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ABSTRACT

This article discusses the nature of science and of the child, and the implications of these natures for the teaching of science in the preschool. It is argued that science has three interrelated aspects: content, process, and attitude. Science education should integrate all three aspects. Content can be separated into the areas of physical, life, and earth science. Process concerns the inquiry skills that children must develop to be directly involved in gathering, organizing, analyzing, and evaluating content. Attitude involves the development of a scientific attitude that includes openness and objectivity. It is argued that children learn best through active hands-on activities and that they should be encouraged to actively explore and construct their own knowledge. Teachers should be aware of daily experiences that might involve science; make available a variety of equipment and materials; and remember that meaningful learning is an active, self-regulated process. (RH)

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# SCIENCE, SCIENCING AND SCIENCE EDUCATION

## an integrated approach to science education in early childhood

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## Abstract

This article discusses the nature of science, the nature of child, and their implementations to science education in early childhood. It is believed that science has three interrelated components--content, process, and attitude, and science education should integrate all the three components. It is also stated that children learn best through active hands-on activeties and they should be encouraged to actively explore and construct their own knowledge. The teacher's role is briefly discussed.

# Science, Sciencing and Science Education

## An Integrated Approach to Science Education in Early Childhood

### The Nature of Science and Science Education

The world is so developed in science, and science has tremendous importance in our lives. Science is everywhere and everywhere has science. Nobody would doubt that everyone should learn science in ord live efficiently and successfully in a science society. However, there is no all-agreed definition of science. There are probably as many definitions of science as there are scientists (Anderson, 1970). Science may be defined as a body of organized knowledge, or the process of becoming aware of and understanding ourselves, other living things, and the environment through the senses and personal exploration, or science is just the belief in the ignorance of experts (Feynman, 1969). As definition differs, different models for science teaching have been developed, and they differ by placing an emphasis on either content, process, discovery learning, or problem solving as the central focus of the curriculum (McNairy, 1985). Obviously, how we define science, to a large extent, determines what and how we teach science. This article will discuss the nature of science , the nature of child, and their implications for science teaching in the preschool.

### Conventional Approaches

In the past, science has been approached as a body of knowledge, or facts, to be memorized and repeated later on a test. The 1960s saw a movement in science away from the product, or content, emphasis toward a process orientation. Science was becoming more of a "doing" thing.

Science educators began using the term sciencing to focus on this change of approach (Cain & Evans, 1984). The hands-on, process-oriented kit approach to elementary science was introduced into many programs. Reliance on the textbook and the teacher for information has given way to a more direct hands-on approach. Science or sciencing is beginning to be seen as a means rather than an end and product. Preschool children are involved in generating, organizing,and evaluating science content, not merely in memorizing it.

Traditionally, science is an accumulation of systematized facts. This is partially correct: Science does accumulate facts. Indeed, it accumulates them at an astonishing rate. Scientific and technical journals publish thousands of research studies every day. Not only are facts accumulating at a rapid pace, but knowledge is constantly being revised. How can you as a teacher possibly keep on top of the facts when they are increasing and changing rapidly? You cannot; nor can a scientist. A scientist can hope only to keep abreast of developments in one small speciality. Of course, many ideas in science have been around for a long time and are of proven validity, but even of these the quantity is enormous. If science teaching is viewed to transmit the facts of science, it is going to be unrealistic, and obviously a teacher can hardly find the time to keep current. A even vital problem is that of choosing the material that will be use to students 20 years from now; to expect to make a valid choice would be presumptuous.

Science teaching that uses a factual approach is primarily concerned with imparting the findings of science to students. The most efficient method of teaching facts is by reading, recitation, demonstration, drill, and testing. There is nothing innately boring about this approach--some teachers are quite skilled in making factual learning exciting--and it is emphasized by many teachers who have a feeling of class control that they do not enjoy with other approaches. This type of learning conveys a sense of efficiency and of ease in evaluating student progress. The facts represent the product of science. To teach only the product of an enterprise is to minimize the importance of the processes that produced this product; moreover, when the process is ignored, the product cannot be fully understood. Teaching only the facts of science also gives the student the impression that science merely catalogues facts. Although some argue that children must learn facts before they can use them in higher mental activities, this is unrealistic. Exactly what problem an individual will be required to solve is unpredictable; yet, unless this is known, it is impossible to decide what facts he is going to need in order to solve the problem.

Another approach also emphasizing the product of science is conceptual approach. For this approach, the principal findings of science can be tied together into a limited number of conceptual schemes. Teaching at a conceptual level involves some problems that are not present on the factual level: Acquisition of concepts is more personal than acquisition of facts and requires more than memorization: the individual must have the opportunity of working with concrete objects, acquiring facts, and mentally manipulating ideas. Teaching the conceptual schemes creates a truer picture of the nature of scientific enterprise than does the teaching of facts. Scientists are not satisfied merely to collect facts, but strive to organize them into a model or explanation. By studying the conceptual schemes, the child can gain some understanding of this aspect of science; by considering the factual basis of the conceptual schemes, he can better understand the strengths and weaknesses of scientists' models.

But science is also a dynamic enterprise. It includes the process, or way in which these products were formulated. A process approach to science teaching is based on the examination of what a scientist does; therefore, the end of instruction would be to have the student behave like

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a scientist. The specific behaviors are derived from an examination of what a scientist does and are called the processes of science. In order to teach the child these behaviors, it is necessary that he actually observe, measure, infer, predict, etc.; in short, that he acts like a scientist. This approach then necessarily involves less reading about science and more involvement with concrete materials. Theoretically, a process approach can give the pupil a valid understanding of the nature of science: He can experience the excitement and frustrations that are a part of science and can better understand its products because he has an awareness of some of the problems of the scientist.

In fact, the three approaches to science teaching overlap in practice. It would be difficult if not impossible to teach solely on a single level. Teachers who emphasize facts often teach conceptual schemes. Unfortunately, though, the concepts are usually taught as facts. Teachers who stress concepts cannot avoid teaching facts, for facts are the basis upon which concepts are built. Neither can the processes be ignored while teaching for concept formation, for the strength of a concept cannot be determined without an understanding of the processes used in its formulation. Teachers of scientific processes must of necessity deal with the products of science, for the children must observe, measure, infer, and predict something. The processes cannot stand alone.

### An Integrated Approach

It is difficult to write a short, simple, universally accepted definition of anything as complex as science. A working definition of science, according to The Columbia Encyclopedia, reflecting the approaches generally accepted today in science education, is:

> Science is an accumulated and systematized learning, in general usage restricted to natural phenomena. The progress of science is marked not only by an accumulation

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of fact, but by the emergence of scientific method and of the scientific attitude.

Science, then, has three components: (1) products--facts, principles, laws, theories; (2) process or methods--certain ways of investigating problems, e.g., making hypotheses, designing and carrying out experiments, evaluating data, measuring, etc. (3) attitudes--certain beliefs, values, opinions, e.g., suspending judgement until enough data has been collected relative to the problem, constantly endeavoring to be objective. A practicing scientist studies natural phenomena through observation, experimentation, and rational analysis. He utilizes certain attitudes, such as trying to be objective, while collecting and evaluating his data. He also follows various experimental and statistical procedures in his efforts to clarify the mysteries of the universe. By so doing, he makes discoveries, and these findings become the products of science.

The product content of science includes the accepted facts, laws, and theories of science. Elementarily, science content can be separated into three areas: physical, life, and earth. Physical science is the examination of nonliving phenomena. Typical topic areas include air, magnets, electricity, changes, energy, matter, sound, simple machines, and light. Life science is the investigation of living things. Three basic divisions of this content area include zoology, the study of animals and humans: botany, the study of plant; and ecology, the study of the interaction of plants, animals, and the environment. Typical topics from these divisions are our bodies, different types of animals, life cycles, seeds, parts of a plant, molds, communities, and pond life. Earth science content is drawn from the areas of astronomy, meteorology, and geology. Astronomy topics include day and night, the planets, seasons, stars, the moon, and the sun. Typical meteorology topics are solar energy, clouds, and weather and weather instruments. Crystal formations, rocks, erosion, and fossils are some geology topics usually studied.

The process component of science focuses on the means used in acquiring science content. In early childhood, science must be thought of not as a noun-a body of knowledge or facts to be memorized-but as a verb-acting, doing, investigating, a means to an end. At this level how children acquire scientific information is more important than committing to memory scientific facts. Preschool children need direct involvement with science content. They need hands-on experiences that involve them in gathering, organizing, analyzing, and evaluating science content. That is the core of sciencing, A sciencing approach necessitates a change in the traditional roles of both the teacher and the preschooler. No longer is the teacher's main role that of information-giver. No longer is the student to be merely a sponge "soaking up" the information given. The sciencing approach demands the active participation of the student, with the teacher serving as guide and resource person. To be successful with the sciencing approach, the learner must develop certain process-inquiry skills. Mcnairy(1985) identified six basic process skills which believed appropriate for young children. These processes are as follows:

1. Observing--using the senses to find out about subject and events;
2. Classifing--grouping things according to similarities or differences;
3. Measuring--making quantitative observations;
4. Computing--finding out quantitative relations;
5. Experimentating--investigating, manipulating, and testing to determine a result;
6. Predicting--making forecasts of future events or conditions based upon observations or inferences.

Process-inquiry skills are basic to all scientific disciplines, certainly to all later learning of preschoolers. They are not separate from science content; rather they are the "tools" of scientific investigation. The utilization of these skills in gathering, organizing, analyzing, and evaluating science content should be an ongoing goal of science education for early childhood.

Scientific attitude is an important component of sciencing. The teacher must encourage children to develop a need for seeking rational answers and explanations to natural and physical phenomena. As a teacher, capitalize on children's natural curiosity and promote an attitude of discovery. Focus on the students' fining out for themselves how and why phenomena occur. Developing objectivity, openness, and tentativeness as well as basing conclusions on available data are all a part of the scientific attitude. As Cain and Evans (1984) Point out that the concept of intelligent failure should be developed at the preschool level. Children should not be afraid to stick their necks out and make intelligent mistakes. Much scientific knowledge has resulted from intelligent mistakes. These scientific attitudes--curiosity, humility, skepticism, open-mindedness, avoidance of dogmatism or gullibility, and a positive approach to failure--have become rules of behavior in scientific investigation, observe Carin and Sund (1975). Science can be fun and stimulating. Children should be involved in "messing about" activities as well as structured experiences

In summary, it is obvic 's that how we define science has an impact or. what and how we teach science. The three science interrelated components-content, process, and attitude-- should provide structure and guidance for the preschool teacher in planning appropriate experiences for children. The first component identifies the physical, life, and earth science content that children should explore. The second component identifies the process-inquiry skills that children must develop to be directly involved in gathering, organizing, analyzing, and evaluating the content. The third component concern tl.. way children "see" science or feel about science. It involves developing a scientific attitude that include openness and objectivity. In answering the question "What is science?", one must describe science as content, science as process, and science as attitude. These three components should provide the teacher with the appropriate structure needed to make decisions about what a student should learn in science, how a student should learn it, and the attitudes that a student should develop.

### The Nature of Child and Science Education

However we know about what science is and what we should teach in science education through above discussions, we need to continue to explore how we should teach science to young children. It is by no means sufficient to know only "what", pracatically more important is to know "how"--ways to carry out ideas and reach goals. By discussing how children construct knowledge according to Piagetian theory, it is hoped that we can find ways to offer young children appropriate science experiences.

Piaget has provided us with one of the best descriptions of how children think and characteristics of their thinking at different stages of their development. The preoperational stage particularly interests early childhood educators because it encompasses a range from two or two-and-a-half to about seven years of age. Children at this stage have not yet developed the ability to think logically or abstractly; reasoning is unsystematic and does not lead to the generalization or formation of logical concepts. Preoperational children's thinking is bound by perception. Children can focus on only one attribute of an object at a time, usually the most predominant feature such as size, shape, or color. Preoperational children can focus only the beginning or end state of a transformation itself, and their thinking is not reversible. preoperational children are unable to conserve and thus are not able to recognize the invariance of a number of objects when their spatial arrangement is transformed. Young



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children also can not compensate for changes in dimensions. Preoperational children's thinking is egocentric. Children view the world from their own perspective. Egocentrism makes it difficult for children to imagine how an object or scene might look when viewed from positions other than their own.

Clearly, science teaching in early childhood should take into account how children think and learn. Decisions about appropriate content and experiences should be based on the immediate needs and developing abilities of each child in the classroom. Smith (1981) clearly points out, "Because preoperational children learn by acting on objects, concepts of natural phenomena must be developed through manipulation of items within children's immediate environment and observation of children's reactions under varying circumstances. Abstract concepts outside the realm of immediate experience should not be included in an early childhood science curriculum."

Although young children might be limited conceptually, there are no limits, unless adults set them, to childre's curiosity, imagination, zest for learning, and interest in the many things about them. Experiences in science not only satisfy childre's curiosity and interest, but also are the best vehicle for helping children make that important transition from thinking that is perception-bound, egocentric, and illogical to thinking that is flexible, reversible, and capable of conserving.

Science for young children is finding out about the world in which they live. Young children find out through hands-on experiences with objects and events in the immediate environment. According to Piaget, experiences build upon each other. Children must actively relate something new in their experience to their experiences previously encountered, assimilated, and stored as mental structures or understandings. Otherwise there is little chance children will understand

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a new experience.

Essentially according to Piaget, there are three types of knowledge--social, physical, and logical-mathematical--that are qualitatively different. Social knowledge is that which is arbitrary or conventional and is based on social consensus or agreement among people. The source of this knowledge is external to the child, and social knowledge must be learned from other people. Physical knowledge, the source of which is also external to the child, is derived from objects themselves rather than from people. Children discover knowledge about physical objects through their actions on the objects and their observation of the reactions of the objects to those actions. In contrast to social and physical knowledge, logical-mathematical knowledge--or the relationships that a child introduces and imposes on the objects of physical knowledge and the content of social knowledge--is internal. These relationships are invented or constructed by the child's own mental activity. These types of knowledge are interrelated in the young child. Children must have a logical-mathematical framework in which to assimilate knowledge about physical objects, and they also must use physical objects to construct the logical-mathematical framework (McNairy, 1985; Smith, 1987).

In summary, an early childhood science program should be child-centered and activity-oriented; it should provide children with a varied environment to explore at their own pace and according to their individual cognitive abilities. In the active explorations, children should be encouraged to observe carefully, note similarities and differences, make predictions, test out their predictions, ask questions, and interact with one another and with the teacher. They should be constantly encouraged to think and talk about what they are doing and seeing. Children will not only be learning science, they will also be engaging in experiences that develop logical and systematical thinking.

## The Teacher's Role in Sciencing

Chil˙ ˙entered and activity-oriented sciencing experiences should by no means disemphasize the teacher's role in facilitating children's learning, to the contrary it challenges the teacher to play a more important and appropriate role. Smith (1987) well describes the teacher's role in sciencing as follows:

1. Teachers should be aware of daily experiences that might involve science. Such an awareness enable. the teacher to capitalize on the children's involvement with a science experience, either by leaving them alone to pursue their own curiosities or initiatives, or by encouraging them to observe more closely, ask questions, and compare and classify what they are acting on, or to make their own discoveries.

2. To encourage and facilitate children's explorations with science-related phenomena, a variety of equipment and materials should be mad available. The way in which materials are introduced to young children can maxmize their initiative. The teacher can put out materials that children will naturally gravitate toward. The teacher can present specific materials and ask children to think of different things they could do with the materials.

3. In guiding children's experiences in science, teachers should remenber that "meanigful learning is an active, self-regulated process". Any attempt to shape the child's behavior according to predetermined objectives may interfere with this self-regulation.

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