DOCUMENT RESUME

ED 040 060 SE 008 723

AUTHOR	Hughes, Earl F.
TITLE	Role Playing as a Technique for Developing a Scientific Attitude in Elementary Teacher Trainees.
INSTITUTION	Nova Univ., Ft. Lauderdale, Fla.
PUB DATE	Mar 70
NOTE	23p.; Paper presented at Annual Meeting of the National Association for Research in Science Teaching (43rd, Minneapolis, Minn., March 5-8, 1970)
EDRS PRICE	EDRS Price MF-$0.25 HC-$1.25
DESCRIPTORS	*Elementary School Science, Elementary School Teachers, *Instruction, *Role Playing, *Scientific Attitudes, *Teacher Education

ABSTRACT

Analyzed were the effectiveness of three types of attitude change techniques for changing the attitude of prospective elementary school teachers toward science. A sample of 219 prospective elementary teachers was administered a pretest to measure selected aspects of attitudes toward science. The subjects were assigned to one of four treatment groups which were stratified according to pretest attitude scores. A persuasive communication was administered to the three treatment groups three and one-half weeks after the pretest. The control group received an innocuous communication and the post-test; one treatment group received persuasive communication and the post-test; the other two treatment groups received the persuasive communication. Of the latter two groups, one role played a proponent of the scientific attitude while the other observed the role playing. Results indicated that the combined treatment groups resulted in a much higher ($p<.001$) mean science attitude score than did the control group; however, the combined role playing experience was no more effective than only reading the persuasive communication, reading the communication and role playing, and reading the communication and role playing the point of view of the communication. (BR)

Role Playing as a Technique for Developing a Scientific Attitude in Elementary Teacher Trainees

Earl F. Hughes

Nova University
Fort Lauderdale, Florida

The problem of devising an effective teaching technique for developing a more positive attitude toward science, scientists, and scientific endeavors has been with us since science entered the classroom. Teaching to acquire these attitudes has been a continuing objective of science educators. Due to this influence, the rationale for requiring science courses and offering science electives in schools at all levels often includes statements of the value of scientific attitudes or interests.[1-3] This type of educational objective was quite succinctly stated by Haney[4] when he wrote, "The pupil should acquire the attitudes of scientists and learn to apply these attitudes appropriately in his daily experiences [p. 24]".

These science curriculum changes that are occurring today are in a direction that makes the attitude of elementary teachers toward science a critical factor in elementary education because these changes are a concentrated attempt at implementing curricula that develop the affective responses of the pupils in science classes.[5-8] The science learned by our elementary teacher is frequently defined as an organized body of knowledge and characterized by specific topics studied, classes attended, facts learned, and laboratory exercises completed. The intent of the newer curricula has been to shift emphasis in science to include the teaching of the processes of science and the development of a scientific or critical way of thinking. The word science is sometimes referred to as a verb rather than as a noun because it refers to a way of thinking and solving problems as well as to the accumulated knowledge on a topic. It then seems apparent that our elementary teachers must have this scientific attitude in order to cope with the task of teaching elementary children an active, more exciting version of science than has existed in the past.

Background of the Problem

A survey of research studies related to existing characteristics of science teachers and science students provides some insight into the existing situation. An investigation of the reasons for teachers spending relatively little time in teaching elementary science was done by Victor.[9] He found that their lack of familiarity with science content and materials and the probable loss of professional prestige from their inadequacy in science may contribute to a reluctance to teach science. When science was taught, Victor found that the teachers seemed unfamiliar with the objectives of science education and stressed the technological aspects of science rather than underlying principles and philosophy. Behnke[10] compared the reactions of science teachers and scientists to various aspects of science and science teaching and found that the two groups can be differentiated on their opinions of the nature of science. He also found that the science teachers with the most science training held opinions closer to the scientists than the less well-trained teachers did. In a study of nine Academic Year Institutes, Gruber[11] found that only 30% of the Academic Year Institute graduates demonstrated appreciable concern for teaching science as a way of thought rather than as an established doctrine. Craven[12] found that the number of quarter hours and total number of grade points earned in science were negatively correlated with scores on the Cornell Critical Thinking Test and with scores on the Test on Understanding Science. He concluded that understanding science is not an outcome of science classes in college. Shanks[13] concluded from a study of the relationship between concept achievement in science and non-intellectual characteristics of prospective elementary school teachers that high concept achievement in science is associated with personality variables that are not conducive to good teaching practices.

It appears that even if more college science courses increase the teacher's confidence and competence in science, they do not cause the teacher to teach for the present day curricular objectives or to develop a scientific way of thinking. If one assumes that the college courses in the above studies were of the traditional lecture type, then we cannot assume that other types of teaching methods and materials will be as ineffective. Support for the benefits of other teaching techniques was given in a study by Klopfer and Cooley[14] where they taught with a series of History of Science Cases for High Schools, which uses materials drawn from the history of science to convey certain important ideas about science and scientists. They found that this type of instruction is definitely effective in increasing student understanding of science and scientists as measured by the Test on Understanding Science.

A number of studies have shown that science education has not provided its recipients with a very accurate image or even an understanding of the scientist and science. Stoker[15] found no negative attitude toward scientists in general, but found that many misconceptions about scientists exist among high school youth. Mead and Metraux[16] concluded that students believe that the scientist is essential to our national life and the world, but that the stereotype of a scientist is a "brain" that engages in dull, monotonous, time-consuming work and has no time for, or interests in, a family or other earthly pleasures. This image has little attraction to high school youth. A poll of high school students resulted in a tenth place ranking for scientists out of ten occupations presented to the students as a desirable occupation.[17] Allen[18] concluded that many high school seniors do not understand the nature of science and scientific work. In all of the above studies, the authors found that many of their subjects believed that only a genius could be a scientist or that an average person could not understand or appreciate modern science.

Statement of the Problem

With the preceding evidence indicating that traditional science content classes or science methods classes do not produce the desired attitudes toward science in their students, an attitude change technique that could be utilized by college instructors of science methods courses could be a valuable tool in teacher training.

The attitude change technique that was investigated in the present study was that of exposing subjects to a persuasive communication or article and requesting that they role play a proponent of the point of view of the communication. There is much evidence showing that this technique of reading a persuasive communication that provides the rationale or benefits on one side of an issue can influence the attitude of its readers.[19-21] Evidence that role playing creates more attitude change than passively reading a communication has been presented by Janis and King,[22] Culbertson,[23] and Zimbardo.[24] By allowing the choice of the content and source of the communication to be controlled by the investigator, this technique makes a close approximation to a classroom situation. In a class, such as a science methods class, the persuasive communication would be a reading assignment and the role playing would be similar to a traditional "class discussion".

Hypotheses

The technique of role playing involves the subject in both reading a persuasive communication and actively stating a position on the topics of the communication. There are two steps to the total persuasive treatment - reading the persuasive message and role playing. The role playing has two components, also; one is the active participation by the subjects and the other is the increase in information that is due to the new examples and rationale given by a role playing subject to support his stated opinion (which is also the opinion expressed in the communication). Therefore, to determine the relative effectiveness of only reading the communication, of reading the communication and receiving the information that is presented by the role players, and reading the communication and actively role playing, the following three hypothesis were tested.

1. Are the combined attitude change techniques of reading a persuasive communication, reading a communication followed by observing a role playing experience, and reading a communication followed by role playing more effective in producing a science attitude change in the desired direction than no attitude change treatment?

2. Is reading a persuasive communication as effective in producing a science attitude change in the desired direction as experiencing the role playing situation?

3. Is reading the persuasive communication followed by role playing a more effective science attitude change technique than reading the persuasive communication followed by observing the role playing?

Sample and Procedures

The sample was chosen from the science methods or physical science for elementary teachers classes from four Midwestern institutions of higher learning. Four class instructors were involved in the study, one from each institution. The sample was selected to obtain classes that had only elementary teacher candidates in the classroom in a setting which was selected to make an experimental treatment related to science and science teaching seem a natural extension of the normal class objectives.

The experimental procedure began with the administration of a science attitude pretest. From the pretest scores, each subject was assigned to one of four experimental groups so that there was no significant difference between the mean science attitude scores of the four groups. Four weeks after the pretest was given, the persuasive treatment was administered. A control group (group C) read an innocuous communication, responded to the ten science attitude items and was dismissed. One treatment group only read the persuasive communication (group R), responded to the science items and was dismissed. The third group (group RO) read the persuasive communication, listened to and observed the role playing, responded to the science items and was dismissed. The fourth group (group RRP) read the persuasive communication, role played a proponent of the position of the communication, responded to the science items and was dismissed. Nine days after the persuasive treatment, a post-posttest was administered to the subjects; the post posttest was identical to the pretest described above.

The pretest sample was 230 subjects. Twenty-three absences during the treatment and three failures to fill out portions of the opinionnaires resulted in a sample of 204 subjects with complete data on the posttest. The distribution of years in college of the 204 posttest subjects resulted in two sophomores, 97 juniors, and 96 seniors; nine subjects had incomplete data on year in school. There were 28 males and 176 females in the sample.

A follow-up attitude measure was administered nine days after the treatment. Of the 204 subjects available for the pretest-posttest experience, 184 were present for the administration of this post-posttest.

Communication Description

The persuasive communication was composed by the author, but was presented to the subjects as an article by an expert in science education. This deception attempted to make the source of the communication more authoritative. In the text of the communication, legitimate references are made tc other noted authors in the area of science and science education for the same purpose. The communication takes a position on each of the ten questions included in the attitude measure. It is slightly less than 2000 words long and required a reading rate of approximately 200 words per minute to complete in the allotted time. The main points emphasized in the persuasive communication were: there are benefits from a discovery approach in elementary science teaching when science is learned as a dynamic process of investigation; elaborate facilities and high ability students are not necessary for teaching science by individual student discovery; and science is a dynamic, analytical, flexible way of approaching a problem.

The content of the innocuous communication for the control group was chosen to be pertinent to education, but in no way related to science or the teaching of science. An article on the characteristics of a good test fit this criteria and was written by this investigator. The length of the innocuous communication was also approximately 2000 words long so that all groups would complete the reading portion of the experiment at the same time.

Attitude Measure

The science attitude measure used in this study utilized a Likert-type rating scale with seven choices per item. The choices were "strongly agree", "agree", "tend to agree", "no opinion", "tend to disagree", "disagree", and "strongly disagree". The pretest was a 34 item opinionnaire with the ten science related items embedded within questions in the areas of mathematics, social studies, and language arts. The placement of the items in this opinionnaire was determined randomly by drawing the items from a container. The same ten items were administered as the posttest immediately following the treatment for all experimental groups. The post-posttest was administered nine days after the treatment.

Statistical Analyses

A computer program using a multiple linear regression analog to a single classification analysis of variance[25] was utilized to test the three hypotheses. This multiple regression technique compares two models of predictors and the criterion variable when making the test. In an analysis of variance analog, a "full" model is defined where membership to a treatment group is utilized as a predictor. A "reduced" model that does not contain any predictive information is also defined. The squared multiple correlation coefficient (R^2) is calculated for both models. The magnitude of the difference between the R^2 for the full and reduced models is computed and the F-ratio is calculated from the R^2 difference. When multiplied by 100, this R^2 difference can be interpreted as the percent of the variance of the criterion variable that is accounted for by the membership to the different treatment groups. This process is completely analagous to the procedure that is usually labelled "single classification analysis of variance, a comparison of means" although the parameters used in the statistical tests differ.

Hypotheses Test Results

The first hypothesis (H1 was a comparison between the composited science attitude items of the three treatment groups combined (R + RO + RRP) and the control group. The test is to answer the question, "Are the combined attitude change techniques of reading a persuasive communication, reading a persuasive communication followed by observing a role playing procedure, and reading a persuasive communication followed by role playing more effective in producing an attitude change than no attitude change treatment?" The comparison resulted in a magnitude of difference that requires rejection of the null hypothesis ($p < .001$) (see Table I). The combined treatment groups resulted in a much higher mean science attitude score than did the control group. This is the most important comparison in the study. Although it does not provide information as to which of the three attitude change treatments creates the most change, it does make it possible to state that attitudes toward science and elementary school science instruction can be modified by the use of an attitude change technique with a persuasive communication as its basic mechanism. The amount of change was not minimally significant. Twenty-one percent of the variance in the posttest attitude scores of the subjects was accounted for by their membership to one of the treatment groups. Such a large difference provides a high degree of confidence in the effectiveness of the attitude change treatments in the context of this study.

TABLE I

Comparison Between Group C and Combined Groups R, RO, and RRP on the Posttest Science Attitude Score

R^2 difference between models	.21
F-ratio with 1 and 202 degrees of freedom	54.42
Probability	< .001
Group R + RO + RRP mean	52.07
Group C mean	43.33

The question to be answered by testing Hypothesis 2 (H2) is, "Is passive reading of a persuasive communication as effective in producing a desired change in the subjects' science attitude as experiencing the role playing situation?". To answer this question, groups RO and RRP were pooled and compared with group R on the post-test responses. Referring to Table II, it is found that H2 cannot be rejected (p = .29). It can then be inferred that the combined role playing experience is no more effective than only reading the persuasive communication. The question that now arises concerns the relationship between the effectiveness of observing the role playing and participating in the role playing. The acceptance of H2 may be due to one of the role playing experiences being superior to and the other being inferior to reading the communication.

TABLE II

Comparison Between Group R and Combined Groups RO and RRP on the Posttest Science Attitude Score

R^2 difference between models	.007
F-ratio with 1 and 159 degrees of freedom	1.115
Probability	.29
Group RO + RRP mean	52.45
Group R mean	51.13

The test of Hypothesis 3 (H3) answers the question, "Is reading the communication followed by role playing a proponent of the opinions expressed in the communication more effective in modifying science attitudes than reading the communication and silently observing the role playing?". Group RO and RRP were the treatment groups being compared; inspection of Table III shows that H3 cannot be rejected (p = .84). From the results of the test for H2 and H3, it can be inferred that there is no significant difference in the relative effectiveness of reading the persuasive communication, reading the communication and observing role playing, and reading the communication and role playing the point of view of the communication.

TABLE III

Comparison Between Group RO and Group RRP on the Posttest Science Attitude Score

R^2 difference between full and reduced models	.0003
F-ratio with 1 and 113 degrees of freedom	.0338
Probability	.849
Group RO mean	52.59
Group RRP mean	52.33

An investigation of two factors that should have contributed to groups RO and RRP being more influenced than group R may explain these results. The first consideration concerns the total amount of information to which each subject was exposed. Groups RO and RRP had an accumulation of nine minutes of exposure to verbal presentations of arguments supporting the position of the communication. Group R did not have this experience. During this time, the subjects were asked to make their presentation as though they were explaining the ideas of the communication to a parent, but they were encouraged to refer to the article if they could not think of anything to say. In addition, they were allowed to read from the communication to avoid long silent periods if a brief scan of the communication did not produce any ideas. The investigator's observations of the role playing detected very little new information or arguments from the role playing.

A second factor that could affect both group RO and RRP is the reiteration of the topics of the communication. Assuming that the subjects had significantly less than 100% comprehension of the content and implications of the communication when reading it, a restatement of the same points during the role playing should fill in some of the missing information as well as cause the subjects to think about ideas a second time. Two reasons could account for the failure of this factor to create a difference between group R and groups RO and RRP. First, the subjects may have read the communication very thoroughly the first time through. This is quite probable since there was adequate time for the majority to re-read many segments of the article. Also, the subjects were told that some of them would be making a verbal presentation on the content of the article which probably motivated the subjects to read more carefully. Secondly, the subjects may not have modified their opinions a measureable amount from a second consideration of the content. This appears reasonable considering that the majority of the subjects were probably much in favor of the point of view of the communication before role playing began if it is assumed that the persuasive communication affected groups RO and RRP as it did group R.

The above discussion concerned factors that were anticipated to have a positive effect on attitude change in addition to the effect of reading the persuasive communication. In attempting to explain the failure of these factors to produce any additional change, it was repeatedly noted that a high level of acceptance of the ideas of the communication prior to the role playing may account for the failure of the factor to create a difference between groups.

This investigator believes that this relatively high acceptance of the ideas of the communication by the groups that role played or observed the role playing was the primary reason that there was no significant difference between the three treatment groups. The term "relatively high" was used because there was obviously room for more movement (change) in the desired direction since the highest group mean on the posttest was 52.59 and a maximum score would be 70.0. However, this available range of movement was all within the portion of the attitude scale representing acceptance of the communication. Evidently, the subjects had changed opinions about as much as they could from verbalization of the arguments of the communication. More verbalization of the same type of argument, as was done in the role playing, simply is not effective in moving attitudes from a high level of acceptance of an idea to an extremely high level of acceptance of the idea.

Post-Posttest Results

The data from the post-posttest of science attitudes was collected nine days after the persuasive treatment. The ten science attitude items were embedded in 24 non-science items that comprised the questionnaire. As on the pretest, only the science related items were scored. The re-administration of this questionnaire was explained to the subjects as the second part of a procedure to develop an instrument to measure opinions on elementary school curriculum. Only 20 of the 204 subjects were lost for the post-posttest; therefore an adequate sample of 184 subjects remained for the post-posttest analysis.

TABLE IV

Comparison Between Group C and Combined Groups R, RO, and RRP on the Post-Posttest Attitude Score

R^2 difference between models	.0667
F-ratio with 1 and 202 degrees of freedom	13.0
Probability	<.001
Group R + RO + RRP mean	47.9
Group C mean	43.8

TABLE V

Comparison Between Group R and Combined Groups RO and RRP on the Post-Posttest Attitude Score

R^2 difference between models	.0019
F-ratio with 1 and 145 degrees of freedom	.27
Probability	.61
Group RO + RRP mean	48.1
Group R mean	47.4

TABLE VI

Comparison Between Group RO and Group RRP on the Post-Posttest Attitude Score

R^2 difference between models	.0001
F-ratio with 1 and 104 degrees of freedom	.01
Probability	.92
Group RO mean	48.0
Group RRP mean	48.1

Tables IV, V, and VI provide post-posttest comparisons between the same groups that were compared in testing H1, H2, and H3. These three hypotheses tested the relative effectiveness of the different attitude change treatments. The differences, or lack of them, between treatment groups cannot be attributed to the effect of the experimental treatments with the same degree of confidence that could be applied to the posttest results. Although the class instructors were asked to avoid discussion of the experiment, the subjects had nine days in which to interact with each other, forget or distort the content of the communication, and receive other information that they may associate with science education. In addition to these random experiences, all of the subjects utilized in the study were studying science teaching methods in class. Even if there was no information presented in these classes that would contradict the ideas of the communication, there was a high probability that some of the concepts of the communication were experienced in a non-persuasive way and that ideas closely related to the communication were presented in the normal class readings and discussions. The assumption is made that the message of the persuasive communication will tend to be attenuated as it is assimilated in the background of similar and overlapping information received in the context of a typical class situation. The post-posttest comparisons are not independent of the comparisons made on the posttest data so the probability values were not reported. The comparison between the combined group R, RO, and RRP and group C resulted in an F-ratio of 13.0 with 1 and 182 degrees of freedom.

The final comparison between group RO and RRP resulted in an F-ratio of .01 with 1 and 104 degrees of freedom. Although the magnitude of difference between the control group and the combined treatment groups was smaller on the post-posttest than on the posttest compariosn, the treatment groups were still significantly different from the control group while not significantly different from each other (see Table VII).

TABLE VII

Posttest and Post-Posttest Means of the Four Experimental Groups

Group	C	R	RO	RRP
Posttest	43.33	51.13	52.59	52.33
Post-posttest	43.8	47.4	48.0	48.1

Discussion and Implications

The subjects had previous exposure to much of the information of the communication from the required readings in their science methods classes. In spite of this exposure to the rationale of new, innovative curricula, which are consistent with the opinions of the experimental communication, the communication created a large shift in attitude scores. The obvious difference between the two types of presentations is that the former presents the material without evaluation while the latter conveys the message, "this is good". It was shown from the literature that teaching toward a scientific or inquiring attitude is an objective of science classes that spans most of the science education literature. The implications from this study suggest that the explicit evaluation of the science programs in terms of the desired pupil activities and terminal objectives may be a better method of creating the desired science attitude in prospective teachers than indiscriminantly presenting science teaching materials, science curriculas, and science teaching methods and hoping that the prospective teacher will synthesize this information in such a way as to develop a "good" science attitude. If the assumption is made that most elementary teacher candidates lack expertise in science and the scientific processes, it may be unrealistic to expect them to discriminate between different science curricula on the variables considered important by science educators. It would be less realistic to expect them to make appropriate decisions concerning the application of these programs. The development of a scientific attitude in the prospective teachers may be accomplished by focusing their learning to specific objectives through a series of persuasive communications oriented toward the cognitive domain of the individual's attitude. In addition to the expected positive relationship of this cognitive attitude change on the affective and conative domains of an attitude, this technique would provide the individual with a vocabulary and arguments to discuss the science program, argue for facilities and conditions to improve the program, and defend his classroom actions if the need arises. Reading about textbooks, curricula, and demonstration apparatus (i.e. surveying science teaching methods) apparently does not provide the average elementary teacher with this capability.

The results of this study do not support the value of role playing as a superior attitude change technique to reading the persuasive communication. However, the results presented in Table VII show that the non-significant differences between the role playing, observing the role playing, and reading only groups favor the groups that participated in the role playing experience. We can then assume that role playing is at least as effective as reading the communication only. The role playing procedure, which did include a discussion period, translates easily into a classroom situation. If the procedure of reading a persuasive communication and role playing, similar to the procedure used in this study, were used as a weekly part of a science methods class, these communications could be made mutually supportive and each role play-discussion period could provide reinforcement to help create and sustain the type of desirable attitude change that was accomplished in this study.

A further consideration of an attitude change that has utilitarian consequences is the relationship between the cognitive and the conative (action) components of the attitude. The science attitude desired by science educators does not refer only to a pencil and paper response; actions in the classroom are the ultimate criteria for a successful attitude change program. A change in an individual's cognitive attitude could be instrumental in creating a behavior change consistent with the attitude. A generally accepted definition of an attitude is a "mental and neural state of <u>readiness to respond</u>, organized through experience and <u>exerting a directive and/or dynamic influence on behavior</u>".[26] If a persuasive communication or a persuasive communication-role playing combination procedure is considered the experience through which the mental state of readiness to respond is developed, the level of readiness should have been raised for the treatment group subjects. From the definition given above, it appears that behavior should be influenced. A subject's readiness to respond may not be raised to a sufficient level to influence his overt behavior a measurable amount, but the probability that a subject will show overt behavior change when an opportunity arises should be raised. The extent of this influence on the prospective teachers will undoubtedly be a function of the ease of application of a science program utilizing the concepts presented in the communication, the social and professional rewards for engaging in the program, and the availability of facilities and resources to support the program.

BIBLIOGRAPHY

1. Dunfee, Maxine, Elementary School Science; A Guide to Current Research, Association for Supervision and Curriculum Development, Washington, D.C.; 1967.

2. Fowler, Horatio S., Secondary School Science Teaching Practices, The Center for Applied Research in Education, Inc., New York; 1964.

3. Washton, Nathan S., Teaching Science Creatively in the Secondary Schools, W. B. Saunders, Philadelphia; 1967.

4. Haney, Richard E., The Changing Curriculum: Science, Association for Supervision and Curriculum Development, Washington, D.C.; 1966.

5. Goodlad, John I., The Changing School Curriculum, The Fund for the Advancement of Education, New York; 1966.

6. Lee, Eugene C., New Developments in Science Teaching, Wadsworth Publishing Co., Belmont, Calif.; 1967.

7. Hurd, Paul DeHart, and James J. Gallagpher, New Directions in Elementary Science Teaching, Wadsworth Publishing Co., Belmont, Calif.; 1968.

8. Karplus, Robert, and Herbert D. Thier, A New Look at Elementary School Science, Rand McNally, Chicago; 1967.

9. Victor, Edward, "Why Are Our Elementary School Teachers Reluctant to Teach Science?," Science Education, 46, 185-192 (1962).

10. Behnke, Frances L., "Reactions of Scientists and Science Teachers to Statements Bearing on Certain Aspects of Science and Science Teaching," School Science and Mathematics, 61, 193-207 (1961).

11. Gruber, Howard E., "Science as Doctrine or Thought? A Critical Study of Nine Academic Year Institutes," Journal of Research in Science Teaching, 1, 124-128 (1963).

12. Craven, Gene F., Critical Thinking Abilities and Understanding of Science by Science Teacher-Candidates at Oregon State University, Doctoral dissertation, Oregon State University, 1966. Ann Arbor, Michigan, University Microfilms, No. 66-7121.

13. Shanks, James L., Concept Achievement in Science and its Relationship to some Non-Intellectual Characteristics of Prospective Elementary Teachers. Unpublished doctoral dissertation, University of California, Berkeley, 1968.

14. Klopfer, Leopold E., and William W. Cooley, "The 'History of Science Cases' for High Schools in the Development of Student Understanding of Science and Scientists; A Report on the HOSC Instruction Project," Journal of Research in Science Teaching, 1, 33-47 (1963).

15. Stoker, Howard W., Aptitude and Attitudes of High School Youth RE: Science as Related to N Variables, Unpublished Doctoral dissertation, Purdue University, 1957.

16. Mead, Margaret, and Rhoda Metraux, "Image of the Scientist among High-School Students; A Pilot Study," Science, 126, 384-390 (1957).

17. Baker, P. C., R. W. Heath, H. W. Stoker, and H. H. Remmers, "Physical Science Aptitude and Attitudes toward Occupations," The Purdue Opinion Panel, 15 (3), 2-5 (1956).

18. Allen, H., Attitudes of Certain High School Seniors Toward Science and Scientific Careers, Bureau of Publications, Teachers College, Columbia University, New York; 1959.

19. Hovland, Carl I., Irving L. Janis, and Harold H. Kelley, Communication and Persuasion, Yale University Press, New Haven, Conn.; 1953.

20. Hovland, Carl I., and Walter Weiss, "The Influence of Source Credibility on Communication Effectiveness," Public Opinion Quarterly, 15, 635-650 (1951).

21. Janis, Irving L., and Carl I. Hovland, "An Overview of Persuasibility Research," Personality and Persuasibility, I. L. Janis and C. I. Hovland, Eds., Yale University Press, New Haven, Conn., 1959, pp. 1-28.

22. Janis, Irving L., and Bert T. King, "The Influence of Role Playing on Opinion Change," Journal of Abnormal and Social Psychology, 49, 211-218 (1954).

23. Culbertson, Frances M., "Modification of an Emotionally Held Attitude Through Role Playing," Journal of Abnormal and Social Psychology, 54, 230-233 (1957).

24. Zimbardo, Philip G., "The Effect of Effort and Improvisation on Self-Persuasion Produced by Role-Playing," Journal of Experimental Social Psychology, 1, 103-120 (1965).

25. Veldman, Donald J., Fortran Programming for the Behavioral Sciences, Holt, Rinehart, and Winston, New York; 1967.

26. Allport, Gordon W., Excerpt from an article in Handbook of Social Psychology, C. Murchison, Ed., Clark University Press, Worcester, Mass., 1935. (Republished: "Attitudes", Readings in Attitude Theory and Measurement, M. Fishbein, Ed., Wiley, New York, 1967, pp. 1-13.)