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AUTHOR	Follette, Everette; Smith, Marian
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ABSTRACT

When teachers search the literature for activities they can do with their students, they are exposed to science process vocabulary that is improperly used and ambiguous in meaning. This is particularly so with the science process skills of observing, inferring, and hypothesizing. This study examines the process understanding of science teachers at various levels in order to see if concerns about their misunderstandings are warranted. To accomplish this goal the Science Process Questionnaire (SPQ) was developed for assessing each teacher's understanding of science processes of observing, inferring, and hypothesizing. The SPQ was administered to 1,378 teachers in 12 states. Total percentage scores (average percentages of correct scores in response to observation inference, and hypothesis statements) are reported: preservice elementary teachers (67%), elementary teachers (70%), preservice secondary teachers (72%), secondary teachers (69%), and college science and science education teachers (77%). Ranges of percentages of correct scores were 84%-93% for observation statements, 59%-77% for inference statements, and 57%-74% for hypothesis statements. (PR)

SCIENCE PROCESS VOCABULARY
OUR FAILURE TO COMMUNICATE

Everette Follette, EdD
Professor of Science Education
Black Hills State University

Marian Smith, PhD
Associate Professor of Biology
Southern University of Illinois

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Everett Follette, EdD, Professor of Science Education, Black Hills State University, Spearfish, South Dakota
Marian Smith, PhD, Associate Professor of Biology, Southern University of Illinois at Edwardsvill, Illinois.

In case you haven't noticed, the nation is embarked on another round of examining the way science is being taught at all levels in the schools. Like the first round of major science curriculum revision that occurred in the early 1960's there is no universal agreement on what science content or concepts should be taught or at what level they should be introduced. However, one of the more universally accepted ideas is that whatever science is taught should involve a good deal of hands-on activity as well as some emphasis on students learning how to "do" science by developing skills in working with and learning the science processes.

The purpose of this article is to share with you what appears to be a major discrepancy between what is being advocated and what is being done in science classes at all levels of learning.

Even though almost every agency c[illegible] for the teaching of the science processes there appears t[illegible] little if any consistency in how the different bo[illegible] define those processes.

Our study of how different gro[illegible] within the education field perceive the science processes originated after a discussion between the co-authors following a four-week workshop we had conducted. The purpose of the workshop was to help elementary teachers improve their science teaching by increasing their skills in hands-on science and their understanding of the science processes as defined by the Commission on Science Education. In our discussion we reflected on what we felt were major gains by the participants in their understanding of science and its processes. We further commented on the hope we had that they would retain their understanding of the processes, a concern that we felt was justified based on what one finds in the current science literature.

We were particularly concerned about the mixed messages that teachers get when they search the literature for activities that they could do with their students. In the procedure of looking they are exposed to process vocabulary that is improperly used. One finds considerable ambiguity of meaning when one examines many of the current science education publications. This is particularly so if part of the reading is with the intention of trying to understand the science processes of observing, inferring or hypothesizing by studying the context in which the terms are used. Following our discussion we felt that it might be informative to examine the process understanding of science teachers at various levels in order to see if our concerns about their misunderstandings were warranted. With this in mind we proposed to develop a Science Process Questionnaire (SPQ) that we could use in assessing each teacher's understanding of the science processes of observing, inferring, and hypothesizing.

Our first step was to submit the science process definitions that we intended to use to experienced science educators (referees) for their inspection. They were asked to examine them, and based on their understanding of the processes, to approve, disapprove or modify the definitions. The science process definitions that we proposed to use were those originally developed by the Commission on Science Education for the elementary science curriculum program called Science - A Process Approach (S-APA) (American Association for the Advancement of Science 1967). Our rationale for this choice of definitions was that the processes that were identified by the commission are the ones most often cited in the science education literature. We were pleased when the definitions were approved by the panel with very little modification.

The following are the definitions that we used in developing the Science Process Questionnaire:

OBSERVATION - Information about objects and events obtained through the use of the five senses.

INFERENCE - An explanation of an observation or a set of observations.

HYPOTHESIS - A generalization that includes all objects or events of the same class.

When the science and science education literature is examined the most frequently misused science process term appears to be that of hypothesis. Often it is used as a synonym for inference rather than in its broader context as a generalization of a set of observations or when an inference is extended to similar situations in slightly different contexts.

In order to make our point about the misuse of the science process terms we would direct you to the following excerpts from recent journal articles and science textbooks:

"As your students complete the assignment, there must be strict rules:
. Before beginning observations, questions (hypotheses) must be completed. (Ciparick, page 59) - Here the author is equating "questions" and "hypotheses".

"A hypothesis is a **possible explanation of an event or a possible solution to a problem.** (emphasis ours) A hypothesis is usually based on the information you have gathered." (Snyder, et al page 22) - In this particular instance "hypothesis" is used in a manner that would be more appropriately called an "inference".

"Once a set of scientific facts (or principles) that describe a natural phenomenon are gathered, investigators try to **explain how or why things happen in the manner**

observed. (emphasis ours) They can do this by constructing a tentative (or untested) **explanation** which we call a scientific hypothesis." (Tarbuck & Lutgens; page 4) - As in the previously cited case the more consistent term would be "inference".

"Present a group of children with a nail, knife or other object that is rusted. Ask them to examine the object and to generate **hypotheses** that would explain how the rusting occurred." (Wasserman and Ivany; page 85) - Another instance where the term "inferences" would be more appropriate than "hypotheses"

"Formulating hypotheses: Making educated guesses based on evidence that can be tested." (Cain and Evans; page 5) - The implication here is that only hypotheses can be tested yet good scientific procedure can be used equally well in testing inferences.

Indeed in examining publications from other countries we find similar inconsistencies as in the following example:

"The children were given a Perspex tank, two liters of water and a glass 'bottle' with a plastic stopper, and asked to find out as much as they could about the bottle. After allowing for such observations as **'the bottle is made of glass'**. I asked for more precision and various measurements were taken. (Head; page 5) - No such observation is possible. The properties of glass can be observed, e.g., it is hard, it is clear, etc. It remains for one to then make the "inference" that the bottle is made of glass.

For persons with a good deal of experience in learning the content of science and who later have done research in the sciences, differentiating between inference statements and hypothesis statements may seem to be an exercise in nitpicking. However, we are proposing that it is this ambiguity of definition and its implications that causes many learners to abandon the learning of science, leaving only those few who persevere and learn to do science in spite of us not because of us.

Once the definitions were approved we developed 20 observation, 40 inference, and 40 hypothesis statements. An attempt was made to develop statements from all science disciplines. The statements were then assembled in random order. The statements along with the approved definitions were sent to our referees with the request to identify the statements as being observations, inferences, and hypotheses.

Following the responses from our referees we determined the statements that received unanimous agreement. From those we chose 10 observation, 20 inference, and 20 hypothesis statements. These statements were then put in random order.

Our next step was to develop a questionnaire that consisted of a series of demographic questions, plus the randomized process statements. The Science Process Questionnaire (SPQ) was then sent to identified persons at universities and schools throughout the country who had agreed to administer the SPQ to various teacher populations in their area. (See appendix for locations and the Science Process Questionnaire)

One thousand three hundred seventy eight SPQ's were administered during the spring and fall of 1990. They were subsequently returned to us where they were scored, sorted by group, i.e. pre-service elementary, pre-service secondary, elementary, secondary, and college teacher, and finally mean percentages were determined for each process as well as mean percentages for the entire questionnaire. No attempt was made to compare groups by geographic location because we were primarily interested in how knowledgeable about the processes of science teachers and future teachers were nationally, or at least to the extent that we felt we could extrapolate to a national population. The scores of each group are shown in the table below.

Group Name	Observation % score	Inference % score	Hypothesis % score	Total % score
Pre-service Elementary Teachers	84	59	57	67
Elementary Teachers	86	61	67	70
Pre-service Secondary Teachers	94	60	74	72
Secondary Teachers	88	63	64	69
College Science and Sci. Ed. Teachers	93	77	68	77

The results we obtained confirmed our original concerns; that is, with the exception of being able to identify observation statements, none of the groups were able to identify inference or hypothesis statements at a level that suggests mastery of the definitions of inference and hypothesis.

In our original discussions we anticipated that if large differences in scores were noted among groups, and if the scores got progressively higher from elementary teachers to college teachers, the difference could probably be attributed to increased training in the sciences. With one exception, we do indeed see increased scores in the expected direction. However, the amount of difference is not of the size one would anticipate when we take into account the difference in scientific training the three groups have received.

Often when concern is expressed about how science learning might best be improved in the elementary schools the conventional response is that pre-service elementary teachers need more science content courses. However, if one of our priorities is that elementary students improve their skills in "doing science" then it would seem to follow that their teachers must also be better trained in "doing science" rather than just spouting science facts documented in their science textbooks.

There is an indication that it is possible to ameliorate the present situation through education of pre-service teachers. Since 1972 Black Hills State University has required that all elementary education majors take a science course called Integrated Physical and Biological Science. The primary focus of this course is on "doing" the processes of science and using whatever science content lends itself to the better understanding of the process being studied. During the fall semester of 1991 Everett Follette had the opportunity to administer the SPQ to 52 elementary education majors who were enrolled in Methods of Teaching Elementary Science. Of the 52 students, 29 had taken the Integrated Physical and Biological Science course while 23 had not. The scores follow with the scores of the Integrated Science students listed first for each process: Observation 89% vs. 81%; Inference 70% vs 41%; Hypothesis 60% vs 50%. It is notable that the students who had taken the Integrated Science course could identify all 3 types of process statements at a higher level than could their counterparts even though both groups had taken essentially the same required general science courses with the exception of the Integrated Science course.

On the basis of our research we would make the following recommendation: If we are going to continue to advocate the teaching of the science processes in the schools it is imperative that the science and science education communities come to some kind of agreement on the definitions of the process terms. Further it would seem appropriate in the interest of clarity that all science textbooks and other science literature be reviewed not only for discipline correctness but also for correctness in the use of the science process vocabulary.

Bibliography

American Association for the Advancement of Science. (1967) Science - A Process Approach, Washington, D.C.

Cain, Sandra and Jack M. Evans, Sciencing An Involvement Approach to Elementary Science Methods. 3rd edition. Merrill Publishing Co., Columbus, Ohio, 1990, page 5.

Ciparick, Joseph D., "Water Works", The Science Teacher vol. 8 no. 6, September 1991, page 59.

Head, Stephen, "The Tipping Cylinder", Primary Science Review 12, Spring 1990, page 5.

Snyder, Robert; Barbara Mann, Frances Ludwig, William Brecht, Jon Stasik; Earth Science The Challenge of Discovery, 1991, D.C. Heath and Company, Lexington, Massachusetts, page 22.

Tarbuck,Edward J., and Frederick K. Lutgens, Earth Science, 5th edition, Merrill Publishing Co., Columbus, Ohio, 1988, page 4.

Wasserman, Selma and J. W. George Ivany, Teaching Elementary Science Who's Afraid of Spiders, 1988, Harper Collins Publishers, Inc., New York, New York, page 85.

Appendix A.

Science educators who agreed to act as consultants for evaluating science process definitions. (These same persons evaluated the science process statements that were eventually used in the Science Process Questionnaire)

Dr. Betty Crocker, Professor of Elementary Education, University of North Texas, Denton, Texas.

Dr. Steven Dyche, Director of Math/Science Education Center, Appalachian State University, Boone, North Carolina.

Dr. Thomas Koballa, Jr., Professor of Science Education, University of Texas at Austin, Austin, Texas.

Dr. Robert Yager, Professor of Science Education and past president of National Science Teachers Association, Department of Science Education, University of Iowa, Iowa City, Iowa.

List of States where Science Process Questionnaires were administered.

Texas	North Carolina
Wyoming	South Dakota
Illinois	Florida
Pennsylvania	Oklahoma
Kansas	Missouri
Indiana	Minnesota