Reports

Science Teachers and the Scientific Attitude: An Appraisal of an Academic Year Institute

Abstract. In a training program for experienced high school science and mathematics teachers, trainees made good academic progress and eventually adjusted well to the return to university work. The program's main weakness was failure to transmit attitudes and information relevant to teaching science, not only as a body of knowledge, but as a way of thinking.

Since its inception in 1950, the National Science Foundation has sponsored a many-sided and far-reaching effort to improve science education. One of its most important programs in this field is the Academic Year Institute. High school teachers of science and mathematics are given stipends to permit them to return to the university for a year of advanced training adapted to their special needs. The courses of study are intended to deal with the subject matter of science and mathematics, not with teaching methods.

The number of institutes has grown from two in 1956–57 to 32 in 1959–60, with about 50 fellows in each, and about 3000 teachers have already been involved in the program. The potential impact of a program of this magnitude on the quality of high school teaching is very great, but unless the additional work is qualitatively different from the 15 or 16 years of education which preceded it, one should not expect an important change in the individual fellow. This suggests the importance of examining the methods and effects of the program, and although this has not been done on a national basis, several participating institutes have chosen to have their work systematically scrutinized. The Academic Year Institute faculty at the University of Colorado were among those who not only endured but welcomed and made use of scrutiny and criticism. Evaluation of the Colorado program was conducted by the Behavior Research Laboratory at the university.

Fifty-five high school science and mathematics teachers came from all parts of the country to Boulder to study at the institute held in 1957–58. As can be seen from the data in Table 1, the fellows were a group of mature, intelligent, and experienced teachers. Their previous training in science and mathematics had been mediocre but not unusually poor; it was above some standards and below others.

In many important respects the initial year of the program was a success. The fellows made good academic progress and were, by the end of the year, quite satisfied with the program. Their average grade in all courses was B—an acceptable average for graduate credit at the University of Colorado—and they gave the program an average rating on a 7-point scale of 5.5, which corresponds to "very good." A new degree, Master of Basic Science, was proposed by the Academic Year Institute faculty and accepted by the Graduate School. Requirements for this degree stress breadth of training rather than the specialization characteristic of other graduate programs. Of the 53 fellows who completed the year, 28 received the M.B.S. degree in 1958 and others have gone on to earn the degree since then.

The program faced three major difficulties: (i) disorientation and a serious drop in morale among the fellows, due largely to the sudden change from the status of teacher to that of student; (ii) conflict because the fellows desired to improve their knowledge of teaching techniques as well as subject matter while the faculty was concerned almost entirely with subject matter; (iii) conflict between the need to cover *specific* subject matter and the more general goal of improving the fellows' broad grasp of the character of science. In the main, the first two problems were solved, partly by clarifying objectives and standards and partly by making some concessions to the special needs of the fellows. The third problem remained as the major weakness of the program; little if any progress was made in the development of a general understanding of the nature of scientific thinking.

Evidence of this weakness was provided by a test of knowledge of the history of science, a questionnaire on the philosophy of science, and a sample teaching performance. In the history of science test, 92 percent of the fellows performed *below* a standard suggested as adequate by four Academic Year Institute faculty members.

Two types of questions were used in this examination. First, the fellows were asked to arrange sets of three names in chronological order, the names in each set being chosen so that knowledge of the scientific contributions of the men would make solution possible without knowledge of the specific years in which they lived (for example: Copernicus, Galileo, Newton). Secondly, they were asked to match the names of scientists with their major contributions to knowledge—for example, Harvey and the circulation of the blood.

Of the 52 fellows taking this test (see Table 2), only 28 put Faraday first in chronological order in question 1; only 25 put Copernicus first in question 2. In question 6, only 19 knew that Darwin came last, and 11 put Darwin before both Linnaeus and Lamarck.

Another approach to the problem of examining the fellows' grasp of the general character of science was a questionnaire, administered at the beginning and end of the year, dealing with their views on the philosophy of science. There is obviously no "right answer" in this area, but one can at least look for signs of growth of appreciation and grasp of problems in the area. The results suggest that no such growth occurred. For example, little consistency in initial views and little change of views could be detected. In one question, the fellows were asked to decide whether each member of a list of terms was a "concept invented by

Table 1. Description of fellows.

Item	N*	Median	Range
Age	54	32	25–48
Army General Classification Test	51	140	118–155
Semester hours in science and mathematics	54	55	19–106
Semester hours in education	54	27	5–69
Years teaching	54	7	3–15

* Although 55 fellows began the program, one dropped out very early, and a few others missed some of the tests.

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Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* **125**, 16 (1957)].

Table 2. Data on correct and incorrect answers in history of science test: eight sets of names to be arranged in chronological order.

Names	Number		
	Correct	Incorrect	Blank
1. Faraday, Hertz, Maxwell	10	30	12
2. Copernicus, Galileo, Newton	23	23	6
3. Berzelius, Kekule, Pasteur	12	26	14
4. Weierstrass, Cantor, Dedekind	3	24	25
5. Mendeleef, Dalton, Lavoisier	12	30	10
6. Darwin, Lamarck, Linnaeus	13	30	9
7. Leibniz, Descartes, Gauss	16	20	16
8. Leeuwenhoek, Schwann, Koch	19	21	12

man" or "a physical reality independent of the observer"; the terms used were *trees, mountains, stars, genes, gravity, photons, molecules,* and *species.* There was virtually no change in response to most of the items in this question or in the number of items designated as "concepts" by the fellows (pretest median = posttest median = 2). Two interesting shifts in opinion took place: in the posttest, seven more fellows saw *genes* as concepts than in the pretest, and seven more saw *photons* as physical realities. Was a move toward "naive realism" in the way they looked at the photon coupled with a move toward "logical positivism" in the way they looked at the gene?

In a related question, the fellows definitely shifted away from the view that mathematical axioms are "self-evident truths" and toward the view that such axioms are "arbitrary conventions."

These results suggest that one can fairly easily inculcate specific changes in thought that have little general effect on the individual's approach to science as a whole. Philosophical issues were not discussed enough in the program to permit much clarification; the changes that did occur resulted from the specific ways in which different faculty members handled certain topics in their classes. One of the fellows, in fact, commented on "knowing the right answer" from attending the seminar in mathematics. The larger issue—of developing some mature appreciation of the history and philosophy of science—has yet to be dealt with; meanwhile, it is perhaps encouraging that some changes in this domain of thought can be made.

Evidence that the fellows had not learned to teach students much about the way in which scientific progress is achieved was given by their sample teaching performances. Each of a representative group of fellows gave a half-hour talk on a topic of his own choice designed for a high school classroom. In these short talks the fellows were almost entirely preoccupied with presenting the known facts and principles of science and mathematics. Very seldom was any effort made to convey a sense of the *way* in which scientific thought unfolds —the thinking and research lying behind the material the teacher was presenting. The history leading up to a scientific discovery and the consequences of such a discovery were never discussed. Within these limitations many of the talks were fluent, interesting, and well organized. There was no change in performance from the beginning of the year to the end of it, except that on occasion the later talks drew on specific material learned in the Academic Year Institute.

It may be that the institute's preoccupation with the goal of teaching specific science material prevented it from dealing adequately with other goals envisioned for the program—envisioned, at least, by the faculty concerned. The working assumption of the institute in its initial year was that if subject matter is adequately taught, other things will take care of themselves. The main conclusion of the evaluation group is that such an assumption is at best questionable.

Science plays an increasingly large part in every individual's life; if it reaches him only through its technological fruits, man will be increasingly divorced from nature, and scientific progress will, paradoxically, impoverish his intellectual and cultural life; but if the study of science gives man a deeper appreciation of nature and increased ability to enjoy the pleasures of rational thought, it will ennoble and enrich him. To accomplish these ends, science teachers must do more than study what scientists know; they must understand how scientists think.

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Notes

This study was supported by the Academic Year Institute at the University of Colorado, with funds from the National Science Foundation. For a more detailed report of the methods and results of the evaluation, see H. E. Gruber, K. P. Brady, and J. R. Means, "Toward the Improvement of Science Teaching," *University of Colorado Behavior Research Lab. Rep. No. 9.* The findings reported here led the evaluation group, in cooperation with the Academic Year Institute faculty, to develop and test experimentally a method of overcoming the difficulties described.

For related discussion, see P. F. Brandwein, F. G. Watson, P. E. Blackwood, *Teaching High School Science: A Book of Methods* (Harcourt, Brace, New York, 1958); J. B. Conant, *On Understanding Science* (Yale Univ. Press, New Haven, 1947); J. R. Oppenheimer, *Physics in the Contemporary World* (Anthoesen, Portland, Me., 1947).

Biosynthesis of Chick Hemoglobins

Abstract. In vivo studies of the biosynthesis of chick hemoglobins 1 and 2 showed an over-all higher incorporation of glycine-2-C^{14}, valine-4-C^{14}, valine-1-C^{14}, leucine-G-C^{14}, and histidine-(2-ring)-C^{14} in hemoglobin 2; in vitro studies made with intact nucleated chick erythrocytes showed the higher incorporation of glycine-2-C^{14}, valine-1-C^{14}, and histidine-(2-ring)-C^{14} in hemoglobin 1. Hybridization of chick hemoglobins produced an electrophoretically distinguishable new component.

Paper electrophoretic investigation on the cell-free hemolyzates obtained from the erythrocytes of birds like chick, guinea fowl, and duck revealed the presence of two hemoglobins (*1*). It has further been observed that in chick one of these hemoglobins (Hb 1) decreases while the other (Hb 2) increases during development (*2*). Both of these hemoglobin components were found to be of the alkali-resistant type (*3*). In view of these findings, it was of interest to investigate the biosynthesis of individual hemoglobin components of chick. This report presents the results of the investigation carried out with adult chicks injected with radioactive amino acids, and the in vitro incorporation of C^{14}-labelled amino acids in the hemoglobin components by the nucleated chick erythrocytes.

For in vivo studies, 6-month-old male white leghorn chicks were intravenously injected with 25 μc of amino acid-C^{14}. Thereafter, 4 ml of heparinized blood was collected from each chick on alternate days for 2 weeks and then every 4th day until the 28th day after the injection. Blood samples were washed four times with ten times their volume of isotonic saline at 2°C in a refrigerated centrifuge. Clear hemoglobin solutions were obtained by hemolysis with water and toluene and by centrifugation as described earlier (*1*).

For in vitro studies, chicks were made mildly anemic with injections of acetylphenylhydrazine. Acetylphenylhydrazine (25 mg) was injected subcutaneously three times, once every 4th day, followed by an initial withdrawal of 15 ml of blood. After this, approximately 10 ml of blood was withdrawn and 20 mg of acetylphenylhydrazine was injected every week. Heparinized blood samples were obtained from these birds 48 hours after the injection of acetylphenylhydrazine. During the washing procedure, care was taken not to remove the light colored upper layer which contained reticulocytes. In the in vitro experiments, to one volume of erythrocytes equal volumes of normal chicken plasma and a synthetic media containing an amino acid mixture as described by Borsook (*4*) (glucose, 1.0 mg/ml; Na-penicillin G and strepto-