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Abstract. This paper reviews some studies relating to the subject matter competency of pre-service elementary teachers. Attention is called to the importance of an understanding of the nature of science by the elementary major, and the need to measure this understanding.

A study designed to test the understanding of and attitude toward science in elementary majors is discussed. The scores of elementary majors on the understanding of science measure are compared with those of other prospective teachers (both secondary and elementary). It is suggested that a measure of this type could be used as a basis for evaluation of innovations in the pre-service training of elementary teachers.

There seems to be a prevalent assumption that elementary science is being inadequately taught. This assumption is frequently coupled with an apparent reluctance on the part of the elementary teacher to teach science.

We live in a scientific civilization and while students of elementary education cannot become specialists in science they will use science in their work with children and in the interpretation of their own daily experiences. In other words, they will not be science teachers, but they will be teachers of science. The prospective elementary teacher is aware of the importance of science in the elementary curriculum. Soy (1967) found that student teachers ranked science first among the subjects which they felt elementary students would like to study, but they ranked science as fifth of seven subject areas in which they felt prepared to teach.

Several workers (Hines 1966, Victor 1962, Hardin 1965) report that an inadequate science background is a definite factor influencing science teaching at the elementary level. Some steps have been taken toward increasing the subject matter background of the elementary teacher. In 1947 (46th Yearbook of the National Society for the Study of Education) it was recommended that elementary teachers have at least 20 hours in science. The National Association of State Directors of Teacher Education and Certification (NASDTEC) and the American Association for the Advancement of Science (1963) recommended that every elementary teacher be

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educated in the fundamental concepts of the biological sciences, the physical sciences, the earth sciences and mathematics.

Implementation of these recommendations has been rather slow. However, a number of institutions have increased the number of hours in science required of the elementary major. There may be some merit in this requirement as there is apparently little inclination on the part of the pre-service elementary teacher to elect science courses beyond the minimum requirements. Soy (1967) indicated that less than 8.1% of the prospective elementary teachers at the University of Northern Iowa in 1963 elected to emphasize science as a subject field. There has been little change in this situation; in 1968 it was found that 6% selected the option of a "science emphasis" (McCollum 1969).

Requiring more hours assumes that this will result in an increased understanding of science. However, this assumption may be questioned since many science courses are directed toward subject matter competency with little inclination toward an understanding of the processes of science. It is assumed that exposure to the scientific content will automatically result in an understanding of the "spirit of science."

Attention has been increasingly called to the importance of an understanding of science. Rogers (1960) indicates that the science major as well as the nonscience student need good teaching of science, i.e., not so much a great wealth of knowledge as a healthy understanding of what science is and how scientists work. Brehm (1968) laments the fact that one rarely observes an upper grade teacher who teaches science for what it is—a stimulating investigation which provides the excitement of producing knowledge or emulating the production of knowledge as opposed to assimilating the end products only. She feels that the primary teacher with less science background will better convey the meaning of science by emphasizing curiosity instead of requiring the student to receive his science through a textbook. Victor (1962) observed that teachers seemed more inclined to teach for, or stress, the technological aspects of science than the underlying principles and philosophy. Simendinger (1969) expressed concern about the area of teacher preparation dealing with an understanding of the history and philosophy of science which, in her opinion, is becoming increasingly important. Richardson (1960) makes the point quite well in the following statement:

"The teacher must have a significant grasp of the social

TABLE 1
TOUS Mean Scores

		Pre-test				Post-test			
	N	I	II	III	Total	I	II	III	Total
Group X	23	11.30	12.61	13.22	37.13	11.96	12.52	13.57	38.05
Group Y	24	13.13	13.42	13.33	39.88	12.79	13.67	14.13	40.59
Group Z	25	12.52	13.00	12.83	38.35	13.80	13.48	13.40	40.68
Total $\overline{X}$	72	12.19	13.02	13.12	38.46	12.88	13.24	13.70	39.81
Range		7-17	8-18	7-17	28-47	6-17	8-18	5-19	26-52

impact of science. He must understand the scientific outlook and breadth of scientific inquiry. He must be able to teach in terms of general and specific goals of science in the educational program."

Blosser and Howe (1969) suggest from an analysis of research reports that science educators have tended to concentrate more of their research efforts on the preparation of teachers for the secondary school than attempting to identify and define problems involved in preparing elementary teachers to do a competent job of teaching science.

It would seem that an attempt should be made to determine the level of understanding of science by the pre-service elementary teacher. If some measure can be attached to this understanding there is then a basis for comparing various methods that might be tried to improve the science competencies of elementary teachers. There is a limited amount of literature relevant to quantifying the understanding of science by elementary teachers although there has been some work at the secondary level (Miller 1962, Schmidt 1968, Kimball 1968).

A group of prospective elementary teachers at the University of Northern Iowa were examined to determine their understanding of and attitude toward science. This group consisted of 72 (3 sections) elementary majors enrolled in a science methods workshop. The students usually take this workshop just prior to student teaching so the class is composed of juniors and seniors.

Two measures were administered to the group, a *Test on Understanding Science* (Cooley and Klopfer 1961) and a *Scale to Measure Attitude Toward Any School Subject* (Remmers 1960). The *Test on Understanding Science* (TOUS) consists of sixty 4-choice items distributed among various themes in three areas. The themes of the 3 major areas are as follows: Area I—Understanding about the scientific enterprise; Area II—Understanding about scientists; Area III—Understanding about the methods and aims of science. The *Scale to Measure Attitude Toward Any School Subject* is a brief 17 item measure with statements ranging from those with a favorable expression toward the subject through more neutral expressions to those that express complete disfavor toward the subject. The student is asked to endorse any one or many of the statements. The median scale value of the statements endorsed is the attitude score.

The two measures discussed above were administered on a pre- and post-test basis. The data are recorded below in TABLE 1 and TABLE 2.

TABLE 2

Attitude Scale Scores

		Pre-test		Post-test	
	N	$\overline{X}$	Range	$\overline{X}$	Range
Group X	23	7.9	5.5-8.9	8.4	7.7-8.9
Group Y	24	7.9	6.0-8.9	8.2	6.0-9.1
Group Z	25	8.1	6.0-8.9	8.1	5.8-8.9
Total	72	7.97	5.5-8.9	8.23	5.8-9.1

Examination of the data indicates that the elementary majors may develop a somewhat greater understanding of science, as measured by the TOUS, and a more favorable attitude toward science, as determined by the attitude scale during the workshop. However, these changes are not statistically significant. Three possible explanations seem plausible. One possibility is that the workshop material is such that it is not possible to cause a significant gain in these areas. Another possibility is that the length of the workshop (3 weeks) is inadequate to produce changes. And of course, it is conceivable, but highly unlikely, that a change in these areas is not possible with elementary majors.

It is interesting to compare the scores of the U.N.I. elementary majors with other groups. Schmidt obtained TOUS scores from 3 groups; his scores are shown below in TABLE 3.

TABLE 3

TOUS Scores (after Schmidt 1968)

Group	$\overline{X}$	N	*Range*
Secondary science methods students	48.0	29	37-58
Elementary science survey	40.5	43	29-50
Scientists of universities & industry in Iowa	50.8	116	36-59

One group consisted of scientists from various universities and certain industrial companies in Iowa. Members of the other two

groups were students at the University of Iowa. One group consisted of college seniors who had just completed a methods course in the teaching of biology which emphasized the nature of science and the philosophy of modern curricular programs. The other group was composed of elementary majors who had just completed a biological science survey course. The majority of these elementary majors were in their sophomore or junior year.

The elementary majors at the University of Northern Iowa compare quite closely with their counterparts at the University of Iowa. Being familiar with the science requirements for elementary majors at both schools it is possible to assume that these students have had approximately the same exposure to science at the university level. Possibly at these stages in the two programs the mean number of hours in science would be slightly higher for the U.N.I. elementary major. The biology methods students scored considerably higher on the TOUS. This could be because the biology methods student has more hours in science than the elementary major or it could be a result of a more intensive study of the nature of science in the biology methods course.

The scores of the scientists are higher than all others, as one might suspect. However, it could be anticipated that the mean score of the scientists would be higher than the 50.8 observed. Actually there is little gap between the scientists and the college seniors. This suggests the possibility that certain items on the TOUS could be revised.

Both groups of elementary majors have a slightly higher level of understanding of science than that exhibited by students who had just completed a course in general education biology at U.N.I. The students in general education biology are for the most part freshman and sophomores. The mean TOUS score for some seven hundred students was 37.63 while the mean score on the attitude scale was 7.46. At the beginning of the science methods workshop the elementary majors had a somewhat better understanding of science and a more favorable attitude toward science than did the general education student at the completion of the biology course. This could be due to an intervening course in science which is required of elementary majors at U.N.I. or it could be a reflection of the overall abilities and attitudes of the two groups.

The problem of providing an adequate pre-service preparation program in science for elementary teachers is one of continuing concern to science educators. Gega (1968) asks the question of how we can improve the pre-service preparation of these people. What specific experiences will prepare them to guide children in

ways that reflect the spirit of modern science? A number of science educators are suggesting possible solutions to these problems (Gega 1968, Brehm 1968, Hardin 1968, Eaton 1966, Gross and Mayo 1969).

I believe that it is generally agreed that an understanding of the nature of science is essential for the elementary teacher. There may not be complete unity on the manner in which this understanding is to be gained by the pre-service elementary teacher. In any event, let us measure this understanding of science by some means such as the TOUS or another comparable instrument. We then will have the beginning of a basis for judgement of the pre-service education of elementary teachers of science. Then let us begin to test the assumption that elementary science is being inadequately taught.

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