DOCUMENT RESUME

ED 224 704 SE 039 824

AUTHOR Martin, Ralph E., Jr.
TITLE "HANDS" - How About New Directions in Science Teaching?
PUB DATE Jan 83
NOTE 16p.; Prepared for teachers of the Athens, OH, City Schools, Inservice Day, January 1983.
PUB TYPE Reports - Descriptive (141)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Discovery Learning; *Discovery Processes; Elementary Education; *Elementary School Science; *Process Education; Science Education; *Science Instruction; *Teaching Methods

ABSTRACT

Many new directions for science teaching were developed during the post-Sputnik era. Hands-on science teaching remains a popular direction, yet may be seen as something complex or mysterious by those not familiar with some of the jargon which usually accompanies any discussion of science teaching. This paper responds to several questions teachers may have about hands-on science teaching. These questions include: What is hands-on science teaching? What are the benefits and liabilities for teachers and students? What should be taught? How should science be taught? Focusing on discovery as hands-on teaching/learning, the nature and benefits of discovery learning are explored, including the use of this teaching method in elementary school science programs. Since the teaching of processes is fostered, examples of what children can do when observing, classifying, measuring, communicating, inferring, and experimenting are provided. Various instructional strategies teachers can use, including questioning techniques, are also provided. (Author/JN)

"HANDS" --

How About New Directions in Science Teaching?

A paper prepared expressly for the teachers of the Athens City Schools, Inservice Day, January, 1983.

Ralph E. Martin, Jr., Ph.D.
Assistant Professor,
School of Curriculum and Instruction
Ohio University
Athens, OH

"HANDS" --

How About New Directions in Science Teaching?

Many new directions for science teaching were developed during the post-Sputnik era. Hands-on science teaching remains a popular direction, yet may be seen as something complex or mysterious by those not familar with some of the jargon which usually accompanies any discussion of science teaching. This brief paper hopes to present my responses to several questions you may have in mind about hands-on science teaching.

1. What is hands-on science teaching?

An approach to teaching a subject should grow out of the philosophical basis for its definition. While you will find probably as many definitions of science as there are teachers, you will also find common elements which comprise its definition. Carin and Sund (1980), highly regard science educators, tell us that science has three major elements: attitudes, processes or methods, and products. Attitudes are regarded as certain beliefs, values, or opinions one has relative to science. These attitudes affect subjectivity or objectivity during the study or act of sciencing. As may be implied through the effects attitudes have, the processes or methods of investigating the problems of science, the way of going about the completion of a task, provides a way of permitting one's attitudes to be expressed. Examples of processes typically are observations, inferences, analyses, and evaluations made in response to science activities. Careful use of processes help the investigator make discoveries and become what are regarded as the findings or products of science.

For many years it has been a practice to focus on the learner's attainment of products, e.g., the learning of facts, principles, laws, and theories, as evidence of scientific learning. But focusing only on products diminishes the development of the attitudes and processes of science. Hence, learning is incomplete. Therefore it appears there is much more to learning science than implied by its Latin translation -- knowledge. A vital part of learning science encompasses attitudes and processes. In fact, a goal of contemporary educators is the training of well-rounded students, those who possess qualities of the three major elements. This goal is called scientific literacy.

What does this have to do with hands-on science? The approach to teaching children science "... should grow out of what we know about the processes and products of science, how they learn best, what goals and objectives we have in science education, and what relationships are among science, humanism, values, and our concerns for the environment" (Carin & Sund, 1980, p. 74). Because each learner is unique, it is difficult to select absolutely one best way to teach all children. But, one approach to teaching science does seem to address the three major elements and the above aspects of learning better than others. This method often is called discovery or inquiry teaching/learning and is most often stressed in the major federally and privately funded science programs. In short, discovery may be called "hands-on" teaching and learning.

The experiences afforded children when they are given an opportunity to manipulate objects are numerous. Those schooled in Piagetian principles of learning recognize the importance of concrete experiences for children in various stages of mental development, yet not capable of sustained learning through abstract operations. Hands-on lessons are designed so students, through their own mental processes, discover concepts and principles for themselves. Students learn by working with their hands and minds. The opposite of helping children discover or learning through hands-on exercises is telling them. "To make their own discoveries, students must perform certain mental processes such as observing, classifying, measuring, predicting, describing, and inferring" (Carin & Sund, 1980, 74). The fun, challenges, frustrations, and accomplishments of hands-on learning contribute to well-rounded realistic attitudes.

Because learners are unique, it is difficult to find one best method of teaching all children. It is fair to challenge the idea that hands-on teaching/learning may be best for all. Also, to be fair, hands-on methods do have liabilities, but do the liabilities outweigh the benefits? In the next section we will examine recent research to help us answer this question.

2. What are the benefits and liabilities for teachers and students?

Hands-on learning is suggested because the discovery made possible by the approach seems to incorporate the best of what is known about the processes and products of science, how children best learn, the goals of science, and the interrelationships among science, values, and human concerns for the environment. Some of the advantages often stressed are that children learn how to learn, are rewarded by their learning, are active participants rather than passive recipients of knowledge, learning is more easily transferred and builds positive self-concepts, and children become responsible learners.

Hands-on teaching/learning and discovery processes are quite flexible. They may take three basic forms: guided, less structured, and free. These forms are frequently found in some combination in the methods specifically suggested by popular curricula: Science - A Process Aproach (SAPA), Science Curriculum Improvement Study (SCIS), and Elementary Science Study (ESS). (A discussion of some of these teaching/learning processes will be taken up during question 4.) Many studies have been conducted over the past years to determine the efficacy of these programs. You might ask, "if they are so good, why doesn't my school district use them?" Expense, too much teacher preparation time, and the students didn't seem to learn are three common reasons given. Each of these reasons has merit, but it is the third, i.e., student learning, which can legitimize the first two. If there are no benefits for students, then it is difficult to justify extra expense and teacher preparation time. Critics accept this argument and interpret no student benefits as being all that is needed to justify going "back to the basic" traditional textbook orientations found before the "new" elementary curricula of the 1960's. But were the "new," hands-on curricula really no more effective than "back to basics" proponents suggest?

To find out, Shymansky et al. (1982) analyzed nearly 100 independent studies that compared the performance of children in SAPA, SCIS, or ESS classrooms with the performance of children in what are regarded as traditionally taught, textbook oriented classrooms. "The average student in the ESS, SCIS, or SAPA classroom performed better than 62% of the students in traditional classrooms across all performance criteria measured -- a 12-percentile-point gain" (Shymansky, 1982, p. 14). Shymansky et al. (1982) provides a profile comparison of synthesized data for the hands-on programs in the following table.

Performance Improvement for Students in Classrooms Using ESS, SCIS, or SAPA as Compared to Students in Traditional Classrooms

Performance Area	Percentile Points Gained ESS	SCIS	SAPA
Achievement	4	34	7
Attitudes	20	3	15
Process Skills	18	21	36
Related Skills	—*	8	4
Creativity	26	34	7
Piagetian Tasks	2	5	12

*No studies reported.

As to the claim that children taught by the new programs didn't learn, Shymansky et al. (1982) has the following to say.

"We analyzed 20 studies that compared student achievement in new science curricula with achievement in traditional programs. Measured in percentile point differences, students in ESS classrooms scored 4 points higher than students in textbook-based classrooms; students in SAPA classrooms scored 7 points higher, and those in SCIS classrooms scored 34 points higher. When we examined the studies for possible test or experimenter bias favoring students in the new curricula, we found no evidence of bias. The results were consistent when either standardized or special tests were used. Contrary to a popular notion that hands-on, activity based science curricula lacked a potent academic content base, we found that students using these three new programs actually outscored students in the more traditional classrooms -- by as much as 34 percentile points." (p.14)

In sum, the hands-on science programs seemed to produce improved attitudes and skills over the levels reported by traditional programs promoted by "back to basics" groups and the perceived lack of rigor in hands-on programs simply is not supported. The argument used by "back to basics" groups, i.e., students don't benefit, doesn't hold. Why then weren't the hands-on programs widely adopted?

When the hands-on programs were popular and widely available many administrators (often without full approval of their teachers) were attracted and purchased district wide programs like SAPA, SCIS, and ESS. Often they did not understand completely what the programs involved or intended to do. A natural consequence was for the programs to be shelved when teachers opposed them. In turn, the textbooks were dusted off and put back into service.

The hands-on programs of yesteryear can provide many worthwhile advantages to teachers and students, yet contemporary science educators do not suggest a complete about face or blind return to these curricula. What is suggested is that teachers, curriculum coordinators, and curriculum selection committees re-examine the hands-on curricula for activities and teaching ideas germane to existing programs. If schools/teachers have relicts of abandoned hands-on programs which can be examined with renewed interest, what types of lessons should be selected for teaching?

3. What should I teach?

A primary goal of any form of education is to expand children's thinking skills. This goal is accommodated in the science teacher's quest for children to attain scientific literacy. For children to grow in their thinking, they need opportunities to explore the properties of objects and share what they've found with others. Exploration and sharing suggests a method, a process for exercising thinking.

"What should I teach?" is often answered in terms of the content or factual knowledge which is prepared by a teacher and learned by students. Hands-on science is concerned with content, but not preoccupied with it. How the knowledge is acquired may be more important than what is learned. It is believed that if a student can learn to think and evaluate the outcome of his/her experiences, then s/he will be better schooled, a more critical thinker, more scientifically literate. Therefore, rather than select lessons on the basis of content, teachers are urged to screen activities and materials with a critical eye toward the processes stressed -- the how of learning.

The how of learning science refers to skills used during the process of acquiring knowledge. These skills are sometimes called science processes because scientists use them when they work. In fact, these skills are common to many fields and every day life experiences. What are these skills and how can they be applied in science teaching?

The following science processes have been adapted from Gega (1980, p. 60-61) and are listed and defined here operationally. Questions a teacher may ask or directions a teacher may give provide an example of how these processes may be used in the classroom.

1. Children observe when they:

    a. Identify properties of objects by using any or all of the senses.

        "What does it smell like?"

    b. Notice changes in objects or events.

        "How has the aquarium water changed since Friday?"

    c. Identify similarities or differences in objects or events.

        "How are these bones different? Alike?"

2. Children classify when they:

    a. Group objects or events by their properties or functions.

        "Think of one property, such as a certain shape. Sort all the objects that have that property into one pile. Leave what is left in another pile."

    b. Arrange objects or events in order, by some property value.

        "How can you group these animals by kind and by what they eat?"

3. Children <u>measure</u> when they:

   a. Use standard tools, e.g., meter stick, ruler, clock, balance, to find quantity.

   "Who is taller?"

   b. Use familar objects as arbitrary units to find quantity.

   "Why don't we get the same number when we use your feet to measure distance?"

   c. Make scale drawings or models.

   "If one inch equals one million miles, how many inches apart should the planets be in our model?"

   d. Use simple sampling and estimating technologies.

   "How can we find out about how many grasshoppers are in the field?"

4. Children <u>communicate</u> when they:

   a. Define words operationally.

   "A towel is dry if it balances an unsoaked towel from the same package."

   b. Describe objects or events accurately.

   c. Make accurate charts and graphs.

   d. Record data accurately as needed.

   e. Construct accurate models.

   f. Draw accurate diagrams, pictures, and maps.

5. Children <u>infer</u> when they:

   a. Distinguish between observation and inference.

   "There are two sets of footprints -- one large and deep, the other small and shallow. One set was probably made by a man, the other by a boy."

   b. Interpret recorded data.

   c. Interpret data received indirectly.

   d. Predicts from data.

   "Today my plant is 10 centimeters tall. Monday I think it will be 11 centimeters tall.

   e. Hypothesize from data.

6. Children experiment when they:

   a. Design an investigation in which variables are controlled.

      "I made sure my seeds were planted the same depth and had the same amount of water, heat, and light, but I planted them in different kinds of soil."

   b. State hypotheses and use other processes in the investigation.

      "I think the seeds in the sandy soil will grow better than the seeds in clay soil."

The use of processes in teaching/learning has ramifications for the kinds of questions teachers ask and how they sequence instruction. The next section affords you an opportunity briefly to examine some teaching strategies used in hands-on classrooms.

4. How should I teach science?

A hands-on teacher of science seldom tells, but often asks questions and sees little wrong with responding to student questions with another question. A properly phrased question is a hint which students can use to solve their own problems, answer their own questions.

Carin and Sund (1980) have a particularly strong chapter which provides practical tips on questioning skills. They advise teachers before devising their questions to decide the following (p. 90);

1. What talents are you trying to develop?
2. What science processes are you trying to nurture?
3. What subject-matter objectives do you want to develop?
4. What are the likely and desireable answers?

Carin and Sund (1980) offer a ready list of suggestions as to the kind of questions appropriate for children. You will notice the obvious stress on process skill development in the list which follows.

Teachers of primary and lower elementary children are urged to devote attention asking questions related to (p. 100):

1. Observing, grouping, measuring, using numbers and placing objects in series or order.

2. Making inferences.

3. Using time and space and conserving substance, length, area.

4. Reversibility and making predictions.

5. Values and interpersonal relations.

Children in the upper elementary grades should be asked questions from the above plus the following list:

1. Forming hypotheses, learning to control variables and design experiments.

2. Interpret the results from experiments.

3. Conservation of weight and volume and making operational definitions.

Questions are probably the most important tool a teacher has and can be used as part of an overall method of teaching. During hands-on lessons teachers often follow a type of pattern or cycle when teaching. A generic learning cycle which students follow as a result of hands-on teaching has basically three components: exploration, concept development, and application of what they have learned.

Exploration is a less structured phase of learning where students are actively involved with hands-on activities teachers have provided. The emphasis is on student observation or study of objects or phenomena through manipulation.

Concept development is a stage of learning where the teacher plays a more active part. The learning environment is somewhat less flexible than during exploration. Here teacher questions serve a vital part of focusing the lesson on the concept to be learned. Teachers may use demonstrations, written materials, or discussion. Emphasis is given to the experiences students had during the exploration phase because they now have a concrete, experiential basis for reflecting upon the concepts explored during the present phase. Any abstract or technical terms may be introduced by the teacher or dealt with as they arise from student questions.

The application phase invovles students in applying what they have learned or discovered during the prior learning phases to new encounters or phenomena. It is a good practice to relate the application phase to the students' everyday lives and the common or mysterious objects/happenings around them. Because of prior hands-on experiences and concepts developed through thoughtful questioning, students are better able to move toward applying what they have learned in more abstract fashions. Critical thinking is developed by using concrete referents.

Aspects of the generic learning cycle are inherent in the teaching strategies used in the major hands-on science programs. Of the three mentioned earlier, SAPA is highly structured and relies nearly completely on process skill development. SCIS is more middle of the road with moderate structure while ESS has little or no structure in processes and content.

SAPA relies on strong adherance to an instructional hierarchy and sequence of prerequisites. Teachers are given detailed lesson plans with specific questions to ask students.

The basic SCIS methodology is a near copy of the learning cycle mentioned earlier while the strategies of ESS bear a resemblance, yet vary much from the generic learning cycle description.

An interesting phrase was coined by David Hawkins, the developer of ESS. After children have been given general teacher instructions or a sense of purpose, they are given an opportunity to "mess-about" with the materials provided. Their purpose is to explore and try to find answers, but there is ample room for them to do so in a creative fashion because they arenot given precise instructions. As children "mess-about" they discover at different paces and are multiply-programmed (second phase) as the teacher gives them wide choices or prescribe learning tasks based on their progress. This phase relies heavily on teacher observation and use of questions as hints or suggestions to students. The last stage, discussion sharing, permits groups or the entire class to share/compare their discoveries and suggest practical applications of newly discovered concepts. The teacher usually provides active leadership during this phase. Hawkins insisted these instructional phases not be viewed in a particular sequence. To reinforce his viewpoint he used symbols to represent the phases, ○, △, □.

Like ESS, be aware it is not necessary nor advisable to follow the generic learning cycle in a strict sequence. The teacher is afforded the flexibility of ordering the phases as best fits the children. Additional exploration and concept development may be necessary in some cases before students are successful at application. Also, additional exploration and application exercises may enhance concept development. In general, the less familiar students are with the concepts to be learned, the more hands-on learning opportunities are necessary. Remember, no amount of reading, writing, or listening will substitute for <u>real</u> experiences with <u>real</u> things.

5. Where can I find ideas, activities, or help?

Many very good products and publications are available for helping you find ideas or activities. I suggest you examine any old programs or textbooks still in your possession. Look at them with an eye toward process oriented activities and opportunities for developing childrens' attitudes and values. I can't stress activities enough which afford students opportunities for trying things for themselves. I suspect the value of this is clear.

Beyond what you might already have, search through the shelves of the local library with attention to books written expressly for children, or contact the college or university near you. Most have someone able and usually willing to help. Below are several of my favorite resources you might wish to examine, some have been used as a reference for this paper. In closing let me add that you shouldn't be afraid to give hands-on science a try. Even if the activities don't work you can have fun and stress the process skills to try to find out what went wrong -- with the help of your students! By all means place the emphasis on the learner, for when children ...

... hear, they forget;

... see, they remember;

... but when they <u>do</u>, they <u>understand</u>.

6. References and Resources

Abruscato, J. and Hassard, J. The Whole Cosmos Catalog of Science Activities, Santa Monica: Goodyear, 1977.

________. Loving and Beyond -- Science Teaching for the Humanistic Classroom, Santa Monica: Goodyear, 1976.

Carin, A. and Sund, R. Teaching Science Through Discovery, Columbus: Merrill, 1980.

DeBruin, Jerry. Creative, Hands-On Science Experiences, Carthage, IL: Good Apple, 1980.

DeVito, A. and Krockover, G. Creative Sciencing: Ideas and Activities for Teachers and Children, Boston: Little, Brown, 1980.

Gega, P. Science In Elementary Education, New York: Wiley, 1977.

Hone, E., Joseph, A. and Victor, E. A Sourcebook for Elementary Science, New York: Harcourt Brace Jovanovich, 1971.

OBIS - Outdoor Biology Instructional Strategies. Nashua, N.H.: Delta Education.

Shymansky, J., Kyle, W. and Alport, J. How Effective Were The Hands-On Science Programs of Yesterday?, Science and Children, November/December, 1982, pp. 14-15.