Science, Silence, and Sanctions

By Mary Budd Rowe

WHEN YOU ASK A child a question, how long do you *think* you wait for an answer before you either repeat the question, ask him another question, or call on another child? If you are like many experienced teachers, you allow an *average of one second* for a child to start an answer. After a child makes a response, you apparently are still in a hurry because you generally wait slightly less than a second to repeat what he said or to rephrase it or ask another question.

In inservice training classes for experienced teachers, we have been studying such questioning-teaching techniques to discover which techniques are most effective for teaching science when utilizing some of the national experimental science programs for the elementary school, e.g., Science Curriculum Improvement Study (SCIS), Science—A Process Approach (AAAS), Elementary Science Study (ESS). We have found that when teachers change certain verbal patterns, students change their verbal patterns too. We began to experiment to test the effect of the following factors on the verbal behavior of children.

1. Increasing the period of time that a teacher waits for students to construct a response to a question.
2. Increasing the period of time that a teacher waits before replying to a student move.
3. Decreasing the pattern of reward and punishment delivered to students.

"Wait-Time"

While a fast pace in questioning may be suited for instruction in some subjects, it presents some special problems for teachers who are trying to conduct inquiry-oriented science lessons. In most of the new science programs that actually give children access to materials and information, ideas that develop come largely from what children do with the materials. In any collection of objects there may be more than one possible arrangement, more than one kind of experiment, more than one kind of result. The basic notion that underlies all new science programs is the belief that in inquiry the information or relevant cues lie hidden in the materials and not in the head of the teacher. Since that is the case, children need to monitor their materials more carefully than they monitor the teacher's face. Ideas can be modified or even discarded if the evidence requires. No particular point of view in the class is more sacred than another. What counts is what happens in the

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system of materials. Authority rests with the idea that "works." That point of view means you and the children need time to think and to evaluate. One second may not be long enough.

What happens in science if you increase the time you wait before you ask another question or call on another child? And what happens if you increase the amount of time you wait to speak *after* a child speaks? It turns out that all kinds of surprising and sometimes puzzling things result.

If you can prolong your average "wait-time" to five seconds, or preferably longer, the length of student responses increases. When wait-time is very short, students tend to give very short answers or they are more prone to say, "I don't know." In addition, their answers often come with a question mark in the tone, as if to say, "Is that what you want?" But if you increase the wait-time, especially the period after a child has made a response, you are more likely to get whole sentences, and the confidence as expressed by tone is higher. Another bonus that results from increased wait-times is the appearance of speculative thinking (e.g., "It might be the water," . . . "but it could be too many plants.") and the use of arguments based on evidence.

If the wait-time is prolonged an average of five seconds or more, young children shift from teacher-centered show-and-tell kinds of behavior to child-child comparing of differences. Why this happens is not clear. It may be that longer wait-time allows children to trust the materials so that they shift from the teacher's face to the objects they are studying.

It is the teacher who gets the most practice asking questions in the classroom. Children rarely ask questions in class even when they have materials in front of them, yet we know they are usually curious. As you increase the wait-time, the number of questions children ask and the number of experiments they need to answer the questions multiply.

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Suppose you do learn to control wait-time, what are the advantages? First, by increasing the wait-time, you buy for yourself an opportunity to hear and to think. As an example, examine a learning experience with a teaching machine. Suppose the machine begins to instruct a student by showing him some objects and saying, "Tell me how these are arranged. What does the arrangement look like?" The student might answer, "A xylophone." Now if the machine is programed to expect the student to say "steps," there is a problem. The machine either goes on with whatever is next in its program or it cycles back and asks the question again and again until the student gives the "right" answer. Teachers often behave the same way. When the wait-times are very short, teachers exhibit little flexibility in the responses they allow. Contests for control of the metaphors (e.g., steps vs. xylophone) are common, and the teacher usually prevails. A machine could do as well. Errors of this kind become less frequent as wait-time increases.

Second, wait-time can change your expectations about what some children can do. Teachers who have learned to use silence report that children who do not ordinarily say much start talking and usually have exciting ideas. In one inservice experiment, each of 50 teachers taught science to two first-grade children. The teachers knew the children had been grouped in combinations of two high verbal children, or two low verbal children, or one high and one low verbal child. At the end of the lesson, each teacher tried to decide which combination she had. To the delight of everyone in the experiment, the teachers usually misjudged the combination. Most often they classified low verbal youngsters as high verbal. The interaction of children with materials plus the protracted silences of the teachers apparently "turned on" children who usually "tuned out." When these teachers returned to their classrooms and experimented with wait-times, they reported that children who did not ordinarily contribute began to take a more active part in doing and talking about science.

Expectations teachers hold for children can have a deadly effect in terms of opportunities in which children get to practice speculative thinking. For example, on request, twelve inservice teachers each identified their five best and five poorest students. After sampling the teachers' wait-times in three lessons each of science and mathematics, it was found that the twelve teachers waited *significantly less time* in both subjects for poor students to reply to questions. That is, students rated as slow or less apt by teachers had to try to answer questions more rapidly than students rated as bright or fast. This result apparently surprised the teachers. As one of them said, "I guess we just don't expect an answer, so we just go on to someone else." This group of twelve teachers then began to experiment deliberately with increasing wait-times for poorer students. Response by "slow" students increased, gradually at first, and then rapidly.

Questioning behavior also varies

with wait-time. As wait-time increases, teachers begin to show much more variability in the kinds of questions they ask. Students get more opportunity to respond to thought rather than straight memory questions. When the pacing is fast, teachers often ask and answer their own questions. ("What color was it? It was green, wasn't it?") For some reason when teachers gain control of wait-time, questioning becomes less barrage-like and more flexible in form.

Rewards and Punishments

There is another factor besides silence that seems to have something to do with how children learn science and whether or not they learn to trust evidence as a basis for making judgments.

Usually, teachers use sanctions (positive and negative rewards) in the classroom somewhat indiscriminately. Sometimes teachers seem to be rewarding effort because they commend answers or work which is incorrect. At other times they reward correct responses. In fact, sanctions constitute as much as one quarter of teacher talk in many classrooms. Since evaluative comments constitute such a large part of teacher talk, it is useful to know how they influence science instruction.

Modern science programs for the elementary school seek to develop self-confidence in children by allowing them to work out their ideas in experiments. Children find out how good their ideas are by the results. When predictions no longer work or when new information makes a point of view untenable, then pupils are free to change their views. The point is that the authority for changing comes from the results of their experiments rather than from the teacher.

It appears that when teachers measurably reduce the amount of overt verbal rewarding they do, children seem to demand less of their time for showing what happens. Instead they do more comparing and arguing which leads to more experiments. When silence on the part of the teacher increases, and/or when sanctions decrease, the incidence of speculative thought on the part of the children increases. It is doubtful whether children can distinguish when they are being rewarded for effort and when for appropriate reasons. When rewards are high, children tend to stop experimenting sooner than when the number of rewards is relatively lower. There is some reason to suspect that when children work on a complex task, rewards given by the teacher may interfere with logical thought processes. When children start attending to the reward rather than to the task, the incidence of error or the necessity to repeat steps increases.

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Try It Yourself

Tape record a science lesson as you would normally teach it. Listen to what children say and how they say it. Now teach another lesson, but this time experiment with the wait-times or the rewards, but not both at once. If you try to change both factors at once, you will find it more difficult to discover the effect each has by itself. Find out whether the following statements are supported by your experiments.

1. Very short wait-times combined with high teacher rewards produce short student responses, high likelihood of inflected answers reflecting low student confidence, virtually no child-child exchanges of ideas, and a high incidence of answers unsupported by evidence.
2. Long wait-times (not less that 5 seconds) combined with low teacher rewards produce longer responses, more confidence, more exchanges between children, and more speculation supported by evidence.

The children may be inquiring about natural phenomena, but inquiry into teaching is the business of the professional teacher. Run your experiments on silence and sanctions in science enough times to be sure of how the factors act in your class.