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ABSTRACT

Presented are abstracts and abstractors' analyses of eight studies related to teacher education and two studies related to the nature of science. Analyses in the area of teacher education are on studies of: attitudes of elementary teachers in Trinidad and Tobago (P. Fraser-Abder and R. Shrigley); educators' categorizations of different models of teaching (H. L. Jones et al.); the effects of televised instruction on attitudes of in-service elementary teachers (D. S. Sheldon and D. Halverson); methodologies used to evaluate teacher education programs (G. D. Herman and R. Willings); methods for improving preservice elementary teachers' process skills (D. Gabel and P. Rubba); student teachers' competency in diagnosing student misconceptions (J. Nussbaum); teachers' perceptions concerning the relative importance of some curricular objectives (R. A. Schibeci); and the characteristics of male and female science teachers (in an attempt to identify factors that attract people to a particular career choice) (W. W. Welch and F. Lawrenz). Analyses related to the nature of science (critiques and responses) are on studies of junior high school students' adherence to certain misconceptions about the nature of science (P. A. Rubba et al.) and science teachers' concepts of the nature of science (M. B. Ogunniyi). Responses to the analyses by the authors of the last two studies are included. (JN)

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INVESTIGATIONS IN
SCIENCE EDUCATION

Volume 10, Number 4, 1984

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NOTES FROM THE EDITOR:

This issue contains article reviews categorized as dealing with teacher education and others which focus on the nature of science.

The eight teacher education articles are varied. Fraser-Abder and Shrigley examined attitudes of elementary teachers in Trinidad and Tobago. Jones et al. studied educators' categorizations of different models of teaching. Sheldon and Halverson's study was designed to evaluate the effect of televised instruction for in-service elementary school teachers. Herman and Willings examined methodologies used to evaluate teacher education programs. Gabel and Rubba looked at methods for improving preservice elementary school teachers' process skills. Nussbaum investigated student teachers' competency in diagnosing pupil misconceptions. Schibeci examined teacher perceptions concerning the relative importance of some curricular objectives. Welch and Lawrenz compared characteristics of male and female science teachers in an attempt to identify factors that attract people to a particular career choice.

Rubba et al. studied junior high school students' adherence to certain misconceptions about the nature of science. Ogunniyi studied science teachers' concept of the nature of science. A response to the reviewer's critique accompanies each of these reviews.

Patricia E. Blosser
Editor

Stanley L. Helgeson
Associate Editor

TEACHER EDUCATION

Fraser-Abder, Pamela and Robert Shrigley. "A Status Study of the Science Attitudes of Elementary School Teachers in Trinidad and Tobago." Science Education, 64 (5): 637-644, 1980.

Descriptors--*Attitudes; College Students; Educational Research; *Elementary School Science; Higher Education; Preservice Teacher Education; Science Education; *Science Teachers; *Teacher Attitudes; Teaching Experience

Expanded abstract and analysis prepared especially for I.S.E. by Patricia H. Suter, Del Mar College, Corpus Christi, Texas.

Purpose

The purpose of this study was to ascertain the attitudes toward science on the part of elementary school teachers prior to the beginning of a new program on science in the curriculum.

Rationale

The rationale for this study was a response to the need for the teachers in elementary schools in Trinidad and Tobago to include science in their plans of study. This area had been neglected in the past, but a new Common Entrance Test was to be given to all sixth grade students to determine their eligibility for free secondary education. The authors felt that a study of the attitudes of the teachers before the program began would be timely and helpful.

Research Design and Procedure

A Likert-type instrument was used to investigate the attitudes of the teachers. Six variables which were thought to be pertinent in analyzing these attitudes were investigated. These variables were:

1. The effect of gender difference on science attitude.
2. The effect of teaching level (5- through 11-year old students).

3. The effect of school type attended (public, private, denominational).
4. The effect of geographical location of teachers (urban, suburban, rural).
5. The effect of mathematics courses.
6. The effect of science courses.

The Science Attitude Scale for In-Service Elementary Teachers (Shrigley and Johnson, 1974) was used in this study. Translation was not necessary because English is the common language. The instrument was administered by the science teachers at six teacher training colleges where the elementary teachers attend in-service training. The 880 subjects in this study represented all the teachers enrolled during 1977-1978.

For each of the variables which were investigated, a null hypothesis was assumed. Respondents were given 40 minutes to reply anonymously to the scale. There was no control group and no treatment.

Findings

The first variable of possible gender differences found that male teachers in this sample did in fact have a more positive attitude toward science and the teaching of science than did female teachers. The authors suggested that attitude modification might become part of the preparation of female teachers.

The second variable, the possible effect of the age level taught on teacher attitudes, did not show results significant enough in the minds of the authors to lead them to feel that attitude modification was needed. There seemed to be some difference between those teaching 6-year olds versus 11-year olds.

The third variable studied, the type of school attended by the teachers, was also found to have little if any effect on their attitudes towards science or science teaching.

The fourth variable, the geographical location of teachers, did show an effect. When the data were subjected to the Tukey WSD multiple range test, two group pairs had mean scores with a significant difference at the .05 level. Rural and suburban teachers had significantly higher attitude mean scores than did the urban teachers. The authors suggest that this deserves further study.

The fifth variable, experience in mathematics courses, did not affect attitudes toward science or science teaching.

The sixth variable, experience in science courses, did have an effect. An analysis of the mean scores using the Tukey WSD test indicated that the attitude scale scores of teachers having science courses at elementary and secondary levels were significantly higher than those of teachers having science in elementary school only or those having no science courses.

Interpretations

The authors comment on their results to the effect that they support the general findings that requiring teachers to take more science and math courses in college does not necessarily improve their attitude towards science. They suggest that it is the mandated Common Entrance Examination which may affect the attitudes more significantly and lead to the teaching of more science in the elementary schools.

ABSTRACTOR'S ANALYSIS

This study appears to be an interesting addition to the investigations of teacher attitudes. The situation in Trinidad and Tobago was unique in that a whole new situation was about to happen. The students would be tested as they completed the sixth grade and their grades in science would in part determine whether or not they would receive free secondary education. This situation puts pressure on the elementary teachers, and the authors conclude that this pressure itself would influence their attitude toward science teaching.

The methodology of the study follows the standard practice for such studies. Their conclusions seem valid. They made suggestions based on the results of gender differences in the attitudes toward science and science teaching and proposed that special attempts be made to improve their offerings to female teachers.

The reference to a Likert-type instrument was unfamiliar to me. It was necessary to consult a psychological reference book to learn just what method the authors were following. It would have been helpful if a direct reference in the bibliography had been made. Not all readers of their article are familiar by name with this attitude measurement. Once I found out that the instrument is a five-point scale used to quantify the responses of subjects to a set of statements reflecting attitudes, beliefs, or judgments, their method became clear. The five points on the scale are: strongly agree, agree, undecided, disagree, strongly disagree (or some similar and balanced expressions of agreement or disagreement). Intervals between each point on the scale are assumed to be equal: hence, each point on the scale is assigned a number value, usually from 5 to 1. Scores are derived by either the summation of the responses or by averaging them.

This paper was published in 1980, reflecting work done earlier. A follow-up study might be in order. It would be interesting to determine whether the necessity to teach more science in the elementary schools brought about any change in the attitudes of teachers. Does more exposure to science on the part of the teachers preparing for their classes bring about a more positive attitude toward science and science teaching?

The situation in Trinidad and Tobago is unique in that a new curriculum was instituted to help prepare students to take a test with a real incentive...free secondary education. This motivation on the part of both teachers and students makes the opportunity for investigation of changing attitudes worthy of additional study.

Jones, Howard L., Bruce Thompson, and Albert H. Miller. "How Teachers Perceive Similarities and Differences Among Various Teaching Models." Journal of Research in Science Teaching, 17 (4): 321-326, 1980.

Descriptors--*Classification; *Differences; Models; Science Education; *Science Instruction; Science Teachers; *Teacher Attitudes; Teacher Educators; *Teaching Methods

Expanded abstract and analysis prepared especially for I.S.E. by Gerald Skoog, Texas Tech University.

Purpose

This study was designed to determine how educators categorized 16 different models of teaching or instructional strategies and what instructional parameters were the basis for the categorization of the models.

Rationale

The existence of a variety of instructional approaches or models of teaching provides teachers with a wide range of teaching strategies. This wide array of choices creates a selection dilemma for elementary and secondary teachers as well as for teacher educators who must select the appropriate curriculum and strategies. These instructional choices might be simplified and the selection dilemma lessened if identifiable similarities within the models of teaching exist. Joyce and Weil (1972) suggest factors such as social interaction, information processing, the individual as a person, and behavior modification are useful in distinguishing between and grouping together various teaching strategies.

Research Design and Procedure

Brief paragraph summaries of 16 models of teaching were prepared and given to two groups of inservice teachers considered experts in implementing the models. Each teacher in the two groups (n_1 = 19; n_2 = 15) was asked to identify by name 10 different randomly assigned summaries. On the basis of this pilot study, it was concluded that the summaries provided representative descriptions of the models.

A sample of 65 beginning teacher education students, 50 teacher education students who had just completed student teaching, and 27 classroom teachers was selected. Each subject analyzed five or six randomly assigned instructional models. Thirty-three instructional parameters, which focused on grouping, grading, sequencing, and teacher warmth, were used for analysis and categorization.

Medians were calculated for each of the 33 ratings of each of the 16 instructional approaches. These medians were used to develop a correlation matrix which was analyzed and used as a basis for identifying prototypes or "supermodel" aggregates of the models.

Findings

Three "supermodels" were identified. One "supermodel" emphasized inquiry and discussion methods and included nine models of teaching. The models categorized in this group included Concept Attainment, Jurisprudential, Inductive, Awareness Training, and Synectics. The three models (Lecture, Advance Organizer, and Operant Conditioning) placed in the second "supermodel" were characterized by a high degree of structure. The three models (Nondirective, Classroom Meeting, and T-Group) grouped in the third "supermodel" were characterized by a lack of structure.

The median ratings and factor scores suggested that the subjects thought "Supermodel I" classrooms reflected a concern for students as people, reflected friendliness, had a focus on the application of knowledge and typically involved teachers who were bright. "Supermodel II" classrooms were seen by the subjects as highly structured environments where teachers made most instructional decisions. "Supermodel III" classrooms were characterized by the subjects as having a significant amount of student decision-making.

Interpretations

Educators perceive there are three categories or groupings of the models. Selection dilemmas confronting educators can be somewhat mitigated if similarities in the models of teaching are considered.

In their analysis and categorization of the models, the subjects emphasized the methods implied by the model. They put much emphasis on the degree of structure possessed by a model. They also viewed the models in terms of their affective orientation and application. They did not analyze the models in terms of their purpose and focus.

The "supermodels" identified in this study may be those that are really used by effective teachers.

ABSTRACTOR'S ANALYSIS

Joyce and Weil (1972) categorized the models of teaching on the basis of the goals they were designed to achieve and how they can be adopted to students' styles and characteristics. The researchers found no clear support for Joyce and Weil's method and rationale for grouping the models in this study.

Because of the parameters and indicators used for categorization in this study, it was not surprising that the subjects did not identify or correlate the models with different purposes as done by Joyce and Weil. The 11 parameters to which the researchers related the 33 indicators and used for the groupings dealt with how instruction is individualized in terms of pace, content selected, sequence and method of study, and locus of decision-making. Other parameters focused on grading method and the intellectual characteristics and affective orientation of teachers. None of the parameters or the indicators dealt with the purpose or focus of the model. As a result, the researchers had no basis for concluding that there was no support for grouping the models into families on the basis of focus or purpose as done by Joyce and Weil.

The researchers' premise that educators face a dilemma in selecting the appropriate model to use is open to challenge. Furthermore, their conclusion that the groupings made in this study would mitigate this dilemma is challengeable. Today, the choice or selection of the objective that is to be pursued probably is a bigger dilemma. The many dimensions of literacy and the complexity and demands of society require schools to pursue a variety of objectives. Educators face dilemmas as they try to decide the relative emphasis each objective deserves. Often the range of objectives selected for emphasis is narrow. As a result, the number of different models of teaching needed and used is small. When a particular educator expands the range of objectives being pursued, a need for different teaching methods develops. Overall, the researchers' failure to relate methods to purpose was a serious oversight.

The 142 member sample used in this study included 115 individuals who were either beginning or finishing their preservice teacher education program. It seems likely that many or most of these individuals would not have used and studied all or most of these models to the point where they could distinguish important differences in their approach and rationale and be able to employ them in terms of a desired objective. When Synectics is grouped with Concept-Attainment, as done in this study, it seems the subjects did not understand how these two different approaches were intended for very different purposes, of they were restricted by the design of the study and could only identify them as being similar because each involves students in answering and asking questions.

Overall, this study's contribution to the literature is minimal. However, there are many questions about the use of the models of teaching that need to be considered in future studies.

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Sheldon, Daniel S. and Dean Halverson. "Effects of a Televised Science Inservice Program on Attitudes of Elementary Teachers." Journal of Research in Science Teaching, 18 (3): 249-254, 1981.

Descriptors--*Educational Television; Elementary Education; *Elementary School Science; Elementary School Teachers; *Inservice Teacher Education; Science Education; *Science Instruction; *Science Teachers; *Teacher Attitudes

Expanded abstract and analysis prepared especially for I.S.E. by Steven Gilbert, Purdue University.

Purpose

This study was intended to evaluate the effect of using televised in-service presentations on the science attitudes of practicing elementary school teachers. It proposed to evaluate the relationships between selected teacher characteristics and attitude changes brought about by the program. These characteristics included the number of graduate credits earned in science courses, previous attendence at in-service science workshops, grade assignment, age, gender, and teaching experience.

Rationale

Teacher in-service programs need to be designed and presented with consideration for both general effectiveness and individual teacher needs. Not all teachers will respond to a given presentation in the same way. This study was designed to extend previous work demonstrating that age and grade level are potentially important factors in determining the effectiveness of in-service education (Schwirian, 1969). It was also expected to elicit findings that could be related to the conclusions of Hasan and Billeh (1975) that in-service programs are positively correlated with attitude change and that the level of education is negatively correlated with changes in attitude.

Consideration of demographic variables such as these is necessary if curriculum designers are to create effective and reliable in-service experiences for teachers.

Research Design and Procedures

This study was conducted with 138 elementary school teachers (K-6) serving in Dubuque, Iowa. Twelve in-service sessions with a duration of approximately thirty minutes each were constructed for televised showing. Two of these sessions were locally produced. The other ten were made by splicing a locally-produced segment of ten minutes to a twenty minute section taken from the Science in the Elementary School series (Western Kentucky University). Each individual teacher was asked to view five sessions, with three of the programs concentrating on science process skills and pedagogy and the other two being individualized by teacher as to subject area (physical or life science) and grade level (primary or intermediate).

The research was of a one-group pretest-posttest design with no control. The major dependent variable was gain score on an instrument called the Science Attitude Teaching Scale (Moore, 1973). This test has six items which are ranked on a Likert scale from 1 to 5, giving a maximum score possible of 30 and a minimum score of 6. Three attributes are measured: personal attractiveness of teaching science, fact vs. process orientation and directive vs. student centered control. Each attribute is measured by two items. A Workshop Evaluation Questionaire was also completed and used to assess the attitudes of the teachers toward the workshop itself.

The independent variables included number of credit hours in science classes at the graduate level, participation in previous inservice science programs, grade level, gender, age and teaching experience. Treatment, which was given to all teachers, was participation in the in-service program.

Data were analyzed using gain scores on the STAS. These scores were grouped according to the 27% rule of Cureton (1957). The Upper 27% of the scores made up one group, the lower 27% made up a second group, and a third group consisted of the middle 46%. Application of this rule to the gain scores resulted in those from -3 to -16 being analyzed together, those from -2 to +4 being analyzed as the second group, and those from +5 to +17 as the third, top group.

Chi square analysis of STAS groups by independent variable was performed for each of the independent variables listed.

Findings

Evaluation of the results showed that there were significant differences between the groups on gain scores when two demographic variables were considered: course credits in science courses and teacher participation in previous science in-service. Both analysis were significant to an alpha level of .038.

For number of credit hours, teachers were grouped as low (0-6), middle (7-12) or high (13+). The distribution of teachers in the STAS categories for the middle and high group was approximately 1:2:1 in both cases. In the low group, the teacher distribution was in a ratio of approximately 1:1:2 in favor of a higher gain score.

In considering the effects of prior in-service experience, teachers were placed into one of two groups: those who had previous experience and those who had not. In the STAS group with the highest gain scores, there were 6 times more teachers who had had no previous inservice than had had it (a 1:6 ratio). This ratio changed to 1:3 in the middle STAS group and 1:1 in the lower group, i.e., those with negative gain scores.

No significant difference was found between STAS groups when considering grade level, gender, age or teaching experience.

On the workshop evaluation instrument, 73% of the participants indicated their willingness to have television used in future in-service presentations. Locally produced segments were preferred by a ratio of 3:1.

Interpretations

When two attributes were considered, televised in-service programs were found to be differentially effective in changing teacher attitudes toward science. Teacher credits in science and participation in previous science in-service programs appear to be negatively related to attitude gain scores. The researchers suggest that this supports previous findings that the more college credits a teacher has, the more negative his or her attitude toward science will be. They suggest that the in-service model that was used was detrimental to those teachers.

Because of the favorable response to the use of television, as well as the relatively positive rating of the locally produced segments over the commercial ones, the researchers conclude that the lack of professionalism inherent in the locally produced segments can be offset by the greater individualization possible by production at the local level.

Their suggestions are that local science in-service directors should consider: (1) using televised components of in-service programs, (2) developing locally produced television programs, (3) assessments of the demographic characteristics of teachers while designing segments and programs, and (4) teachers' predispositions toward science and the teaching of science.

ABSTRACTOR'S ANALYSIS

The importance of tailoring in-service programs more closely to the needs of the practicing teacher is apparent to those who have spent any time in the classroom. Just as there has been a movement to try to accomodate the interests and attitudes of child-learners, so should there now be an attempt to do this with teacher-learners. Central to this effort is the need to identify relevant learner attributes.

A number of major problems are apparent in this work, at least one of which is serious enough to cast doubt on its usefulness. This one particular problem is the loss of information which occurs because of the decision to use the 27% rule to group gain scores. The decision to do this means that it is not possible to distinguish a gain score of +5 from one of +17 or, alternatively, to distinguish a relatively minor loss of -3 from a major loss of -16.

This loss of information is combined with a failure to present any information at all concerning the true test scores of the teachers. This is important since it is probable that those who started out the lowest would be expected to show the greatest gains, while those who started out the highest might show less gain or even a negative score due to regression toward the mean. Teachers who have few science credits and no previous in-service training in science might be expected to score low on the pretest, but then to make the highest gains. This is the pattern we see in terms of gain scores, but because the scores themselves are not presented, we cannot see where each teacher was to begin with.

Teachers who have had a relatively high level of training in science might begin high and make little gain in terms of attitudes, or even show a loss because of the effects of regression. Because losses of -3 are lumped together with losses of -16, we have no notion of how much of the loss we are seeing is slight and how much is major. This distinction is important when considering the influence of regression. Here, too, it is important to know the scores you are starting with.

The authors use these gain scores to support the contention that the more college credits a teacher has, the more negative his or her attitude toward science will be. In fact, they present no evidence for this. To say that teachers who have more college credit have lower gain scores is not the same thing as saying that they have lower test scores, which is presumably the basis for this claim. A teacher who begins high and then regresses may still have a better science attitude score than one who begins low and gains a great deal.

The researchers also contend that "the in-service model used in this study was actually detrimental to these (high credit) teachers." Again, for the reasons previously stated, this claim is not validated. There might be any number of reasons why teachers with more science credit have lower gain scores. The most obvious reason is that they already have a good attitude; other teachers have the most to gain from the program.

In fact, the distribution of teachers in the high-credit (13+) group is approximately 1:2:1 in the STAS categories, very near the 27:46:27 expected by the 27% rule. These teachers do not "pile up" in the high-loss category as would be expected if they were being detrimentally affected. It appears, rather, that there is not much effect at all. In the case of prior in-service experience, teachers who have the greatest loss in gain scores - who are in the lower group - are equally divided between those who have had prior in-service and those who have not. This is, again, not the pattern to be expected if the program was actively detrimental to those who have prior in-service experience.

A second major problem is apparent in the choice of instrument. While the STAS is defended with regard to its reliability and construct validity, it is questionable whether or not a six-item instrument has the ability to measure such a wide-ranging attribute as attitude toward science.

On an instrument with a fairly large number of items, differences in interpretation tend to have less effect on the total score than when fewer items are used. On a small test, items should be tightly drawn with little room for alternative interpretations. Unfortunately, the STAS does not appear to be either tightly drawn or large enough to compensate for its lack of precision. Examples of this lack of tightness are the items: "There are certain facts in science that children should know" and "Science teaching should be guiding or facilitating learning." Even the most process-oriented teacher might agree with the first, depending upon the interpretation of what is meant by certain facts, and knowing. The two terms, "guiding" and "facilitating" are also dependent upon an understanding of what these concepts actually imply.

The researchers in this case also fail to report reliabilities with regard to their own administration of the test.

Other problems also crop up, though they are less destructive to the intent of the research. For instance, no hypotheses are presented, though the nature of the work is suitable for their formulation. A statement of the research problems is included, but the expectations of the authors are not apparent.

Another important problem is the definition of "science process skills and pedagogy" which is used to describe the content of three of the five televised sessions. It is important to know whether or not the attitudes being stressed in these sessions are the same, or essentially similar, to the attitudes being measured on the STAS. This points up the reasonable supposition that an attitude questionaire based on the content of the presentation might be far and away a better measure of attitude change than a standard instrument such as the STAS. This is especially true if we are concerned with the <u>process</u> of attitude change, rather than the content.

The lack of a control group was unfortunate, but would not be serious with proper handling of the data. With 138 teachers, a control group would seem to be possible and would have added to the analysis of the treatment effects. Randomly assigning half of the teachers to an in-service in art or English would have provided a control while still making a worthwhile contribution to the needs of the teachers and the district.

Finally, the suggestion that locally produced in-service segments provide for greater individualization, despite their lack of "professional polish," is simply not supported by anything presented in the paper. While 73% of the participants in the in-service agreed that television should be used in future in-service sessions, and while there was a 3 to 1 preference for the locally produced segments, this amounts to little more than the results of a popularity contest. Nothing is presented to show that locally produced segments were less professional or more individualized than the commercial ones. Either important supportive information was not included in the report, or the conclusions cannot be supported by the data collected.

The need for research on the effectiveness of televised in-service training is certainly evident. However, what is really important if this research is to provide a basis for curriculum design is the discovery of reasons for observed changes. If it is true that science in-service programs are positively related to attitude changes toward science, and negatively affected by advanced training, then the question that really needs answering is: Why?

Certainly Sheldon and Halverson's conclusions that demographic variables should be considered when designing specific in-service programs is true, as it's their contention that predispositional attitudes toward science and the teaching of science should be considered. With more preparation, it might have been possible to gather much more information about teachers' feelings and attitudes than was presented here. A more complete presentation and analysis of the data, and a more open-ended approach in questioning teacher's perceptions of the value of the workshops might have added considerable depth and meaning to this work.

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Herman, G. D. and R. Willings. "Evaluation of Science Teacher Education Programs." Science Education, 64 (2): 175-183, 198, 1980

Descriptors--College Science; *Evaluation Methods; Higher Education; Preservice Teacher Education; *Program Evaluation; Science Education; *Science Programs; *Science Teachers; *Teacher Education Curriculum

Expanded abstract and analysis prepared especially for I.S.E. by Dorothy L. Gabel, Indiana University.

Purpose

The major reason for conducting this study was to examine the methodologies that can be used to evaluate teacher education programs. In so doing, the authors evaluated a teacher education program in Australia.

Rationale

The authors examined evaluation studies of teacher education programs and found that the methodology used in the evaluations was flawed. In previous studies, when students rated the degree to which they thought the teacher education program in which they had been enrolled influenced their attainment of certain attributes or objectives, when an attribute was given a low rating, it was impossible to tell whether the rating was low because their program did not include the attainment of the attribute as an objective, whether the program was ineffective, or whether the attribute was attained in some other way besides the specified program. In order to overcome this ambiguity in interpretation, the authors proposed an alternative way to collect and analyze data to evaluate teacher education programs.

Research Design and Procedures

The evaluation design utilized in the study is based on the Stake model which includes three phases. These are:

1. the evaluation of the intrinsic worth of the objectives.
2. the evaluation of the degree of attainment of the objectives.
3. ascertaining factors associated with the degree of attainment of the stated objectives.

The authors examined the suitability of various analytical techniques such as the t-test, congruence, discrepancy, correlation, ordering-theory hierarchy, and open-ended questions within this framework. The evaluation consisted of (1) comparing ratings of the importance of the objectives of the science methods component of a teacher education program by the two course designers, by 51 relatively new science teachers, and by 32 master teachers, (2) rating the attainment of the objectives both directly by the new teachers and indirectly by observations of the new teachers by the master teachers, and (3) the answering of open-ended questions.

Findings

The three phases of the evaluation process each employed different techniques. For Phase 1, the evaluation of the intrinsic worth of the objectives, the authors made comparisons between the ratings of the course designers and the new teachers (products of the program), and between the ratings of the course designers and the master teachers. This was done by using both t-tests and by rank ordering. The superiority of the rank ordering procedures was shown. Ordering-theory analysis was then used to indicate why teachers rated some objectives more important than others. Comparisons between the analysis of the teachers' rating and those of the master teachers using ordering-theory analysis led to the conclusion that "effective rapport-class control leading to or interacting with good student motivation, the use of activity-oriented lessons, and the ability to develop such attitudes as curiosity" are necessary for effective science instruction.

To determine the perceived attainment of objectives, Phase 2 of the study, an absolute criterion was necessary for the questionnaire data. Point 3 on a five point scale was used. Results were not given in the report.

Phase 3 of the study, investigation of possible factors associated with the perceived attainment of objectives, was investigated by comparing the designers' ratings of importance of the objectives with the new teachers' attainment of the objectives as rated by the master teachers. Data were anlayzed using the Spearman rank-order correlation coefficient and tests of congruence for individual objectives. This coupled with the new teachers' comments on open-ended questions led to the conclusion that an increase in school experience during which activity lessons were being taught, and a greater knowledge of evaluation techniques would have led to the attainment of the other objectives.

Interpretations

The authors conclude that the congruency-discrepancy approach in conjunction with a rank-order analysis and the ordering-theory analysis are useful tools for evaluating teacher education programs.

ABSTRACTOR'S ANALYSIS

Evaluation of teacher education programs is important if the quality of teaching in this country is to improve. Frequently teacher education program evaluations are quite superficial. In most instances, only small components of the programs are tested, and the evaluation is not extended beyond those students still enrolled in the program. Hermann and Willings provide techniques in this report that can be used to evaluate teacher education programs with the products of those programs. They identify errors made in the research procedures in previous studies and suggest new methodological techniques. The techniques that are suggested are not new. What is new is the application of these techniques in evaluating teacher education programs.

This research report merely highlights the techniques used. Unfortunately, not enough detail is given, particularly for phases 2 and 3 of the study, to make the evaluation procedures stated in the report comprehensible to the ordinary reader. References are given, however, so it can probably be assumed that a science education researcher who is interested in applying the techniques described in the report has ready sources of information accessible to him/her.

Gabel, Dorothy and Peter Rubba. "Science Process Skills: Where Should They be Taught?," School Science and Mathematics Journal, 80 (2): 121-126, February, 1980.

Descriptors--*Attitudes; *Educational Research; Higher Education; *Methods Courses; *Physics; Preservice Teacher Education; *Process Education; Science Instruction; *Teacher Education

Expanded abstract and analysis prepared especially for I.S.E. by Jerry G. Horn, Kansas State University.

Purpose

The study was designed to determine which of two types of courses, a modified physics course or a methods course, would best improve the preservice teachers' attitudes toward science and science teaching and their ability to use the process skills. More specifically, this study was designed:

1) to determine whether there was any difference in process skill acquisition when students were taught the skills as an integral part of a physics course or whether they were taught in isolation in a science methods course.
2) to compare physics students' attitudes toward science and science teaching when the course related to teaching science with attitudes of students in a methods course with similar experiences.

Rationale

The usual college preparation programs for elementary teachers include instruction in science and in teaching methodology. In larger institutions, these two processes are often performed by different instructors and in different colleges, i.e. a college of arts and sciences and a college of education. There is an obvious need for students in teacher education programs to relate the science learned in the college science courses to the teaching of science to children.

An attempt was made at Indiana University to modify an existing physics course to help elementary education majors see the relationship between their physics course and the science they would teach in the elementary schools. Modifications included:

1) using elementary science curriculum project experiments as part of the laboratory instruction
2) an emphasis on process skills
3) additional experiences related to children.

Research Design and Procedures

The subjects consisted of 58 students enrolled in physics (one lecture and four lab sections taught by two instructors) and 52 students enrolled in science methods the same semester (two sections taught by the same instructor).

The treatment consisted of participating in one of the two courses. Instruction in the physics course included the use of ESS, S-APA, and SCIS experiments, science process skill emphasis in the lab reports (for half the students), and experience related to children. The science methods instruction consisted of three major components: the curriculum projects, the science process skills, and generic skills (lesson planning, objectives, questioning, etc.). Methods students also had experiences related to children, i.e., observing and teaching science lessons in local elementary school classrooms.

The research design was primarily two parallel "One-Group Pretest-Post Test Designs" for some comparisons and a modification of the "Pretest-Posttest Control Group Design" for others. In this case, the control group was in reality another treatment (experimental group).

All subjects were administered two pretests. One was Moore's "Science Teaching Attitude Scales." This instrument, containing 140 Likert-type items keyed to four position statements about science (Part I) and three statements about science teaching (Part II), has a calculated reliability coefficient using the test-retest method, of

0.93 for Part I and 0.89 for Part II. The other pretest "The Science Measure for Teachers," developed by AAAS, was used to determine students' proficiency in the science process skills. This test assesses both the simple and integrated process skills normally presented in the elementary school classroom, and it has a reported reliability of 0.89. The same two instruments were administered to the subjects of the treatment groups (physics students and methods students) as a posttest to "evaluate the effectiveness of instruction."

Findings

The data from the pretest results of the two comparison groups were compared, using Parts I and II subscales and the total score of the attitude instrument and the score of the process skill test. On the attitude measure, significant differences at the 0.01 level ($F = 8.48$) was found on Part II and a difference at the 0.05 level ($F = 4.05$) on total score. In both cases, the results favored the subjects in the methods course, with regard to attitude toward science teaching (Part II) and total score. No significant differences were found between the groups on Part I (attitude toward science) and the process skill test.

Analyses of the posttest results produced a significant difference at the 0.001 level ($F = 11.87$) on Part II and 0.5 ($F = 6.81$) on the total score of the attitudinal measure. Again, the methods students scored higher. On the process skill measure, a difference at the 0.05 level ($F = 3.94$) was found, with the physics students producing the higher scores. Only one of the two physics instructors used specific training in the process skills; and, when only students trained in the process skills are considered and using pretest scores as a covariate, the difference between the physics students and methods students becomes even greater.

Interpretations

The data analysis seems to indicate that elementary majors will make substantial gains in attitudes toward science teaching whether enrolled in a specially designed physics course or in a science methods course. Equally or more important is the finding that science process skills appear to be more effectively taught in the physics course than in the methods course. This suggests a division of emphases between the two courses. Teaching science process skills in a physics course may help students come to the realization that the science process skills are a vital part of science and not exercises to be performed in a methods course.

ABSTRACTOR'S ANALYSIS

The search for the most effective and efficient placement and emphases of activities and learning experiences to develop knowledge, skills and attitudes for teaching is perplexing and a long standing problem. Teacher educators and others look to research on occasion for guidance, but in many cases resort to "best professional judgment." Research on this topic is often incomplete, or the studies are based on such unique situations that generalizability is difficult. This study, reported by Gabel and Rubba, does add to the literature, and it certainly was intended to address an unanswered question.

However, I fear that in its sample, treatment, and design, the study is another reflection of the problems cited above. In essence, the sample is not adequately defined and the description of the treatment would be difficult, if not impossible, to replicate. The authors identified inherent differences between the students in the treatment groups, i.e., class level/years in college, previous coursework in science, and possible motives for choosing physics; but these differences were not addressed in the analyses-with one exception, and that was due to differential treatment in the physics course.

However, in the Conclusions and Discussion of the original article, they cautioned about interpretations of the results "because students were not randomly assigned to groups and the students enrolled in the two courses may not be equivalent." I fully appreciate the authors' interest in comparing these two courses and the usual makeup of the student population in them, but they narrowed their focus in the treatment, and that is what should be addressed in the report.

The authors state in the conclusions that "elementary majors will make substantial gains in attitudes toward science teaching whether enrolled in a specially designed physics course or in a science methods course." This is an important consideration, and the data were available, but it was not addressed in the statistical analyses of this study. While the authors may feel this conclusion is obvious in looking at the means of the data, I would think a similar statement about the process skills could be made. The means for the process skills test increased from 11.02 to 54.17 and 9.96 to 50.73 when pre- and posttest scores are considered, for the physics students and methods students, respectively. This is a rather obvious inconsistency, especially since both attitudes and processes of science were of central focus in the study.

Some of the problems in the design, conduct, and reporting of this type of study can be easily corrected. However, there are others that will always be present. Specifically, lack of opportunity to assign subjects to treatment groups in a random manner and the lack of total control over the treatment, when regularly scheduled courses in an educational program are utilized, plague research in education and certain other social and behavioral sciences. As a researcher, one must weigh the potential problems and select the most valid and useful option, and one option might be to not do the study. Invalid or misinterpreted findings may cause a consumer to have false expectations and security in suggested practices.

This study has addressed but one question of many in this domain. With increasing knowledge and with more and more requirements for teacher education programs being imposed from external forces, we must constantly seek the most effective curriculum possible. Gabel and Rubba have provided a springboard for others to seek additional answers to important questions.

Nussbaum, J. "Towards the Diagnosis by Science Teachers of Pupils' Misconceptions: An Exercise with Student Teachers." European Journal of Science Education, 3 (2): 159-169, 1981.

Descriptors--Biology; Chemistry; College Science; Competency Based Teacher Education; Higher Education; *Listening Skills; *Preservice Teacher Education; Science Education; *Science Teachers

Expanded abstract and analysis prepared especially for I.S.E. by Eugene L. Chiapetta, University of Houston.

Purpose

The purpose of this study was to investigate student teachers' competency to diagnose pupils' answers for possible misconceptions.

Rationale

The science education research literature is replete with information which indicates that students who have taken science lack in their understanding of even the most basic science concepts. One possible cause for this learning problem lies in the difficulty students have in listening to and comprehending what the teacher says during instruction. Obviously this one-way communication pattern from teacher to students is ineffective for the teaching of many abstract science concepts. Science teachers must build in another component to the instructional process in order to improve pupil understanding, and that is to listen to their pupils in order to determine the nature of their misconceptions. Then they must turn this knowledge into useful information that can be given to the pupils to improve their comprehension of science concepts.

The approach taken in this research was based on that found in the British Science Teacher Education Project (STEP). The present researcher modified the STEP model to include exercises for science student teachers which emphasized the following:

(1) To develop awareness, it is not enough to evaluate a pupil's answers in terms of scientific correctness, but it is of equal importance to pay attention to the nature of the pupil's misconceptions.

(2) To enhance competency in rapidly scanning a pupil's written answers and 'reading between the lines' for detection of possible misconceptions.

(3) To enhance competency in diagnosing a pupil's misconceptions using psychological and philosophical terms and ideas.

(4) To increase ability in raising various considerations leading to more appropriate reactions to pupils' misconceptions in the teaching-learning process.

Research Design and Procedures

Subjects. The subjects in this study consisted of three biology (n=52) and two chemistry (n=31) student teacher sections, and one graduate (n=11) student group. The graduate students were pursuing M.Sc. and Ph.D. degrees in science education and possessed various backgrounds in science content areas. The student teachers were from various universities and colleges in Israel and were believed to be typical of student teachers (STs) in the country.

Materials. The materials consisted of two supposed explanations of a given physical phenomenon. The explanations were constructed from the results of previous research by the author (Nussbaum and Novick, 1979) in which pupils' explanations of certain physical phenomena were analyzed. From that study, the researchers were able to detect various misconceptions which appeared to exist in the reasoning of youngsters about the physical world.

Administration. The procedures for this investigation were as follows:

(1) Student teachers (STs) were informed that, as part of their program, they were going to do an exercise on "reading pupils'

answers." They were informed that the exercise would begin by working individually on worksheets, which would be followed by small-team and whole-group discussions.

(2) STs were given a worksheet in which they were asked to read and respond to pupils' response A and then to response B.

(3) Each ST reported his responses to the task orally, while a tutor tabulated all the data on the chalkboard. The tutor tabulated the data on the board and pointed out the great variety that existed among the STs' analyses of the pupils' explanations of physical phenomena.

(4) The STs were then asked to re-read and analyze certain pupils' responses.

(5) The tutor ended the procedure with a group discussion to: clarify the difference between technical or informational errors and misconceptions; and to elaborate and advance the quality of the diagnosis of the misconceptions made earlier by the STs. This was done by applying concepts and terms from cognitive psychology and the philosophy of science.

Results

1. There was considerable variance in the analyses of pupils' explanations of physical phenomena within the groups (biology STs, chemistry STs, and graduate students) as well as between these groups.
2. The misconception that was detected with highest frequency was the tendency of pupils to relate animism to dynamic physical phenomena. Even this most frequently identified misconception was detected only by about half of the STs (54 out of 94 Ss). Each of the other two misconceptions was identified by less than one third of the STs (31 and 27 out of 94 Ss).
3. The biology STs showed lower awareness of misconception 3 (science laws as separate from nature) than of misconception 1 (continuous model for the structure of matter).

4. The STs, in attempting to analyze pupils' explanations and misconceptions of physical phenomena, gave general remarks about pupil responses rather than those which had interpretive quality.

Interpretations

Teaching pupils science concepts is a difficult task, which is evidenced by the lack of knowledge and the misconceptions that pupils possess about these ideas. Training programs must address this serious problem. One solution to this problem is to make prospective science teachers aware of the difficulties inherent in promoting the achievement of the most basic science concepts by helping them to realize the extent to which students misunderstand these ideas.

The first step toward improving students' conceptions is to assist new teachers to analyze pupils' explanations about natural phenomena. We can begin with student teachers, and we will probably find that they have considerable difficulty in identifying misconceptions and explaining why they occurred. The diagnostic approach appears to be an excellent instructional strategy to correct and improve a student teacher's own understanding of the physical world.

ABSTRACTOR'S ANALYSIS

The present study is one among many investigations by the author and other researchers to investigate the misconceptions that exist in the thinking of students who have been taught science course subject matter. These studies usually employ an interview procedure, similar to that used by Jean Piaget, to assess the cognitive development of children and adolescents. Nussbaum and Novak (1976) used this approach to determine children's concepts of the earth and Nussbaum (1979) more recently investigated children's conceptions of the earth as a cosmic body. Erickson (1979) analyzed children's conceptions of heat and temperature. Brumby (1984) recently reported a study on the misconceptions about the concept of natural selection by medical biology students.

The studies cited above and many others which have focused on science content seem to provide the same conclusions that were reported in earlier research (Chiappetta, 1976) on science process skill acquisition and cognitive development: People usually show less understanding of science subject matter and intellectual skill development than what ought to be expected, given their age and schooling. Further, the intellectual competence of adults on science related learning tasks has been just as disappointing as that demonstrated by children.

Analysis of students' conceptions of science concepts appears to be a powerful teacher strategy. First, it can be used to increase awareness of misconceptions about major ideas that all students should learn in their science course work. Second, it can be used to design instruction to change the thinking of students who possess misconceptions. Third, it can be used to design instruction that may insure more accurate concept learning than that which presently exists. Science instruction at all levels should slow down and provide the learner with greater depth and breadth of experiences to improve knowledge acquisition and to prevent misconceptions.

The interview technique appears to hold great promise for improving the teaching competence of science teachers. It can heighten awareness of the errorful learning that is occurring, and use this knowledge to improve the design and delivery of instruction. Since few would be shocked by the conceptual level of most students who have taken science courses, the real problem is to do something about it. Experimental studies must now be conducted to determine the extent to which it is possible to improve students' achievement by teachers who have used the clinical interview technique to become sensitized to students' understanding of science concepts. Further, what are the contributions of poor instruction, cognitive development, and forgetting to this problem of misconception? These questions must be answered in the near future in order to support the interview method as a useful teacher training strategy.

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Schibeci, R. A. "Do Teachers Rate Science Attitude Objectives As Highly As Cognitive Objectives?" Journal of Research in Science Teaching, 18 (1): 69-72, 1981.

Descriptors--*Affective Objectives; Behavioral Objectives; *Cognitive Objectives; Interviews; Questionnaires; *Science Curriculum; *Science Education; *Science Teachers; Secondary Education; Secondary School Science, *Teacher Attitudes

Expanded abstract and analysis prepared especially for I.S.E. by Robert E. Yager, The University of Iowa.

Purpose

The purpose of this investigation was to conduct a study of teacher perceptions concerning the relative importance of various curricular objectives. Specifically, the investigator hypothesized that objectives in the affective domain are regarded as less important by teachers than are cognitive objectives.

Rationale

Schibeci asserts that curriculum developers have emphasized attitude objectives to a much greater extent recently than in the past. He cites reviews by Gardner and by Ormerod and Duckworth indicating greater research interest with objectives in the affective domain. He also reported on recent reviews of articles dealing with objectives which have appeared in Science Education and the Journal of Research in Science Teaching. The most frequently mentioned category was objectives dealing with attitudes and interests. Attitude objectives are reported as commonly included in teacher guides for new curricula.

Schibeci notes that there is little evidence that teacher views have been sought as affective objectives have been emphasized by curriculum developers and researchers. He does note studies by Taylor and Maguire, and ten years later by Carey, that report teacher ratings of various objectives and then compares such ratings with other groups, such as administrators and parents. Schibeci suggests that such studies may not consider what teachers do on a daily basis to meet various objectives and/or that they may not indicate an actual valuing of affective objectives except in some general abstract way.

The study includes a very general review of actions taken by curriculum developers with respect to focus on objectives in the affective domain and the interest in the domain by researchers. It suggests that teachers may agree that such objectives are important but that they may do little or nothing to teach toward such goals and/or evaluate their success in meeting them.

Research Design and Procedures

A questionnaire was constructed to use with random samples of science teachers for grades 8-10; the results indicate teacher reaction to basic objectives associated with the science programs for the selected grade levels in schools in Western Australia. In a follow-up study, some of the teachers who completed the questionnaire were interviewed as a means of gaining additional information concerning teacher perceptions and rationale in responding to items on the questionnaire.

The sample consisted of teachers who were listed by the Western Australian Education Department as teaching two or more hours of science per week in government high schools. A random sample of 202 was drawn from the 632 teachers on the list. Of the 202 contacted, 149 or nearly 74% replied after two reminder letters were distributed. In addition, principals of all 68 non-government schools were invited to participate by identifying one teacher for involvement in the study. Only 57.4% of the teachers so identified completed the questionnaire and thereby were included in the study.

The sample was described as representative of all science teachers in the state for the following reasons. A total of 83.9% of the government teachers were male; a total of 83.7% of the sample were male.

When the non-government teachers were included, the percentage of males was 82.4%. When the teaching experience of respondents was compared to the situation with all teachers as reported by the Schools Commission, the average was "very similar." Science teachers in Western Australia are typically male, relatively inexperienced (four years or fewer in teaching), and have a four-year preservice qualification which includes a three year Bachelor of Science degree and a one year graduate diploma in Education.

The teachers selected for the study reacted to each of four objectives found in the science curriculum guide for grades 8 - 10 in the Education Department of Western Australia (1974). The first two objectives were classified as cognitive objectives since they were concerned with the nature of science and scientific procedures. The next two objectives were classified as attitude objectives since they dealt with such items as attitude of inquiry, willingness to suspend judgement, and an awareness of the impact of science on society.

A semantic differential format was used to elicit responses to the four objectives. Twenty bipolar objective pairs, separated by a seven-point rating scale, were used: important-unimportant, subjective-objective, useless-useful, complex-simple, undesirable-desirable, exciting-dull, effective-ineffective, unpleasant-pleasant, practical-impractical, uninteresting-interesting, unsuccessful-successful, easy-difficult, vague-precise, helpful-unhelpful, clear-unclear, meaningless-meaningful, profound-superficial, certain-uncertain, positive-negative, and necessary-unnecessary. These 20 scales appeared to have face validity for evaluating each objective. Cronbach's for each of the four semantic differential concepts (i.e., the four objectives) was, respectively, .89, .95, .95, and .95.

Every teacher in the Perth metropolitan area who was willing to discuss the issues raised in the questionnaire was interviewed; this included a total of 35 teachers. These teachers were interviewed because it was feasible to do so; they were not unlike all teachers who were included in the total sample. Although a variety of issues arose in the 35 interviews, common questions included the following:

1. Are student attitudes to science important?
2. Are they assessed?
3. Are scientific attitudes important?
4. Are they assessed?

Findings

Responses to individual items in the questionnaire by different subgroups within the sample were compared. Analysis using one-way analysis of variance or X^2 tests as appropriate (the .01 level of significance was chosen) but revealed that there were no statistically significant differences in responses among any subgroups in the total sample.

For the semantic differential scales, a total score for each objective was calculated by summing the 20 individual scale scores. The ratings were summed because each scale was designed to evaluate the particular objective. The possible range of scores was 20 (highly positive) to 140 (highly negative). The mean score for each objective was, respectively, 54.1, 56.6, 56.8, and 61.9. The corresponding standard deviations were 12.1, 16.0, 19.0, and 17.0.

The a priori hypothesis was that the first two (cognitive domain) objectives would be rated more highly than the second two (affective domain) objectives. Analysis of variance indicated that there was a statistically significant difference between the pairs of means, $F(1,187)=22.99$, $p < .001$.

A comparison of responses to each item in the questionnaire (analysis of variance or X^2 test) showed that there were no statistically significant differences between those teachers interviewed and those who were not. The responses of interviewed teachers were considered representative of their colleagues. Most teachers interviewed agreed that student attitudes to science (in the sense of enjoyment of, and satisfaction with, the science program) were important. However, teachers reported that they regarded these attitudes as less important than other curriculum objectives. This is consistent with the results of the questionnaire data.

None of the teachers interviewed said that they assessed attitudes formally--that is, no use was made of instruments developed specifically to measure attitudes. Some felt that attitudes were beyond the teachers' control: much more powerful variables (such as home environment) exerted an influence that the teacher could not hope to overcome. Others were not as pessimistic: they believed that variables such as teaching methods could and did influence attitudes. These teachers invariably nominated teacher enthusiasm as the crucial variable. Teachers also reported that they made no attempt to assess formally the development of scientific attitudes (such as "attitude of inquiry" and "willingness to suspend judgement") in students.

Interpretation

The following four statements represent Schibeci's conclusions, inferences, and implications of his study:

Both questionnaire and interview data supported the hypothesis that science teachers regard cognitive objectives as more important than affective objectives.

Teachers interviewed indicated quite clearly that they made no systematic attempts to teach towards affective objectives. Since professional and biographical characteristics of interviewed teachers suggest that they are a representative sample of their colleagues, teachers generally make little attempt to implement all aspects of the science program specified in the curriculum guide.

Curriculum writers and developers need to be more aware of teachers' perceptions of affective domain objectives. While teachers may share the view that attitude objectives are important, they certainly do not systematically teach towards attitudes. Rather, they teach towards students' acquisition of knowledge. A clearer justification for attitude objectives is needed, together with guidance for teachers on how these objectives can be achieved and assessed.

Teachers' reported lack of attempts to teach attitudes directly leads to a number of questions which have not been considered in the current research in the affective domain. These questions include: "What kinds of attitudes are students acquiring?" "Are these attitudes acquired mainly outside the science classrooms?" "What classroom process variables are most closely linked with students' attitudes?"

ABSTRACTOR'S ANALYSIS

Relationship of studies to others. Although the literature review section is very brief, it is no doubt justified by the brevity of the manuscript itself. The research cited is relevant and exemplifies the focus on affective objectives by curriculum developers and researchers. The review of literature and the context provided for the study is appropriate. It is clear that little has been done to discern the degree to which science teachers work specifically to meet affective objectives and that they give little or no attention to assessing the degree to which such objectives are met.

Certainly the setting for the study could have been expanded considerably and to good advantage if more care had been taken in terms of the actual research undertaken and the reporting of the results. The manuscript is like an expanded abstract--perhaps a pilot study. An appropriate case is developed for more extensive study in the areas of teacher opinion and actions regarding instructional objectives in the affective domain.

New conceptual contributions. This study merely illustrates that there is a difference between stated objectives by curriculum developers, agreement among teachers concerning the appropriateness of goals, and interest on the part of researchers for assessing goals. It illustrates well our emerging understanding of the differences in values and perspectives between researcher and teacher, between school leaders and teachers, between members of the public and teachers, and between students and teachers.

The study illustrates well how certain objectives can be agreed upon--almost without objection. However, stating and agreeing to such objectives often does not alter teaching and/or testing/assessment. The study is simple and illustrates this situation vividly.

New methodological contributions. There is nothing new in terms of the procedures followed. The questionnaire, the use of a semantic differential, and the analysis performed are all quite common. Perhaps the main contribution is the follow-up with actual interviews with a significant sample of the respondents to the questionnaire. Such a practice provided insights and reasons for interpreting the questionnaire data in certain ways.

Validity of the study. There is no reason to doubt the validity of the study. However, as indicated previously, the study is simple in design and the information reported about specific procedures, data collection, and interpretation of specific data is almost completely missing. The entire study is reported as a general summary of a study or as a pilot effort that can be expanded with careful controls, precise measures, actual numbers reported. Even the exact wording on the four objectives used in the questionnaire is not too clear.

Comments on research design. The design seems adequate. However, the specificity of information on the report is inadequate for other investigators to replicate the specific study. Perhaps Schibeci should have taken more time in describing the questionnaire, the source for the objectives studied, and even more rationale for their classification.

Comments on adequacy of written report. The written report is a general statement. When taken at face value, the experiment is interesting and the results clear. However, when one wants to examine the objectives used, the actual results or the semantic differential, the protocols used for the interviews, the reader is left with only the general statements provided in the short manuscript. It almost seems as if the author prepared the report in haste and is not too excited about the design, the data, and/or their meaning.

Too often researchers spend too much time on design, data reporting, precision of experimentation--and then have no results (or very limited ones) to tabulate and to discuss. The reader of this study is left with questions—questions related to the quantity, quality, format for the objectives in the curriculum guide for grades 8 - 10. With the limited information about the cognitive objectives as well as the affective ones, questions arise concerning the author's classification scheme. For example, objectives dealing with the nature of science and scientific procedures need not be cognitive objectives at all. And, similarly, objectives "dealing" with attitude of inquiry, willingness to suspend judgment, and awareness of the impact of science on society need not be affective objectives. In fact, the one dealing with awareness seems very likely to be a cognitive objective--at least with the brief information presented in the manuscript.

The discussion section seems to merely substantiate this concern that the report is much too general and non-specific. No real discussion is included. Instead the four short paragraphs (and one of these is only one sentence) seem to be summary statements and/or to point out implications (i.e., what teachers do in their teaching and failure of curriculum developers to realize that fate of their materials in the hands of teachers). All of these points are interesting and warrant some real discussion.

The three questions raised are interesting. Perhaps the author should have developed them further and made them a part of a discussion instead of presenting them as a way of ending the manuscript.

<u>Assessment of current state of research in this area.</u> The author offers little such assessment. He merely points to research reviews illustrating interest on the part of researchers in stating affective objectives. He merely asserts that curriculum developers have tended to emphasize more affective objectives in recent times. Such references can hardly be classified as an assessment of the current state of research concerning the affective domain in science education. The author surely could have reported on the affective batteries of items used in 1976-77 as a part of the Third Assessment of Science by the National Assessment of Educational Progress in the United States.

Suggestions for future research. Again, Schibeci makes some very interesting points and, at the very end, he posits interesting questions for next-step research. Unfortunately, Schibeci is much too brief and superficial if one wished to follow up with specific experiments in the area of teacher opinions, practices, and assessment regarding objectives inthe affective domain.

Welch, Wayne W., and Frances Lawrenz. "Characteristics of Male and Female Science Teachers." Journal of Research in Science Teaching, 19 (7): 587-594, 1982.

Descriptors--*Females; Science Careers; Science Education; *Science Teachers; Secondary Education; *Secondary School Science; *Sex Differences; *Teacher Attitudes; *Teacher Characteristics

Expanded abstract and analysis prepared especially for I.S.E. by Hans O. Andersen, Indiana University.

Purpose

The purpose established for this study was to compare the characteristics of male and female science teachers to determine if it is possible that the factors that attract people to a particular career choice might operate similarly on males and females. The hypothesis of the study was:

There are no significant differences between male and female science teachers on a set of cognitive, affective, and behavioral measures.

Rationale

Cognitive, affective, and behavioral differences between males and females in mathematics and science among the general public have often been reported by researchers. The general public, of course, includes a wide variety of people including science teachers who might be very much alike. In this study, the investigator sought to determine whether or not affective, cognitive, and behavioral differences existed between a sample of male and female science teachers and, if differences existed, to discover their nature. This discovery, they felt, would become an important first step in trying to understand why females select science and science teaching careers.

Research Design and Procedures

Four categories of science teacher characteristics, thought to represent a broad spectrum of important teacher characteristics, were identified for this study. These categories were: (1) interest in science, (2) knowledge of science, (3) receptivity to change, and (4) teachers' perception of themselves and their environment.

A random sample of 345 teachers, selected from fourteen states and including 273 males and 73 females, were the subjects of the study. The sample was stratified by city size, and representative proportions of schools within each level were randomly selected. Once the school was selected, the high school physics, chemistry, biology or a junior high school science teacher was randomly selected. Each selected teacher completed four instruments: The Science Attitude Inventory (SAI), The Science Process Inventory (SPI), The Welch Curriculum Attitude Survey (WCA), and a teachers' questionnaire.

Teacher interest in science was assessed by scores on the SAI developed by Moore and Sutman (1970) which is a sixty item, four option, Likert scale designed to measure attitudes toward science. These variables include the score on the SPI, the number of semester hours of science taken, and the number of years teaching were used to indicate teacher competence. The SPI is a forced choice (agree - disagree) designed to measure knowledge of processes of science (Welch and Pella, 1967). To measure the teacher's perception of themselves and their environment, five measures were used. The teachers were asked their opinion of their effectiveness, curriculum work facilities, and support they received. A five option scale ranging from much improvement needed (1), to excellent (5), was used. Two measures were used to determine the teacher's receptivity to change. These were a professionalism scale consisting of teacher questionnaires and the Curriculum Attitude Survey (Welch CAS) (Welch, 1979). The fourteen item professionalism scale directed the participant to indicate the number of times they had participated in the activity during the previous year. These items were designed to measure a desire to participate in learning activities and to become knowledgeable about new developments. The Welch CAS is a forty-two item, five option Likert scale designed to determine attitude toward curricular change. The relationships of these instruments are reported in Table 1.

TABLE 1

Reliabilities for Teacher Characteristics Measures

INSTRUMENT	RELIABILITY
Interest in Science	
Science Attitude Inventory	.93[2]
Knowledge of Science	
Science Process Inventory	.90[2]
Perceptions	
Effectiveness (7)	.67
Curriculum (4)	.82
Work Load (4)	.77
Facilities (9)	.88
Support (3)	.75
Receptivity to Change	
Curriculum Attitude Survey	.85[2]
Professionalism (13)	.77

1. The reliabilities are all Cronbach Alpha coefficients.
2. Reliabilities are reported in the test manuals. The rest are calculated on the present sample.

Five questions, which addressed general science education issues rather than teacher characteristics, were included in the teacher questionnaire to check for possible response bias on the scale items. These were used to determine if either males or females were responding to item format rather than item content.

A multivariate analysis of variance was performed on the data. Science teacher characteristics was the dependent variable and sex, the independent variable. Since the multi-variate test was significant, the univariate tests was also examined.

Findings

The male science teachers in the study scored significantly higher on measures of science knowledge and they also perceived their teaching support to be better than the women perceived theirs. The female science teachers in the study scored significantly higher on the measure of interest and receptivity to change. While the women scored significantly higher on the interest measure and men scored significantly higher on the process skill measure, the scores of both men and women on these measures were high indicating that both groups had high interest in science and a good understanding of the process skills.

As a group, all the teachers had considerable training and experience. While the males scored significantly higher, the high standard deviation in each group suggests that there is considerable variance in the number of hours of science taken. This was confirmed by examining the range which was 0 to over 100.

There was very little difference between the two groups' perception of their environment in four of five measures. Men, however, demonstrated a significantly greater perception that they were receiving appropriate teaching support.

The bias scale showed no difference between male and female science teachers. This indicates that there probably was not any response bias on this set of Likert-type items.

Interpretations

The hypothesis that science teachers from a homogenous group regardless of sex was not supported. Male and female science teachers were found to be quite different.

The higher interest and higher receptivity to change of the women science teacher can be explained in two ways. First, science has always been a male domain. Hence it is probable that only highly interested females would risk entering the science profession. Second, females tend to be more fearful and anxious and therefore are more compliant and willing to engage in behavior considered more socially desirable (Block, 1981). The fact that principals are most frequently men may be a strong influence on women's receptivity to change.

The fact that women do not perceive receiving as much teaching support as did the men may be a reflection of the truth since most school support personnel are female, males may be receiving more support. It is also possible that women expect more support than do men.

The significantly higher knowledge scores of men as indicated by their scores on the SPI is probably a function of the fact that they have taken more science courses and taught science longer than women. Women probably have not taught as long because they interrupted their careers to manage the raising of children.

ABSTRACTOR'S ANALYSIS

Welch and Lawrenz hypothesized that differences between male and female science teachers on a set of cognitive, affective, and behavioral measures would not be significant. They reasoned that while there are cognitive, affective, and behavioral differences between males and females in mathematics or science classes among the general population, science teachers are a subset of the general population and this subset of males and females may not differ in any significant way. That is, it is possible that the factors that attract people to a particular career choice might operate similarly. While this appeared to be an acceptable proposition, it was not supported by the results of this study.

In identifying male-female science teachers' differences, Welch and Lawrenz provide an important first step in an attempt to understand why females select science and science teaching careers; this could lend to intelligent modification of science programs which would facilitate, rather than discourage, women's entry into a science career.

The randomized design procedure used by the investigators allows one to accept this conclusion with considerable confidence in spite of the fact that females were underrepresented. As the authors stated, women are also underrepresented in science which is, of course, a reason why this study is important. The reliabilities of the instruments used in the study similarly add to the credibility of the results.

Welch and Lawrenz used the Moore and Sutman (1970) instrument, which was designed to measure attitude toward science, as their measure of interest in science. Some, but not all, of the items measure an interest in science. However, this instrument may be one of the better instruments available for measuring science interests, which points out the need for additional test development. Women scored significantly higher on this instrument. This was explained as a function of the fact that only the women who are interested in science entered science careers and, when they entered this foreign field, they became more anxious and fearful than men. This compels them to perform more socially acceptable behaviors such as expressing an interest in science (Block, 1981). A similar anxiety explanation was offered for the women's higher score on the receptivity to change instruments. This is believeable. However, it is also possible to believe that anxiety and fearfulness would constrain a person and precipitate an opposite reaction.

Anxiety could possibly also account for the fact that women scored lower on the SPI. If women science teachers are indeed more anxious than their male counterparts, their anxiety could influence what and how they learned science. Anxiety may well facilitate the memorization of facts over gaining a real appreciation of science as a process.

The idea that extra years of teaching may influence the scores on the SPI is plausible. The extra years of experience may have been enough time to allow more men to experience teaching the process-oriented courses of the sixties and early seventies. In recent years textbooks have once again focused more attention on science as the body of knowledge, and process is being ignored. One tends to learn what one experiences and if women experienced less process oriented science curricula, their understanding of science would surely be more aligned with the science is content belief.

Interpretations of the data lead the authors to suggest additional research questions. (1) What factors influence the science career choice of boys and girls? (2) Do women science teachers serve as effective role models for women contemplating scientific careers? (3) How do students perceive the social learning environment in science classes taught by male and female science teachers? Another question that should be asked is: What are the characteristics of good science teachers - good male and good female science teachers?

This study was timely, well designed, and well reported. The authors are complimented.

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THE NATURE OF SCIENCE:
CRITIQUES AND RESPONSES

Rubba, Peter A., Jack A. Horner, and Joyce A. Smith. "A Study of Two Misconceptions About the Nature of Science Among Junior High School Students." School Science and Mathematics, 81 (3): 221-226, March, 1981.

Descriptors--*Fables, Grade 7, Grade 8, Junior High School Students, *Mythology, Science Education, *Scientific Literacy, Secondary Education, *Secondary School Science, *Student Evaluation, *Student Reaction

Expanded abstract and analysis by Michael J. Padilla and Rosemary K. Lund Padilla, University of Georgia.

Purpose

The purpose of the study was to determine the extent of junior high age students adherence to certain misconceptions about the nature of science.

Rationale

For the past thirty years science instruction has attempted to aid students develop an understanding of the nature of science. However, while developing an instrument to evaluate students' understanding of the nature of scientific knowledge, the authors discovered that many of these students adhere to at least two misconceptions about science. One misconception is termed the "myth of absolute truth," which focuses on the tentative nature of scientific knowledge. The other misconception is termed the "laws-are-mature-theories fable," which focuses on the differences between law and theories. The authors refer to these misconceptions as the Myth and Fable, respectively. Given the nature of present day secondary science curricula, the authors were surprised at the apparent degreee of adherence to the Myth and Fable. In previous research, the authors noted that both textbook style and format, and teacher behavior might be sources of the students' acceptance of misconceptions about science.

Research Design and Procedure

Participants at a twenty-two county area science fair in Illinois comprised the sample population. Public and private school students were included in the sample of 102 students. There were 40 seventh-graders and 62 eight-graders, with 56 males and 46 females.

A fourteen item questionnaire was developed. Items 1-7 collected demographic data. Items 8-12 were five-point Likert type items, each of which assessed one of the two misconceptions (the Myth or the Fable). One sample item which assessed the myth was "Scientific laws are true beyond a doubt." Respondents were asked to indicate the degree to which they agreed or disagreed with this statement. The authors claim content validity of items 8-12. Two items assessed the Myth (8 and 11) and three items assessed the Fable (9, 10, 12).

Students responded to the questionnaire with unlimited time while displaying their science fair projects. Items 1-7 were coded with nominal scales. Items 8-12 were scored from 1-5, with a score of 3 indicating a neutral response. To discourage students from developing a response set, the authors varied whether or not a 5 or a 1 indicated adherence or non-adherence to the Myth or the Fable. Descriptive statistics (means and standard deviations) were calculated for each item using the total sample, the Myth subtest (items 8 and 11), and the Fable subtest (items 9, 10, 12). A two-factor analysis of variance was employed to test for differences in acceptance of the Myth and Fable between sexes and grade levels.

Findings

Descriptive statistics revealed that students were neutral towards the Myth, and tended toward unacceptance of the Fable. No statistically significant differences were found between males and females, or seventh or eight graders in their degreee of acceptance of the myth or the fable.

Interpretations

Although the authors did not find strong adherence to either the

Myth or the Fable among their sample of junior high aged students, they also did not find strong rejection of these misconceptions. Given that their sample probably drew from more capable students, the authors found this lack of rejection a cause for concern. The authors concluded that even these students appeared not to understand the conditional nature of science and the role of laws and theories in explaining phenomena.

ABSTRACTORS' ANALYSIS

Much of the science curriculum development which took place during the 1960's was based upon creating curricula and training teachers to use these curricula that properly represented the true nature of science. From this emphasis grew a better understanding of the role of process in science as well as a richer insight into the scientific products created through this process. Yet the question remains--what with all this new understanding and emphasis, do science students have a true appreciation of the nature of science? This question, which is the focus of the present article, seems to be a significant one in the light of the last 20-30 years of work in science education.

The authors operationally define the nature of science as those ideas embodied in the "myth of absolute truth" and the "laws-are-mature-theories fable." This definition seems a bit narrow, especially if the authors wished to draw generalizations and conclusions about the broad topic--nature of science. Yet both the Myth and Fable are important ideas in the nature of science.

The sample of students chosen is biased and probably not representative of the true population of seventh and eighth graders (as the authors admit). All the subjects were interested in and accomplished enough in science to have gotten top honors at local and district science fairs before getting to a regional fair. Yet it is the biased nature of the sample which makes the potential results from this study quite interesting. If any group of middle grades students should do well, it is this group. That the results seem to indicate they truly do not understand either the Myth or the Fable should be a cause of concern to science educators.

The most serious difficulty with the study involves the measurement of the Myth and Fable. While the authors say they gave a 14 item questionnaire to the students, items 1-7 focused on demographic data only and items 13-14 dealt with an issue not relevant to this study. Thus only five items on the test, two for the Myth and three for the Fable subtest, were used to measure the nature of science. The reliability of the test was not reported. With this small number of items, it could be assumed that the test and subtest reliabilities might be exceedingly low. If this is the case, then the mean response of 3.04 on the Myth misconception and 3.55 on the Fable might only represent random responses to the questions. The authors interpreted these two scores as indicating that the students were neutral on the Myth and "tended toward disaffirmation" on the Fable. Yet, without reliability data, no conclusion can or should be drawn.

The authors also report that the questionnaire was content valid because the researchers themselves constructed the items from explications of their own previous work on the two misconceptions. Had they gone a step further and asked some independent experts to evaluate whether the items matched the explications of the misconceptions, it would have strengthened their claims. However, the validity of the questionnaire might be a moot question since a test which is unreliable (as this one potentially is) cannot be a valid test.

Lastly, the use of grade as an independent variable can give science educators some important information about what abilities and understandings students have at certain points in time. However, comparing seventh and eighth graders does not give us much information because the students are so close in age and, in all probabilities, experience and ability. Because most educaitonal researchers must work with available populations of students, the authors of this study should not be severely criticized for this shortcoming. It would have been much more enlightening and the probability of finding grade level differences would have been greatly enhanced had more disparate grade levels been tested, however.

In summary, the authors reported on students' understandings of two misconceptions dealing with the nature of science. Yet the results of this study probably should not be given too much credence because of the serious lack of test and subtest reliabilities. Were the mean scores on the two subtests a function of an unreliable test or were they representative of what the students really knew about the Myth and Fable? Future research might help to enlighten science educators on this issue.

IN RESPONSE TO THE ANALYSIS OF

Rubba, Peter A., et al. "A Study of Two Misconceptions About the Nature of Science Among Junior High School Students" by Rosemary L. and Michael J. Padilla. Investigations in Science Education, 10 (4): 55-59, 1984.

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A recent issue of Investigations in Science Education contained an abstract and analysis of the research report, "A Study of Two Misconceptions About the Nature of Science Among Junior High School Students" (Rubba, Horner and Smith, 1981) prepared by Padilla and Lund Padilla (1984). In the analysis the abstractors raised three difficulties they perceived with the research. In this response the researchers will argue that each of the three points was inappropriately raised.

First, the abstractors state, "The authors operationally defined the nature of science as those ideas embodied in the 'myth of absolute truth' and the 'laws-are-mature-theories fable'. This definition seems a bit narrow . . ." Contrary to the abstractors' claim, the researchers did not state an operational definition of the nature of science in the report. In fact, at the bottom of page 221 of the report, the researchers state, ". . . it is generally agreed that an adequate treatment of the nature of science in secondary school should dispel, at the least, the grosser misconceptions about it. The Myth and Fable are two of the more glaring delusions students in secondary school might have about science."

Secondly, the abstractors imply the researchers failed to expose the ". . . bias and probably not representative . . ." nature of the sample. However, in "The Sample" section of the report, the researchers clearly describe the select nature of the sample: "The sample consisted of 102 seventh and eighth graders who displayed science projects at a regional (22 county) science fair in Illinois during 1979." Later in the report, in association with drawing a conclusion at the bottom of page 225, the researchers again refer to the select nature of the sample.

The third and ". . .most serious difficulty . . ." raised by the abstractors concerns the measurement instrument used in the study. In particular, they were critical of the researchers' failure to report reliability values for the set, and sub-sets of, the five items used to assess students' adherence to the Myth and Fable, and of the procedures the researchers used to establish items content validity. In response, the researchers again refer readers to the research report wherein the research instrument is clearly identified as a 14-item questionnaire. In addition, the questionnaire development procedures described in the report are broadly accepted (Ary, 1979, pp. 176-178; Babbie, 1983, pp. 209-222; Bailey, 1982, pp. 109-134; Best, 1981, pp. 177-178; Borg, 1983, pp. 415-435; Gay, 1976, pp. 129-130).

Unlike other types of measurement instruments (e.g., tests, inventories, scales), questionnaires typically are used as one-shot data gathering devices with limited populations. Most questionnaires contain items which individually or in small sets relate to a diversity of research questions. Given these considerations, it is common practice to establish the content validity of the items, but not their reliability. In fact, it is not meaningful to assess the internal reliability of most questionnaires because of the heterogeneous nature of their items.

In hindsight, it might have been advisable for the researchers to have submitted the pools of questionnaire items constructed for the Myth and Fable (Rubba, Horner and Smith, 1981, p. 223) to a panel of experts for the purpose of having the items' content validity judged against the researcher questions, if for no other reason than to avert inaccurate perceptions. Still, the researchers do not believe a much different set of items on the Myth and Fable would have composed the questionnaire. Effectively, the questionnaire items were content valid in that they were trivial variants of the substantive structure of the Myth and Fable as these misconceptions about science were characterized by the researchers

(Horner and Rubba, 1978; 1979).

In summary, it would appear to the researchers that the three points of criticism raised by the abstractors rest on rather serious misunderstandings of the researchers' claims.

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Rubba, P.A., J.K. Horner and J.M. Smith. "A Study of Two Misconceptions About the Nature of Science Among Junior High School Students." School Science and Mathematics, 81 (3): 221-226, 1981.

Ogunniyi, M. B. "An Analysis of Prospective Science Teachers' Understanding of the Nature of Science." Journal of Research in Science Teaching 19(1): 25-32, 1982.

Descriptors--College Students; *Generalization; Higher Education; Majors Students; Measures Individuals; Philosophy; *Preservice Teacher Education; *Science Education; *Scientific Concepts; Teacher Attitudes; *Theories

Expanded abstract and analysis prepared especially for I.S.E. by John P. Smith, University of Washington.

Purpose

The purpose of this study was to determine if prospective science teachers in a developing country tend to ascribe to a particular point-of-view relative to the language of science as described by seven selected philosophies of science. First the author had to develop an instrument to measure conceptions of the language of science as proposed in the formal language of the selected philosophers.

Rationale

In developing countries, as in developed countries, one of the major objectives of science instruction is the development of an understanding of the nature of science. It is expected that science teachers would not only hold, but, in their instruction, present a view of the nature of science consistent with a view held by practicing scientists.

As the author points out, a concept of the nature of science is of necessity complex. Such a concept must include all those factors, e.g., processes, products, ethics, principles, etc. which affect inquiry in science. However, as may be expected, there is not unanimity with regard to a single description of the nature of science. Rather the nature of science is seen as having somewhat differing structures when described by different philosophers of science.

It is assumed, and Ogunniyi's concern, that science teachers do have a valid and coherent concept of the nature of science that can be expressed in their science instruction. As Ogunniyi points out, however, not much has been done to determine to what extent the assumption is well founded.

Research Design and Procedure

The first step in investigating science teacher understanding of the nature of science was the development of a valid and reliable measuring instrument. Since the nature of science is bound in the language of science, philosophers of science whose writings dealt with the epistemology of science were used as the basis for obtaining statements that could be considered to reflect points-of-view about the nature of science.

After an extensive review of the philosophical literature, the works of seven philosophers (Carnap, Hempel, Frank, Kememy, Nagel, and Popper) were selected to provide the basis for developing the Language of Science (LOS) instrument. The first form of the instrument consisted of 57 statements characteristic of the language of science. A statement was included if it met the approval of four independent philosophers using the following selection criteria:

(1) The statements about the language of science reflect viewpoints of the selected philosophers as closely as possible;
(2) The statements reflect varied viewpoints of the language of science;
(3) Each statement is capable of being subsumed under only one of the well defined categories: definition, characteristic, function formation, etc., relative to the nature of science;
(4) Any statement considered as not belonging to the stipulated categories or quoted out of context is to be eliminated.

Using the smallest number of statements by any one philosopher, six non-overlapping statements were selected from the work of each philosopher. To this total of 42 statements, were added 15 overlapping statements that could be attributed to a least two philosophers. Thirteen additional statements from sources other than the seven philosophers were added to check the consistency of the instrument. A review of the instrument was made by ten science educators. The review resulted in the rewording of some items and the elimination of two of the "additional statements." The total number of statements at this stage was sixty-eight.

After administering the instrument to 85 practicing teachers and discussing the instrument with them, the author decided to revise the instrument further by including statements characteristic of the "new" emphasis on the "nature of science." Consequently, Ogunniyi selected seven statements from Kimball's Nature of Science Scale for inclusion in the LOS. To keep the instrument from becoming too long, nine of the "over-lapping" and two of the "additional statements" were dropped for a new total of 64 statements on the LOS.

The final 64 statement version of the LOS was then administered to 53 University of Ibadan, Nigeria, prospective science teachers at the beginning and end of a semester-long science methods course. The purpose of administering the instrument to this group was to determine what effect a methods course modified to emphasize the development of valid understandings of the nature of the language of science had on prospective science teachers. The instrument was also administered once to a control group of 53 science majors at the same university. The author reported LOS pretest reliability was 0.91 (using the Kuder-Richardson formula 21). Posttest reliability was also 0.91.

The results of the study are reported in terms of percentage of students aggreeing with individual statements about the Language of Science. For the preservice science teachers, the results reflect preferences both before and after taking the specially designed science methods course. The preferences of the science majors are also included as a percentage of agreement.

Findings

The prospective science teachers tended to prefer the language of science as defined by Hempel followed closely by preferences for Nash, Kemeny, and Nagel; then Frank, Carnap and lastly Popper. After taking the science methods course emphasizing the "nature of science," the prospective science teachers indicated a preference for the views of

Hempel, Nash, Frank, and statements attributed to "all the philosophers" and a lower preference for Carnap, Kemeny, and Popper. Their agreement with Nagel remained the same. The pattern of preferences of the science majors was the same as for the prospective science teachers with the exception of a relatively higher percentage of agreement with the views of Carnap and Popper than accorded by the prospective science teachers.

In essence, both groups of students tended to agree with statements reflecting a moderate or empirical point-of-view as opposed to the strong deductivist position of Popper or inductivist position of Carnap.

With regard to the "additional statements" and nature of science statements (kimball), the analysis indicated that subjects:

(1) did not consistently distinguish between empirical and theoretical concepts or laws, and

(2) did not consistently hold valid conceptions of the "nature of science."

Interpretations

Generally, both prospective science teachers and science majors preferred Hempel's statements with regard to the nature of the language of science. Least preferred was Popper's point-of-view. Except for a few statements, there did not appear to be any systematic diffferences between the two groups with regard to their views on the language of science.

The author has suggested that future studies examine the viewpoints of similar groups of students cross-culturally, examine Hempel's philosophy of the nature of science for its implications for science instruction, and compare the viewpoints of science teachers with those of science texts. Finally he raises the question of whether the development of instruments focusing on other elements of science, e.g., ethics, methods, etc., might not also contribute to a better understanding of the nature of science.

ABSTRACTOR'S ANALYSIS

Ogunniyi's study raises some interesting questions not only with regard to the view of the nature of science held by prospective teachers but also with regard to how students develop a view of the nature of science and why one particular point-of-view and not another.

It is not too surprising to find that both the prospective science teachers and the science majors studies tended to share the same view of the nature of science if one makes the assumption that the undergraduate training in science of both groups is essentially the same at the University of Ibadan. And if that is so, then one may ask " to what extent is it valid to infer that the view of the nature of science preferred by the two groups of students is a reflection of the view of the nature of science held by their scientist/professors?" Or, knowing that they must agree or disagree with each statement, do these newly trained in science simply tend to be somewhat conservative in their point of view and select moderate statements (Hempel) as opposed to the more polarized and conceptually riskier positions characteristic of Popper and Carnap?

One might also ask what role should science classes and science methods classes play in developing a coherent view of the nature of science in conjunction with teaching the concepts and processes of science and procedures for teaching science? Obviously students do develop a point-of-view about the nature of science. Is it the one intended? If one's point-of-view can be modified by a science methods class emphasizing the nature of science (as suggested by this study) then one might ask how stable or coherent is one's point-of-view as developed incidentally through course work in science versus the effects of direct instruction on the nature of science?

In the main, Ogunniyi's LOS instrument has provided us with a means of identifying one's view of the nature of science in representative terms that may be expanded into a more complete and coherent philosophy as described in the completed works of the selected philosophers of science represented in the instrument.

The methodology followed by Ogunniyi in developing the LOS appears to be consistent with customary practice. His sampling of statements was balanced in number and kind and represented the entire range of philosophies of science. His use of experts in determining content validity is commendable as are his pilot study and review by another set of experts as he continued his effort to refine the instrument.

Although is might have been better to have randomly selected subjects in the treatment and control groups, the subjects selected represent the reality of doing research in a setting where the researcher must use intact, available groups.

My greater concern is with Ogunniyi's analysis of the results of the study. Since he reports the results only in terms of percentages, the reader has no way of knowing if the pre-post changes are significant or not. Likewise treatment-control group differences are also difficult to interpret. While Ogunniyi reports a modest pre-post shift for the treatment group, one has no way of checking that since the criteria for reporting such a shift are not evident. One might also ask if any differences are due to pretest-posttest experience or to instruction in the methods class. Finally, are the changes really systematic? One might just as easily say that the changes and/or differences are random in nature and do not reflect a change due to instruction.

As with most studies of this type, in particular studies of understanding science, the researcher stops at reporting the results and describing the beliefs of the respective groups. In my opinion, Ogunniyi's work provides the basis for taking that next step into the realm of examining the effects of science instruction of the development of a view of the nature of science over time. Thus, carried further, his work may enable us to identify one's point-of-view as opposed to those aspect that have no influence on developing a view of the nature of science. To me, the prospects for future research initiated by Ogunniyi's study are most exciting and deserving of careful attention.

IN RESPONSE TO THE ANALYSIS OF

Ogunniyi, M.B. "An Analysis of Prospective Science Teachers' Understanding of the Nature of Science," by John P. Smith. Investigations in Science Education, 10 (4): 63-68, 1984.

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Smith's concern about whether or not the subjects' viewpoints of science reflected their instructors' viewpoints or merely represented their taking a moderate position irrespective of instruction is a genuine one, considering the limited nature of the report. In fact the article in question (although published rather late) was merely the first stage report of the whole study. In another report published in the African Journal of Educational Research Vol. 2, No. 2, 1979 a much more detailed analysis of the study was done. The means obtained by science majors, prospective science teachers and the scientists who taught them were quite identical, i.e.; 35.27, 32.87 and 34.78 respectively. The posttest means of the experimental group (prospective science teachers) was 35.25. Because of the small number of scientists (nine in all responded) only the scores of the two groups of students were compared using UNOVA. I shall refer to this later on.

The conclusion that can be drawn from this finding is that: (1) the subjects have been exposed to similar viewpoints of science, most probably, their instructors' viewpoints; and (2) the subjects have expressed their own opinions about the nature of science. Whatever the case, there is enough evidence to show that the subjects generally preferred Hempel's viewpoint of science and that the treatment group tended to shift their viewpoints of science after taking a science methods course. Why they preferred Hempel's viewpoint of science requires further investigation. The potential of his viewpoint of science for classroom instruction is certainly worth close examination.

What roles science and science methods classes should play will depend to a large extent on the way the classes are organized and what point-of-view of science is emphasized. It should be expected that regular science courses would help students to develop valid viewpoints of science. This, very often, is not the case. What one encounters in most science classes is a series of lectures interspersed with long hours of practical work concerned primarily with the verification of classical experiments rather than truly open-ended investigative activities. A science methods course on the other hand which provides enough opportunities for inquiry, discussions and reflection would certainly fill this gap left by the regular science course. To be effective, however, ample opportunities should be provided for students to learn and test new ideas and techniques, ask questions, discuss, create models, etc. in the same way scientists do.

In the present study I have been able to determine how a science methods course actually affected significantly prospective science teachers' viewpoints of science. When the mean of the treatment group was compared with the mean of the Control group an F - statistic of 0.24 ($x = 0.05$) was obtained, indicating that the difference between the two means was not statistically significant. But when the posttest mean of the former was compared with the mean of the latter an F - value of 11.59 ($x = 0.05$) was obtained, indicating that the difference between the two means was statistically significant. The same is true even at $x = 0.01$ level. Such a high significant difference between two similar groups could not have happened by chance alone. That this assumption is well grounded is further reinforced when the pretest and the posttest means of the treatment group were compared. The F - statistic obtained for the two means was 14.03 indicating that the said methods course did have a significant influence on the subjects' viewpoints of science.

In anticipation of Smith's question as to what aspects of the methods course may have influenced subjects' shift of viewpoint I asked the subjects to make free comments on each statement on the instrument and to explain why they responded in a particular way. Although it is difficult at this stage to be too specific, it is quite clear from the various comments made by the subjects that certain variables, viz: questions, arguments, discussions, extra reading etc., involved in the said course did have some impact on their overall point-of-view of science. It appears that a science methods which permits ample opportunities for informal discussions before and/or after class activities will probably promote the development of more valid viewpoints of science than one lacking such opportunities. The relative import of this reflective aspect of instruction deserves close attention.