DOCUMENT RES ME

ED 054 933 SE 012 317

AUTHOR Wood, Roger L.

TITLE University Education Student's Understanding of the Nature and Processes of Science. Final Report.

INSTITUTION Wisconsin State Universities Consortium of Research Development, Stevens Point.

SPONS AGENCY Office of Education (DHEW), Washington, D.C. Bureau of Research.

BUREAU NO BR-6-2728-51

PUB DATE Feb 70

GRANT OEG-3-6-062728-2129

NOTE 36p.

EDRS PRICE MF-$0.65 HC-$3.29

DESCRIPTORS College Students; Concept Formation; *Educational Research; *Preservice Education; Science Education; *Scientific Enterprise; *Student Attitudes; Teacher Education

ABSTRACT

This study examined the concept of the nature and processes of science held by college students in both elementary and secondary education as measured by the Wisconsin Inventory of Science Processes (WISP). Secondary science education students scored significantly higher than students enrolled in primary or intermediate education. The difference between the means of the secondary science students and the primary and intermediate groups was statistically significant at greater than 0.01, supporting the premise that secondary education students majoring in science do possess more understanding of the nature and processes of science, as measured by the WISP. Little relationship was identified between sex, number of university science courses and years of high school science and knowledge of the nature and processes of science. A relationship between the average grade of science courses taken at the university level and the WISP score was significant at the .01 level. Three areas (scientific observations, experimentation, and communication of scientific knowledge) seemed to be well understood by over 90 per cent of the students. (BB)

ED 054933

51
WSU-CORD

BR 6-2728-51

The Wisconsin State Universities Consortium of Research Development

Research Report

UNIVERSITY EDUCATION STUDENT'S UNDERSTANDING OF THE NATURE AND PROCESSES OF SCIENCE

Roger L. Wood
Wisconsin State University - Stevens Point
Stevens Point, Wisconsin

Cooperative Research

Wisconsin State Universities
and the
United States Office of Education
Bureau of Research - Higher Education

Office of the Director WSU-CORD
240 Main Building
Wisconsin State University
Stevens Point, Wisconsin 54481

012 317

FINAL REPORT

CORD Project

Project No. 760-541-70-1007-06
Grant No. 3-6-062728-2129
Local Project No. 51

UNIVERSITY EDUCATION STUDENT'S UNDERSTANDING OF THE NATURE AND PROCESSES OF SCIENCE

Dr. Roger L. Wood

Wisconsin State University - Stevens Point

Stevens Point, Wisconsin

February 11, 1970

U.S. DEPARTMENT OF

HEALTH, EDUCATION, AND WELFARE

Office of Education

Bureau of Research

FINAL REPORT

CORD Project

UNIVERSITY EDUCATION STUDENT'S UNDERSTANDING OF THE NATURE AND PROCESSES OF SCIENCE

Dr. Roger L. Wood

Wisconsin State University - Stevens Point

Stevens Point, Wisconsin

February 11, 1970

The research reported herein was performed pursuant to a Wisconsin CORD grant with the Office of Education, U.S. Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgement in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

U.S. DEPARTMENT OF

HEALTH, EDUCATION AND WELFARE

Office of Education

Bureau of Research

TABLE OF CONTENTS

CHAPTER I

INTRODUCTION

Background for the Study

Since the Russians orbited Sputnik I in 1957, a renewed interest in science education has taken place both at the elementary and secondary school level. In fact, one could say that the entire country, if not the world, is in the midst of another "revolution", a revolution in science. One of the major outcomes of this renewed interest in science is a review and restatement of the objectives of science teaching. A review of the current literature in science education quickly reveals that science instruction involves more than merely teaching the facts, concepts and principles of science. Numerous scientists, science educators and philosophers (Paul DeH. Hurd, 1960, (1); Jerome Bronowski, 1956, (2); James Conant, 1951, (3); Louis Kuslan and A. Harris Stone, 1968, (4); William Kessen, 1964, (5); Paul Blackwood, 1964, (6); Arthur Livermore, 1964, (7); have stated that science includes more than the facts, concepts, and theories; it also includes the philosophy and processes of science. Kessen, 1964, (5) states that "Science is more than a body of facts, a collection of principles, and a set of machines for measurement; it is a structured and directed way of asking and answering questions." Paul DeH. Hurd, 1964, (8) emphasizes the idea that "One of the first tasks in teaching science is to teach the inquiry processes of science."

A second outcome of the "revolution" in science has been the development of many "new" science curricula at the elementary and secondary school level. National programs, such as AAAS, ESS, SCIS, SSCP, PSSC, BSCS, ECCP, IPS, to name a few, all stress the process aspect of science and the nature of the scientific enterprise as well as the knowledge of science. Due to this emphasis upon process and the nature of science in these new science curricula, it would seem apparent that new elementary and secondary teachers entering the teaching profession should possess a working knowledge of the nature and processes of science, along with the conceptual knowledge, if they are to be able to teach these new science curricula effectively.

Several studies have already been undertaken to determine the understanding of the nature of science by university education students. Olstad, 1969, (9); conducted a study at the University of Washington and found that the understanding of the nature of science (as measured by the TOUS Test) possessed by elementary education students could be increased by having the students enrolled in a course entitled "Science in the Elementary School." He also found that there was no significant relationship between the subject matter knowledge of the students and their understanding of the scientific enterprise.

A similar study by Carey and Stauss, 1968, (10); with prospective secondary science teachers revealed the following; (a) the student's concept of the nature of science was varied and seemed to indicate that they do not possess an adequate concept of the nature of science, (b) there appears to be little, if any, relationship between their understanding of the nature of science (measured by the WISP instrument) and various academic variables and (c) that a secondary science methods course can make a positive contribution toward their understanding of the nature of science.

Purpose of the Study

The purpose of this study was to examine the understanding of the nature and processes of science possessed by university education students being propared to teach at the elementary and secondary level by the various Wisconsin State Universities. The following questions were investigated in this study:

1. What is the prospective elementary and secondary (science) teacher's concept of the nature and processes of science, as measured by the Wisconsin Inventory of Science Processes (WISP) instrument?
2. What relationship exists between the prospective elementary and secondary (science) teacher's concept of the nature and processes of science, as measured by the WISP instrument, and the variables of sex, number of university science credits, number of years of high school science, and the average grade in science at the university level?

3. Is there any difference between university students majoring in primary, intermediate, or secondary (science) education and their concept of the nature and processes of science, as measured by the WISP instrument?

CHAPTER II

Plan and Organization of the Study

The population selected for this study consisted of students enrolled in the elementary and secondary science methods courses in the fall term of 1969 at the following Wisconsin State Universities: Eau Claire, LaCrosse, Oshkosh, Platteville, and Stevens Point.

Each student was administered the Wisconsin Inventory of Science Processes (WISP) instrument by the instructors of the elementary and secondary (science) methods courses at the five state universities before the end of the third week of the course. The instrument utilization in this study was developed at the University of Wisconsin Scientific Literacy Research Center (11), (12), to measure knowledge of the scientific enterprise. The 93 statements of the WISP instrument are concerned with the assumptions, activities, objectives and products of science. The student checked each statement as being always or nearly always <u>accurate</u>, as being always or nearly <u>inaccurate</u>, or didn't know or didn't understand the statement.

In addition to their responses to the WISP test, the following data was collected:

1. Sex
2. Teaching area
   (a) primary education
   (b) intermediate education
   (c) secondary education (science)

3. Secondary science major
   (a) biology
   (b) chemistry
   (c) physics
   (d) general or physical science
   (e) conservation
   (f) earth science
   (g) others
4. Total university science credits
5. Number of years of science taken in the high school (grades 9-12).
6. Average grade of all the science courses taken at the university level.

All of the data from each student was recorded on IBM optical scan sheets no. 516. This data was then transferred to punched cards and analyzed, using the IBM 1130 computer at Wisconsin State University, Stevens Point. The following analyses were made:

1. Correlation coefficients were calculated between the WISP test scores and the variables of sex, university credits in science, years of high school science, and average grade in university science courses. These coefficients were tested for significance from zero at alpha = .05, .01.

2. The mean and standard deviation for each of the three groups (primary, intermediate, and secondary (science) students) was calculated from their scores on the WISP test. The significance between the means of the various groups was obtained by calculating the "t" value for the groups being compared.

3. An item-analysis was obtained, showing the percentage of students correctly answering each of the 93 statements on the WISP test. A print-out of each of the students scores on the WISP test was also obtained.

4. Regression coefficients for the variables of (a) sex, (b) university credits in science, (c) years of high school science, and (d) average grade of university science courses relative to the scores on the WISP test were calculated.

CHAPTER III

Results of the Study

The total number of students who participated in the study was 443. The raw scores on the WISP instrument ranged from a low of 45 to a high of 81, with a mean of 65.89 and a standard deviation of 6.04. Table I summarizes the results of the WISP test scores of the three groups participating in this study. Students in primary education had the lowest mean score (65.16) while the students in secondary education (science) had the highest mean score (68.67). It is also noted from Table I that students in primary and intermediate education score significantly lower ($p > 0.01$) than students in secondary education (science). There is no significant difference between the scores obtained on the WISP test by the students in primary and intermediate education.

When the factors of sex, university credits in science, years of high school science, and average grade in university science courses are compared to the scores on the WISP instrument, as shown in Table II, only the relationship between the average grade of university science courses had any significant correlation with the WISP scores. The higher the average grade in science, the higher the score the WISP instrument.

It might also be noted from Table II that the relationship between sex and the number of science courses taken in high school (r=0.267) was also significant. Boys take more science courses in high school than girls.

TABLE I

Summary of Scores on the WISP Test

Group	Number of Students	Mean Score	Standard Deviation	"t" Value	df	Groups Compared
I - Primary	250	65.16	5.83	4.69*	326	I and III
II - Intermediate	115	65.73	6.31	3.34*	191	II and III
III - Secondary	78	68.67	5.55	0.83	363	I and II

*Significant at > 0.01.

TABLE II

Correlation Coefficients between WISP Scores and Selected Variables

	Sex	No. of Univ. Science Credits	No. of High School Science Courses	Average Univ. Science Grade	WISP Score
Sex	1.000	-0.148	0.267*	0.041	-0.059
No. of Univ. Science Credits	-0.148	1.000	-0.029	-0.063	-0.014
No. of High School Science Courses	0.267*	-0.029	1.000	-0.096	-0.153
Average Univ. Science Grade	0.041	-0.063	-0.096	1.000	0.266*
WISP Score	-0.059	-0.014	-0.153	0.266*	1.000

* Significantly different from zero ($p > 0.01$)

Table III summarizes the percentage of students correctly answering each of the 93 statements. An analysis of Table III reveals that only eight (8) statements were inaccurate answered by more than 60% of the students, whereas twenty (20) of the statements were accurately answered by more than 90% of the students.

TABLE III

Item Analysis of WISP Inventory

Statement Number	Percentage of Accurate Responses
1	89.3%
2	32.6%
3	52.1%
4	73.6%
5	93.0%
6	92.6%
7	82.3%
8	46.0%
9	63.6%
10	91.0%
11	33.0%
12	45.8%
13	57.1%
14	92.1%
15	90.6%
16	82.3%
17	34.5%
18	35.2%
19	64.1%
20	85.6%

TABLE III

Statement Number	Percentage of Accurate Responses
21	33.0%
22	68.9%
23	88.0%
24	52.6%
25	53.9%
26	41.0%
27	93.9%
28	88.2%
29	97.3%
30	94.7%
31	76.3%
32	78.4%
33	64.7%
34	80.8%
35	73.2%
36	78.6%
37	65.6%
38	41.3%
39	57.3%
40	69.1%
41	79.1%
42	36.5%
43	43.9%
44	74.7%
45	97.8%
46	77.3%
47	72.6%
48	95.8%
49	69.7%
50	98.2%

51	54.3%
52	88.6%
53	83.9%
54	81.0%
55	89.3%
56	88.6%
57	94.7%
58	50.0%
59	81.9%
60	49.7%
61	75.2%
62	43.2%
63	67.6%
64	64.1%
65	96.5%
66	51.5%
67	81.9%
68	87.3%
69	48.0%
70	68.0%
71	94.7%
72	83.6%
73	35.4%
74	43.2%
75	67.3%
76	86.5%
77	85.4%
78	78.6%
79	98.2%
80	95.2%
81	56.9%
82	91.9%
83	61.3%

84	95.8%
85	46.7%
86	95.2%
87	23.0%
88	67.8%
89	77.6%
90	41.0%
91	52.1%
92	85.0%
93	98.2%

A further analysis of Table III relative to the various areas concerning the nature and processes of science, as measured by the WISP inventory (Appendix B-Key to WISP), reveals that three (3) of these areas appear to be well understood by over 90% of the participants. The first area deals with the actions and operations of the scientist, namely, that scientific observations should be described and recorded accurately. The second area deals with experimentation in science, that is, that experimentation involves the identification, manipulation, and control of variables. The third area concerns communication as a method of recording scientific information and adding it to the cumulative fund of "knowledge".

Table IV lists the eight (8) statements inaccurately answered by over 60% of the students. In reviewing these 8 statements, no one area concerned with the nature and processes of science appears to be appreciably misunderstood. (Refer to Appendix B-Key to WISP).

TABLE IV

Statements on the WISP Instrument Inaccurately Answered by More than 60% of the Participants

Item Number	Statement
2	Unpredicted observations have played a role in a majority of scientific achievements.
11	A scientist formulates a working hypothesis after he has exhaustively examined the available facts and data.

Item Number	Statement
17	The scientist assumes a moral responsibility when he elects to do research in an area in which his findings could be destructive to society.
18	Scientists attempt to keep the number of hypotheses and axioms utilized at a minimum.
21	A basic objective of science is the generation of knowledge with technological application.
42	The formulation of theories in science is basically a deductive procedure.
73	Errors in measurement are due to errors in the techniques of measurement.
87	One purpose of setting up a laboratory experiment is to devise a situation in which the observations and physical conditions can be controlled to the same degree that they are in the ordinary course of events.

The regression coefficients of the four variables relative to their predictive ability on the WISP instrument is tabulated in Table V. An analysis of these "beta weights" reveals that the average university science grade of a student has the greatest predictive power while the number of university science credits has the lowest predictive power.

TABLE V

Regression Coefficient between WISP Scores and Selected Variables

Variables	Regression Coefficients (beta weights)
sex	0.1422
number of university science credits	0.0140
number of high school science courses	0.7187
average university science grades	2.2590

CHAPTER IV

Summary and Conclusions

Summary

This study was concerned with inventoring the knowledge of the nature and processes of science possessed by 443 elementary and secondary (science) education students at five (5) Wisconsin State Universities. Each student was administered the Wisconsin Inventory of Science Processes (WISP) instrument in either their elementary or secondary science methods course in the fall of 1969. In addition to the WISP score, the following data was collected from each student; sex, teaching area (primary, intermediate, secondary), science major (s) (for secondary education students only), total university science credits, number of high school science courses, and average grade in university science courses.

Findings and Conclusions

The conclusions drawn in this study are restricted to the population, instruments, techniques and procedures employed in this study. When the data obtained in this study was analyzed, the following results were obtained.

1. Secondary education (science) students score significantly higher on the WISP instrument that either students enrolled in primary or intermediate education. The difference between the mean of the secondary education group (68.67) and the mean of the primary (65.16) and intermediate (65.73) groups was statistically significant at greater than 0.01.

In reference to the question, "Is there any difference between university students majoring in primary, intermediate, or secondary (science) education and their concept of the nature and processes of science, as measured by the WISP instrument?", this study supports the premise that there is a difference, namely, that secondary education students majoring in science do understand more about the nature and processes of science, as measured by the WISP instrument, than students enrolled in primary or intermediate education.

2. When the factors of sex, number of university science credits, years of high school science and average grade in university science courses are compared to the WISP scores, only the relationship between the average grade of science courses taken at the university level and the WISP score was found to be significant ($p > 0.01$). The higher the students average science grade, the higher was his score on the WISP instrument. There appears to be little, if any, relationship between the factors of sex, number of university science courses and years of high school science and their knowledge of the nature and processes of science.

3. In reference to the question concerned with what the prospective elementary or secondary (science) teacher's concept is of the nature and processes of science, it appears from analyzing the data that no one specific area concerned with the nature or processes of

science is grossly misunderstood. Only eight (8) of the 93 statements were inaccurately answered by over 60% of the students. However, three of the areas seem to be well understood by over 90% of the students. These areas are concerned with scientific observations, experimentation, and communication of scientific knowledge.

Implications

Some of the implications from this study that warrant further exploration are:

1. Many of our prospective elementary and secondary (science) teachers may find it difficult to teach science in accordance with the modern philosophies and trends due to a lack of an adequate knowledge of the nature and processes of science. This is an area which needs further exploration.
2. The student's understanding of the nature and processes of science may not be a product of university science courses. Perhaps these science courses need to focus more upon the nature and processes of science, if we expect our future teachers to possess this knowledge.
3. One of the prime objectives of the science techniques courses might be to focus upon the nature and processes of science in relationship to the teaching of science to elementary and secondary students.

Bibliography

1. DeH. Hurd, Paul. "Summary of Science Education for Changing Times," In: Rethinking Science Education, 59th Yearbook NSSE, University of Chicago Press, 1960.

2. Bronowski, Jacob. "The Educated Man in 1984," Science 123: 710-12, April 27, 1956.

3. Conant, James B. "Science and Common Sense," New Haven, Connecticut: Yale Press, 1951.

4. Kuslan, Louis and Stone, A. Harris. "Teaching Children Science: An Inquiry Approach," Belmont, California: Wadsworth Publishing Company, Inc., 1968.

5. Kessen, William. "Statement of Purposes and Objectives of Science Education in the Elementary School," Journal of Research in Science Teaching, Vol. 2, Issue 1, 1964, p. 4-6.

6. Blackwood, Paul. "Science Teaching in the Elementary School," Science and Children, Vol. 2, No. 1, September 1964, p. 21-25.

7. Livermore, Arthur. "The Process Approach of the AAAS Commission on Science Education," Journal of Research in Science Teaching, Vol. 2, Issue 4, 1964, p. 271-282.

8. DeH. Hurd, Paul. "Toward a Theory of Science Education Consistent with Modern Science," In: Theory Into Action. . . in Science Curriculum Development, National Science Teachers Association, Washington, D.C., 1964.

9. Olstad, Roger. "The Effort of Science Teaching Methods on the Understanding of Science," Science Education, Vol. 53, No. 1, February, 1969, p. 9-11.

10. Carey, Russell and Stauss, Nyles. "An Analysis of the Understanding of the Nature of Science by Prospective Secondary Science Teachers," Science Education, Vol. 52, No. 4, October, 1968, p. 358-363.

11. The Scientific Literacy Research Center, The University of Wisconsin. "Wisconsin Inventory of Science Processes," Madison, Wisconsin: The University of Wisconsin, 1967.

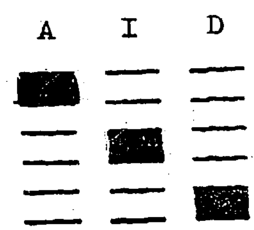
12. Welch, Wayne and Pella, Milton. "The Development of an Instrument for Inventorying Knowledge of the Process of Science," Journal of Research in Science Teaching, Vol. 5, Issue 1, p. 64-68.

APPENDIX

THE WISCONSIN INVENTORY OF SCIENCE PROCESSES

This instrument is designed as an inventory of knowledge of the scientific enterprise. The statements on the following pages are concerned with the assumptions, activities, objectives, and products of science. Some statements are accurate, some inaccurate.

MARK YOUR ANSWERS
ON THE ANSWER SHEET



If the statement is always or nearly always <u>accurate</u> mark space (A).

If the statement is always or nearly always <u>inaccurate</u> mark space (I).

If you do not know or do not understand the statement mark space (D).

Make the mark a heavy black line using a lead pencil. Do not use a pen or a ballpoint.

If you change an answer, erase the first mark completely.

Answer <u>all</u> the statements.

REMEMBER:

Use Pencil.
Do Not Write in This Booklet.

Reproduced with the permission of the University of Wisconsin Scientific Literacy Center, March 6, 1969.

THE WISCONSIN INVENTORY OF SCIENCE PROCESSES

a scientist repeatedly observes that condition A is followed by state then he can, by observing an instance of condition A, predict the currence of state B. 1. A I D

predicted observations have played a role in a majority of scientific hievements. 2. A I D

he assumption made by scientists that space and time are real is efensible on the basis of past experience. 3. A I D

ientists look upon the existence of error in measurement as inevitable. 4. A I D

e of the interests of the scientist is in finding relationships of the pe, "When A occurs, then B will occur." 5. A I D

athematical systems are used by scientists for organizing and communicating information about data. 6. A I D

assification schemes, such as the periodic table of the elements, are sed on observed similarities and differences. 7. A I D

scientist prefers simple interpretations of phenomena. 8. A I D

cientists can, by following the scientific method step by step, answer lmost any question concerning natural phenomena. 9. A I D

actual evidence produced by means of experimentation is the primary means f establishing the credibility of a scientific theory. 10. A I D

scientist formulates a working hypothesis after he has exhaustively xamined the available facts and data. 11. A I D

cience is a self-correcting enterprise. 12. A I D

scientist must have a definite idea of the kinds of observations he xpects to make during an experiment. 13. A I D

rior to approaching a new problem, a scientist reviews the literature for elevant information. 14. A I D

he scientist must be able to establish the credibility of the data he collects. 15. A I D

Scientists use their present knowledge of events and phenomena as a means of explaining events and phenomena of the past. 16. A I D

The scientist assumes a moral responsibility when he elects to do research in an area in which his findings could be destructive to society. 17. A I D

Scientists attempt to keep the number of hypotheses and axioms utilized at a minimum. 18. A I D

19. Scientists obtain and utilize data expressed in terms of statements of probability. 19. A I D

20. A law in science is derived from a vast body of consistent experience. 20. A I D

21. A basic objective of science is the generation of knowledge with technological application. 21. A I D

22. A scientist publishes his research findings so that other members of the academic community may independently evaluate his work. 22. A I D

23. A classification scheme is a useful method of organizing scientific observations. 23. A I D

24. Scientists assume that all natural phenomena have natural causes. 24. A I D

25. Scientific models are idealizations of reality. 25. A I D

26. All contributions to the fund of scientific knowledge are public property, beyond the minimum credits for the achievement of discovery. 26. A I D

27. Scientists assume that matter is an idea and is not real. 27. A I D

28. Present scientific knowledge is tentative and in a continuous stage of refinement. 28. A I D

29. Science establishes a cumulative fund of knowledge that provides a basis for scientific advancement. 29. A I D

30. Many presently accepted scientific theories were rejected by some scientists when the theories were first proposed. 30. A I D

31. Classification schemes are vital to progress in science. 31. A I D

32. A scientific theory, regardless of its credibility, always contains elements of chance. 32. A I D

33. A scientist usually chooses to make those observations which have the highest probability of use in answering a specific question. 33. A I D

34. Scientists rely on the outside authority of the general scientific community to guide them in the formulation of conclusions from experiments. 34. A I D

35. A law in science is a statement with demonstrated high probability. 35. A I D

36. Hypotheses in science seldom have their origin in "speculative ideas," "inspired guesses," or "intuitive hunches." 36. A I D

37. If two scientists individually examine the same data, they will arrive at very similar conclusions. 37. A I D

38. Scientific models are not intended to photographically represent reality. 38. A I D

39. Observations and descriptions expressed in terms of numerical measurements are more accurate than observations and descriptions not expressed as numerical measurements. 39. A I D

40. The scientist varies as many factors as possible at one time in a single experiment so that the maximum interaction of these factors may be observed. 40. A I D

41. Experimentation includes those procedures by which errors in observation and measurement are limited or controlled. 41. A I D

42. The formulation of theories in science is basically a deductive procedure. 42. A I D

43. Scientific knowledge is ethically and morally neutral. 43. A I D

44. Scientists believe that some natural phenomena are too complex to ever be explained by science. 44. A I D

45. Once accepted, scientific knowledge is no longer subject to change. 45. A I D

46. The morality of a scientific discovery is determined by its use by a society. 46. A I D

47. Scientists assume that the human mind is capable of understanding the events and materials of the physical universe. 47. A I D

48. One of the uses of a hypothesis is the development of new or further experimentation. 48. A I D

49. Scientific knowledge is, at best, an approximate explanation of natural phenomena. 49. A I D

50. One phase of an experiment is the establishment of a set of conditions under which observations are made. 50. A I D

51. Induction is the process of arriving at specific facts from generalizations. 51. A I D

52. Providing explanations of the phenomena of the physical universe is a basic objective in science. 52. A I D

53. The scientists and most of the nonscientists believe in the reality of the universe. 53. A I D

54. A scientist usually reports only those observations relevant to his hypothesis. 54. A I D

55. A scientific experiment will always yield information even though it may not yield the predicted information. 55. A I D

56. From facts collected by means of experimentation, the scientist creates theories which are used to explain natural phenomena. 56. A I D

57. A scientist is more likely to accept a theory on the basis of his personal opinion than on the available experimental evidence. 57. A I D

Statistical inference is a form of deductive reasoning. 58. A I D

59. Classification systems in science are in a continual state of refinement. 59. A I D

60. Scientists reject data collected from an experiment or event if the experiment or event cannot be reproduced. 60. A I D

61. A scientist puts a limit on the number of variables he observes at any given time. 61. A I D

62. Scientists discover the classification schemes that are inherent in the physical universe. 62. A I D

63. Scientists believe that certain natural phenomena will never be understood. 63. A I D

64. A law in science can be used to predict but not be prescribe the occurrence of events in the physical universe. 64. A I D

65. Modern scientific measurements are so refined that they contain no error. 65. A I D

66. Conclusions in science are essentially statistical in nature. 66. A I D

67. Scientific data and results contain an expressed or implied estimate of error. 67. A I D

68. The scientist's motivation for studying the physical universe is mainly curiosity--the desire to know. 68. A I D

69. Induction is the process of predicting particular occurrences from the general class of occurrences. 69. A I D

70. Models in science are mental constructs that are used to describe phenomena in terms of familiar concepts. 70. A I D

71. The scientist assumes that if under a given set of conditions a particular phenomenon repeatedly occurs, then a duplication or repetition of the same set of conditions should produce a similar phenomenon. 71. A I D

72. A hypothesis is equivalent to a theory. 72. A I D

73. Errors in measurement are due to errors in the techniques of measurement. 73. A I D

74. Science starts with facts and ultimately ends with facts no matter what theoretical structures are built between them. 74. A I D

75. Public presentation, publication and review of scientific information is a system of checks and balances self-imposed by science to regulate the quality of the products of science. 75. A I D

76. If two scientists simultaneously view the same natural phenomena, both will notice the same things. 76. A I D

77. An essential test of a scientific theory is its use in successfully predicting events and phenomena. 77. A I D

78. Scientific observations gain significance when they are related to something previously observed or known. 78. A I D

79. Concise and precise recording of observations is an essential activity in scientific research. 79. A I D

80. If a choice is to be made between two different scientific theories, both of which account for the observed facts, the more complex is chosen. 80. A I D

81. There are many different classification systems which could be used for any given set of observations. 81. A I D

82. Objective observation is less important in modern science since the development of new instruments such as the electron microscope. 82. A I D

83. Data requiring interpretation or judgment by the scientist is of little value because it is subject to the unconscious bias of the scientist. 83. A I D

84. Scientists are unwilling to communicate their findings to other members of the scientific community. 84. A I D

85. A majority of the scientific discoveries are the result of fortuitous (fortunate) observations. 85. A I D

86. It is undesirable for a scientist to record descriptions of his experiments because this information may bias another scientist who is attempting to verify the results. 86. A I D

87. One purpose of setting up a laboratory experiment is to devise a situation in which the observations and physical conditions can be controlled to the same degree that they are in the ordinary course of events. 87. A I D

88. When a scientist makes a prediction, he is assuming that the physical universe is consistent. 88. A I D

89. Inductive logic is more likely to yield valid conclusions than is deductive logic. 89. A I D

90. The scientist assigns numerical values to data so that these data may be incorporated into numerical laws. 90. A I D

91. The use of scientific theories is an inductive process. 91. A I D

92. If two scientists use radically different procedures to attack the same problem, it is highly unlikely that both scientists will solve the problem. 92. A I D

93. The activities of a scientist include the keeping of accurate records of observations and experimental conditions. 93. A I D

KEY TO WISP

The key to WISP is arranged by item number as indicated on the instrument by ( ) and list factor, i.e. assumptions, products, motives, and procedures.

Reliability:

Students (12th grade). . .0.82 mean. . .54.2

Teachers. . . . . .0.823 mean. . .66.9

Note: The items with the accepted answer as accurate are given. Inaccurate or do not understand apply to all others.

I. THE SCIENTIST ASSUMES THAT:

A. THE UNIVERSE AND NATURAL PHENOMENA ARE:

1. Real
   - (3) accurate
   - (27)
   - (53) accurate

2. Intelligible
   - (47) accurate
   - (44)
   - (63)

3. Consistent
   - (71) accurate
   - (88) accurate
   - (16) accurate

4. Casual
   - (1) accurate
   - (5) accurate
   - (24) accurate

B. THE PRODUCTS (RESULTS) OF SCIENCE ARE:

1. Amoral
   - (46) accurate
   - (17)
   - (43) accurate

2. Repeatable
   - (12) accurate
   - (15) accurate
   - (60)

3. Parsimonious
   - (18) accurate
   - (8) accurate
   - (80)

4. Tentative
   (49) accurate
   (28) accurate
   (45)

5. Probabilistic
   (19) accurate
   (67) accurate
   (66) accurate

C. HE AND HIS FELLOW SCIENTISTS ARE:

1. Objective
   (83)
   (57)
   (54)

2. Anti-authoritarian
   (74) accurate
   (30) accurate
   (34)

3. Motivated by a desire to understand the physical universe
   (52) accurate
   (68) accurate
   (21)

II. THE ACTIONS OR OPERATIONS OF THE SCIENTIST INCLUDE:

A. OBSERVATIONS WHICH ARE:

1. Selected
   (61) accurate
   (78) accurate
   (33) accurate

2. Influenced by instrumentation and past experience
   (37)
   (76)
   (82)

3. Described and recorded accurately
   (86)
   (79) accurate
   (93) accurate

4. Sometimes unexpected
   (13) accurate
   (85)
   (2)

B. MEASUREMENT WHICH:

1. Has inherent error
   (65)
   (4) accurate
   (73)

2. Is a method of quantitative expression
   (39) accurate
   (6) accurate
   (90) accurate

C. CLASSIFICATION, WHICH IS:

1. An invention of man used for the organization of data
   (31) accurate
   (62)
   (23) accurate

2. Based on observed relations between variables and hence has inherent weaknesses
   (59) accurate
   (81) accurate
   (7) accurate

D. EXPERIMENT, WHICH IS:

1. Used to test hypotheses and theories and to expose new areas to empirical exploration
   (41) accurate
   (87)
   (55) accurate

2. The identification, manipulation and control of variables
   (10) accurate
   (50) accurate
   (40)

E. COMMUNICATION, WHICH IS:

1. A method of recording scientific information and adding it to the cumulative fund of "knowledge"
   (84)
   (29) accurate
   (14) accurate

2. An academic obligation which makes scientific information available for independent confirmation and verification
   (26) accurate
   (75) accurate
   (22) accurate

F. PREDICTION, WHICH IS ACHIEVED BY THE UTILIZATION OF:

1. Inductive logic
   (91)
   (42)
   (58)

2. Deductive logic
   (51)
   (69)
   (89)

3. A multiplicity of techniques and procedures
   (11)
   (92)
   (9)

G. THE FORMULATION OF:

1. Hypotheses
   (36)
   (48) accurate
   (72)

2. Theories
   (32) accurate
   (56) accurate
   (77) accurate

3. Laws
   (64) accurate
   (35) accurate
   (20) accurate

4. Models
   (25) accurate
   (70) accurate
   (38) accurate