Letters

Science Education: "Process" and "Content" in Grade Schools

Gagné's paper "Elementary science: a new scheme of instruction" (7 January, p. 49) presents a concise description of a project based on a view of science as "process." Since Gagné makes a few casual references to certain other current approaches to curriculum improvement—the "content" view, for example—it is useful perhaps to examine some of the assumptions that seem to underlie each of these contrasting attempts to reformulate science education programs for elementary schools.

First, Gagné postulates certain fundamental "skills" required in most scientific activities (observation, classification, measurement, inference, formulating hypotheses). Also he assumes that these "skills" can be developed in relative isolation from the context of specific science disciplines but that they can be applied later in the study of *any* science discipline. Furthermore, he suggests that certain "skills" (observation, classification) are taught optimally before other "skills" (formulating hypotheses, interpreting data). Each of these assumptions seems deserving of further study.

Gagné does not specify the source of the list of "skills" fostered in the project. From other writings of his, however, I infer that this list was derived primarily from a careful analysis of science by physical and biological scientists working with psychologists. I stress here only that scientists' views of science as a generalizable human enterprise are often at variance with the views of philosophers and historians of science. Scientists, for example, frequently characterize scientific activity as more objective and dispassionate than many philosophers of science do. (Of course individual scientists—Polanyi, for one—recognize the intense subjectivity of science.) But as a rule scientific training and research *alone* do not equip one particularly well to analyze science in general terms. Gagné makes no mention of the possible limitations of the perspective of science taken by the scientists with whom he worked.

"Skills" are developed in the project by use of specific situations deemed conducive to the exemplification of particular procedures. The fact that one uses several senses in making observations is taught by having children pop corn. Knowledge of scientific principles illustrated by popping corn is not the objective of the lesson, however. The assumption is made that this activity helps the child to recognize the usefulness and limitations of sense experience; he can then more fruitfully observe the motion of a rolling ball or the growth of a mold garden. The continuity is based, as Gagné says, on a particular view of human development. But the generalizability of the "skills" to fresh science contexts is highly questionable. The approach is more than slightly reminiscent of that of "faculty" psychologists, who late in the 19th century taught "observation" on the assumption that "reasoning" could then be learned more readily.

A basic flaw in the "process" approach is the apparent assumption that science is a sort of commonsensical activity and that the appropriate "skills" are the *primary* ingredients in doing productive work. There is no explicit recognition of the powerful role of the conceptual frames of reference within which scientists and children operate and to which they are firmly bound. These general views of the physical world demand careful nurture and modification by a variety of means, including observation. The "content" approach, which, as Gagné suggests, need not exclude attention to "process," has the virtue of leading the child toward a comprehensive and sequential understanding of conceptual frameworks characteristic of recognized science fields. The child begins to feel mastery of a subject while still learning how scientific problems are approached in this distinct area of knowledge. The observational aspects of science, to cite one "process," assume greater meaning because they are particularized.

In one of the new programs based on a "content" orientation, certain aspects of measurement are taught in developing the notion of parallax, but the story line offers motivation for the child because he sees parallax as contributing to his increasing comprehension of astronomy. As a desirable by-product he learns something about a few general problems of measurement. Gagné correctly criticizes existing programs for "imparting isolated facts which perhaps never are connected with a structured body of knowledge." The "process" approach he describes seems to suffer from the same limitation.

In short, those who seem to start from a "content" view hold that scientists can make the greatest contribution to curriculum improvement by identifying potent scientific ideas that help children see the essential framework of a discipline and how scientists in that discipline have operated. These relatively stable and pervasive ideas equip the child to peg new learning on an emerging conceptual structure—while learning concomitantly that science is a human activity. Scientists often measure, and they sometimes hypothesize, and they always make inferences, but they do all these things on the basis of the demands of accepted paradigms within identifiable fields. Scientists don't usually study how to hypothesize, or interpret data, or make operational definitions in some abstract fashion preparatory to conducting research.

There is at least some possibility that children, too, can most effectively learn about the "processes" associated with scientific activity when they seek to learn how scientists, in the usual disciplinary contexts, attempt to solve problems. But, even if they don't, they will have learned through a "content" approach a few fundamental principles of considerable intellectual mileage that can contribute to their quest for ordering the complex phenomena with which scientists deal. And they don't risk the possible danger of painstakingly mastering only certain abstracted processes which may not, on further analysis, turn out to reflect accurately the nature of scientific inquiry.

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