Children should have the prior knowledge necessary to make a reasonable prediction.

ii. Ability and willingness to take a risk and form a prediction such as “If you race the metal car with the wooden car, the metal car will go faster” is of great importance in developing an awareness and understanding of cause and effect.

1. This awareness can be developed and refined in many situations into the related skill of perceiving a pattern emerging and predicting accurately how it will continue.
2. The more predictions children are able to make, the more accurate they become
3. Always ask children to explain how they arrived at their prediction
   a. By listening to their reasoning you may find that children know more than you think
h. Hypothesizing and controlling variables = investigation
   i. To be called an experiment, an investigation must contain a hypothesis and control variables
      1. A hypothesis is a more formal operation than the investigative questions that young children explore in the preschool and primary grades
         a. It is a statement of a relationship that might exist between two variables
         b. Typical form of a hypothesis is: if _____, then _____.
         c. With young children, a hypothesis can take the form of a question such as, “What happens if the magnet drops?”
      2. In a formal experiment, variables are defined and controlled
         a. Although experiments can be attempted with primary age children, experimental investigations are most appropriate in the middle and upper grades
ii. Question of “What is a hypothesis?” has probably caused more confusion than the other science processes
   1. Hypotheses can be described as simply the tentative answers or untried solutions to the questions, puzzles, or problems that scientists are investigating
   2. Major types of hypotheses are varied in character, but they correspond to the types of knowledge or understanding that the investigation aims to develop
V. Developing Scientific Attitudes Used in Inquiry
   a. Curiosity
      i. Preschool and primary students are obviously not mentally developed to a point where they can think consciously about forming attitudes for systematically pursuing problems, but they can practice behaviors that will create lifelong habits that reflect scientific attitudes
      ii. Curiosity is thought to be one of the most valuable attitudes that can be possessed by anyone
         1. Takes a curious individual to look at something from a new perspective, question something long believed to be true, or look more carefully at an exception to the rule
         2. This approach that is basic to science is natural to young children
         3. Educational experiences that utilize firsthand inquiry experiences like the learning cycle make use of a child’s natural curiosity rather than trying to suppress it
   b. Skepticism
i. Both science and the child’s environment require healthy skepticism
   1. Children need to be encouraged to:
      a. Question
      b. Wonder
      c. Ask “why?”
      d. Be cautious about accepting things at face value

ii. Experiences designed around direct observation of phenomena and gathering data naturally encourage children to explore new situations in an objective and open-minded fashion
   1. This type of experience can do much toward developing confidence and a healthy skepticism

c. Positive approach to failure and self-image
i. Closely related attitudes
   1. Students need the opportunity to ask their own questions and seek their own solutions to problems
   2. May, at times, mean that they will pursue dead ends, but often much more is learned in the pursuit than in the correct answer
   3. If children are conditioned to look to adult authority figures to identify and solve problems, they will have a difficult time approaching new problems both as students and as adults

ii. For the last 20 years, some educators have believed that children should not be allowed to experience failure
   1. Educational situations were structured so that every child could be successful nearly all the time
      a. Was reasoned that the experience of failure would discourage students from future study
   2. In the field of science it is as important to find out what does not work as it is to find out what does
      a. Real growth in science tends to happen when solutions do not fit what was predicted
      b. Students should not be constantly confronted with frustrating learning situations, but a positive attitude toward failure may better serve them in developing problem-solving skills

iii. The remaining science attitudes include:
   1. Willingness to change
   2. Positive attitude toward change
   3. Withholding judgment
   4. Avoiding superstitions
   5. Integrity
   6. Humility

iv. These remaining science attitudes are additional important attitudes both to science and functioning as a successful adult
   1. Can be encouraged in science teaching both through the teacher’s exhibiting these behaviors and acknowledging students when they demonstrate them
2. All of these attitudes that support the enterprise of science are also quite valuable tools for young students in approaching life’s inevitable problems.

VI. Science Content Knowledge and Learning and the Development of Literacy

a. Why take time to teach science to young children?
   i. You cannot afford not to teach science
   ii. Piaget’s theory leaves no question as to the importance of learning through activity
   iii. The Council for Basic Education reports that there is impressive evidence that hands-on science programs aid in the development of language and reading skills
   iv. Some evidence indicates that achievement scores increase as a result of such programs
      1. This statement is supported by many researchers
      2. Possible explanations for this improvement:
         a. In its early stages, literacy can be supported by giving children an opportunity to manipulate familiar and unfamiliar objects
         b. During science experiences children use the thinking skills of science to match, discriminate, sequence, describe, and classify objects
            i. These perceptual skills are among those needed for reading and writing
         c. As children develop conventional reading and writing skills, they can apply their knowledge to facilitate their explorations in science by reading background material and recording hypotheses, observations, and interactions
         d. Depending on the age level, children may want to communicate what they are doing to the teacher and other students
            i. May even start talking about themselves
         e. Communication by talking, drawing, painting, modeling, constructing, drama, puppets, and writing should be encouraged
            i. These are natural communication outcomes of hands-on science
         f. Reading and listening to stories about the world is difficult when you do not have a base of experience
            i. Once a child has contact with the object represented by the written word, meaning can be developed
            ii. Words do not make a lot of sense when you do not have the background experience to understand what you read
      v. Science also provides various opportunities to determine cause-and-effect relationships
1. Sense of self-esteem and control over their lives develops when children discover cause-and-effect relationships and when they learn to influence the outcome of events

2. Predicting the most probable outcome of actions gives children a sense of control, which is identified by Mary Budd Rowe as “fate control”
   a. She found that problem-solving behaviors seem to differ according to how people rate on fate control measures
   b. Children scoring high on these measures performed better at solving problems

vi. Keep in mind that the child who is academically advanced in math and reading is not always the first to solve a problem or assemble the most interesting collection
   1. If sufficient time to work with materials is provided, children with poor language development may exhibit good reasoning. It is a mistake to correlate language skills with mental ability

VII. Appropriate Science Content
   a. Science content for preschool and primary education is not greatly different form that of any other elementary grade level in that the depth and complexity of the science content and process skills are determined by the developmental level of the child
      i. The way that science is taught is probably far more important than the science content itself
   b. Four main areas of science emphasis that are common in the primary grades are:
      i. Life science
      ii. Health science
      iii. Physical science
      iv. Earth and environmental science
   c. Ideally, each of the four main areas should be given balanced coverage

VIII. Life Science, Physical Science, and Earth and Space Science
   a. Life science
      i. In life science, children in grades kindergarten through four are expected to develop an understanding of:
         1. Characteristics of organisms
         2. Life cycles of organisms
         3. Organisms and environments
      ii. Science teaching at this level is traditionally dominated by life science experiences
         1. Teaching at early elementary grades has its roots in the nature study and garden school movements of the first half of the 20th century
         2. Many programs and materials for young children concentrate much time on life science to the exclusion of other science content
            a. Can be attributed to teachers seeking to take advantage
of children’s interest in what makes up their world

3. Although life science should not be the entire curriculum for young children, it can be an important part of the curriculum.

iii. Life science investigations lend themselves quite readily to simple observations, explorations, and classifications

1. Hands-on experiences are essential to development of relevant concepts, skills, and attitudes
2. Areas of content typically covered with young children are plants, animals, and ecology
3. These experiences should build a foundation for students’ understanding of environmental problems and solutions in higher grade levels and in adult life

b. Physical science

i. In physical science, children in grades kindergarten through four are expected to develop an understanding of:
   1. Properties of objects and materials
   2. Position and motion of objects
   3. Light, heat, electricity, and magnetism

ii. Although prekindergarten children are not able to learn the science concepts at this level, they are able to learn the basic fundamental concepts and skills and gain the familiarity with materials needed to prepare them for higher-level thinking

iii. Young children enjoy pushing on levers, making bulbs light, working with magnets, using a string-and can telephone, and changing matter
   1. This is the study of physical science—forces, motion, energy, and machines
   2. Physical science activities are guaranteed to make a child’s face light up or ask, “How did you do that?”
   3. While it may take years for children to fully understand systems and levers, children of all ages tend to insist that gears must make physical contact with each other in order to form a working system

iv. Sometimes the content of this area is overlooked, which is unfortunate because physical science lends itself quite well to the needs of young children
   1. One advantage of physical science activities is that they are more foolproof than many other activities
   a. Repeatability of activities is a significant advantage in developing a process orientation to science

v. Keep in mind that children are growing up in a technological world
   1. They interact daily with technology
   2. Likely that future lifestyles and job opportunities may depend on skills related to the realm of physical science

c. Earth and space science

i. In earth and space science, students in kindergarten through grade four gain an understanding of:
1. Properties of earth materials
2. Objects in the sky
3. Changes in the earth and sky

ii. The study of earth science also allows many opportunities to help children develop process skills
   1. Children are eager to learn about weather and how soil is formed
   2. Air, land, water, rocks, and the sun, moon, and stars are all a part of earth science
   3. Although these topics are attention grabbers, the teacher of young children must be certain to make the phenomena concrete for them to be effective
      a. Hands-on experiences need not be difficult

IX. Science in Personal and Social Perspectives
a. Health science and nutrition
   i. In the *National Science Education Standards* content standard of Science in Personal and Social Perspectives, children are expected to develop an understanding of:
      1. Personal health
      2. Characteristics and changes in populations
      3. Types of resources
      4. Changes in environments,
      5. Science and technology in local challenges
   ii. Study of health and the human body is receiving increased emphasis in elementary education
      1. Recent concerns about problems of drug abuse, communicable diseases, and the relationship of nutrition and health have given rise to education in both factual information and refusal skills like “saying no”
      2. These learnings will help children take action to prevent the spread of disease, maintain a healthy body, and ask the types of questions that will ensure informed decisions
   iii. Young children are curious about their bodies and are eager to learn more about themselves
      1. Will enjoy exploring body parts and their relationships, body systems, foods, and nutrition
      2. Misconceptions and worries that children have can be clarified by learning “all about me” in a variety of hands-on experiences
b. Science and technology education
   i. Content standard of Science and Technology focuses on establishing connections between the natural and designed worlds and providing opportunities for children to develop their decision-making skills
   ii. By the fourth grade, a child is expected to have gained:
      1. Ability to distinguish between natural objects and objects made by humans
      2. Ability of technological design
3. Basic understanding about science and technology
c. History and nature of science
   i. In the History and Nature of Science content standard, students are expected to develop an understanding of science as a human endeavor
      1. When children are at an early age, teachers should begin to encourage their questions and investigations and when appropriate, offer experiences that involve investigating and thinking about explanations
   ii. Fundamental concepts and principles that underlie this standard have been practiced by people for a long time and extend over all of the units:
      1. Men and women have made a variety of contributions throughout the history of science and technology
      2. Although men and women using scientific inquiry have learned much about the objects, events, and phenomena in nature, much more remains to be understood
         a. Science will never be finished
      3. Many people choose science as a career and devote their entire lives to studying it
         a. Many people derive great pleasure from doing science
   iii. *Taking Science to School* highlights four themes that cut across all of the discussions of knowledge growth after preschool:
      1. Primary age children are building on the products of preschool knowledge growth
         a. Clear that the cognitive achievements of infants and toddler provide older children with the foundation for further understanding
      2. A great deal of developmental science learning during the elementary school years involves learning about more detailed aspects of mechanisms and facts explored in earlier years
         a. Whether it is gear action or notions of digestion, primary age children use concrete thinking to explore the details learned in preschool and infancy
      3. As children develop more concrete models of thinking, they will form many misconceptions, some of them dramatic
         a. Not necessarily a step backward
         b. Moving through a series of misconceptions may be the only way for progress toward an accurate notion of mechanism to develop
      4. Keep in mind that the primary and elementary years include further periods of conceptual change for children
         a. New insights can change the way a concept is understood and there is a growing awareness of the similarities between children's and scientists' concept development as well as the differences between them