DOCUMENT RESUME

ED 254 412 SE 045 428

AUTHOR Boram, Robert D.; Renner, John W.

TITLE Measured Formal Thought and That Required to Understand Formal Concepts in College Level Physical Science.

PUB DATE 85

NOTE 6p.; Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (58th, French Lick Springs, IN, April 15-18, 1985).

PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.

DESCRIPTORS *Abstract Reasoning; Cognitive Processes; Cognitive Structures; *College Science; *Comprehension; Higher Education; Logical Thinking; *Physics; Preservice Teacher Education; *Problem Solving; Science Education; *Scientific Concepts; Student Characteristics

IDENTIFIERS *Formal Operations; Piagetian Tasks; Science Education Research

ABSTRACT

Students (N=49) enrolled in a physics course for elementary teachers were evaluated for their abilities to use: (1) combinatorial logic; (2) separation and control of variables; (3) proportional reasoning; and (4) reciprocal implications. Performance of four Piagetian tasks during interviews was treated as a measure of the degree to which students could function with these four formal thought characteristics. Students were also evaluated for their abilities to use the four formal thought characterstics in problem-solving situations. Students' responses to items inserted into five course examinations were treated as measures of their abilities to use the charactertistics of formal thought in problem-solving. These items focused on six physics concepts dealing with torque, electricity, optics, and heat (since understanding these concepts requires use of one or more characteristics of formal thought). Results suggest that a non-significant relationship exists between formal thought characteristics required to solve a problem and demonstrating the possession of those characteristics. When success on each of the interview tasks was correlated with success on each of the other tasks, all correlation coefficients obtained were significant and moderately high, suggesting that success on a problem which requires formal thought depends on an overall formal thought structure. (Author/JN)

Measured Formal Thought and That Required to Understand Formal Concepts in College Level Physical Science

by

Robert D. Boram

and

John W. Renner

MEASURED FORMAL THOUGHT AND THAT REQUIRED TO UNDERSTAND FORMAL CONCEPTS IN COLLEGE LEVEL PHYSICAL SCIENCE

Abstract

In The Growth of Logical Thinking*, Piaget and Inhelder describe the operations and schemata which are postulated as being the characteristics of formal operational thought. Those formal thought characteristics, therefore, are used in solving problems which require formal thought. The hypothesis can be made, therefore, that persons who possess certain characteristics of formal thought will do better on tasks judged as requiring those characteristics than those persons who do not possess them.

Using the individual interview technique 53 students enrolled in a physics course for elementary teachers were evaluated for their abilities to use combinatorial logic, separation and control of variables, proportional reasoning, and reciprocal implications. The performance of each student in the interviews was treated as a measure of the degree to which that student could function with those four formal-thought characteristics.

During one semester the students were given experience with 30 physics concepts using the learning cycle. Six of those concepts dealing with torque, electricity, optics and heat were used in the research. Understanding those concepts required using one or more of the characteristics of formal thought given earlier. Questions to measure the understanding of each concept were written and content validated. The validated questions were inserted into the five course examinations at the proper time during the semester. The students' success on the questions was treated as a measure of their abilities to use the characteristics of formal thought in problem solving. Data were available, therefore, on the formal thought characteristics the students possessed and their abilities to use those characteristics in problem solving.

A total of 52 correlation coefficients was computed between the ability to use the formal thought characteristic in solving a problem and to demonstrate possession of those characteristics. Only eight of the correlation coefficients were statistically significant and the largest was 0.34. The conclusion was drawn that a non-significant relationship exists between the formal thought characteristics required to solve a problem and demonstrating the possession of those characteristics. When success on each of the interview tasks was correlated with success on each of the other tasks all the coefficients were statistically significant and moderately high. That finding led to the conclusion that success on a problem which requires formal thought depends upon an overall formal-thought structure.

*Barbel Inhelder and Jean Piaget, The Growth of Logical Thinking, Basic Books, Inc., New York, 1958.

MEASURED FORMAL THOUGHT AND THAT REQUIRED TO UNDERSTAND FORMAL CONCEPTS IN COLLEGE LEVEL PHYSICAL SCIENCE

Purpose

The purpose of this research was to determine whether the logic assessed by specific Piagetian tasks is related to the logic postulated as needed to develop complete understandings of specific concepts in Physics.

Theoretical Basis

In The Growth of Logical Thinking (1958), Piaget and Inhelder describe the operations and schemata which are postulated as being the characteristics of formal operational thought. It follows that those formal thought characteristics are used in solving problems which require formal thought. Therefore, persons who possess certain characteristics of formal thought will do better on tasks judged as requiring those characteristics than those persons who do not possess them.

The sample used in this research was composed of students enrolled in a physics class taught using the learning cycle. The learning cycle is based on Piaget's model of mental functioning, found in Genetic Epistemology (1970).

Procedure

Six concepts were selected from the 30 concepts taught in the course Physical Science for Elementary Teachers. The six concepts were torque, Ohm's Law, series circuits, law of reflection, focal length, and heat equilibrium. After each of the concepts had been taught, the students were given questions covering the concept on the unit examinations. Included on the comprehensive final examination were questions on each of the six concepts. Each examination question was graded on a scale of one to four.

1 = no understanding
2 = misunderstanding
3 - partial understanding
4 = complete understanding

Each question used on the examinations was validated by physics professors as to whether it evaluated the concept.

Near the beginning of the semester, each of the students was given four Piagetian tasks in an interview setting. The four tasks were used to evaluate proportional reasoning (balance beam task), separation of variables (bending rods task), reciprocal implications (billiard-type task), and combinatorial logic (colored beads task). Each student was given a score for each task on a scale of zero to four:

0 = pre-operational (I)
1 = early concrete (IIA)
2 = concrete (IIB)
3 = transitional (IIIA)
4 = formal (IIIB)

The Piagetian interview procedures were validated by people skilled in administering the interviews.

All of the students enrolled in the course <u>Physical Science for Elementary Teachers</u>, who took all the examinations and completed the Piagetian tasks were included in the sample. This provided a sample size of 49 subjects.

Each of the concepts was analyzed to determine the types of logic postulated to be required in their understanding. The results of this analysis are listed below.

Torque Concept	-	Proportional Reasoning and Separation of Variables
Series Circuits	-	Combinatorial Logic and Separation of Variables
Ohm's Law	-	Proportional Reasoning and Separation of Variables
Focal Length	-	Proportional Reasoning and Separation of Variables
Law of Reflection	-	Reciprocal Implications
Heat Equilibrium	-	Proportional Reasoning, Separation of Variables and Combinatorial Logic

The data from the concept examination questions were correlated with the data from the Piagetian task interviews. This was done by comparing the mean concept scores with the specific task scores. Where more than one type of logic was postulated to be needed for an understanding of the concept the task scores were averaged. Further correlations were calculated relating each task to the other tasks, each concept to the other concepts, a total task score to each concept score, and a total task score to a total concept score.

The statistical significance was determined by calculating the t-score of the correlation coefficients.

Results

The correlation coefficients relating the concepts and the postulated logic required to understand the concepts were mainly positive, but not statistically significant. Another set of correlation coefficients were calculated relating the Piagetian task mean scores to each of the task scores. Again, all but one of the correlation coefficients were positive and none of them was statistically significant. An overall correlation coefficient was calculated relating the Piagetian task mean scores to the concept mean scores. The value of this correlation coefficient was 0.14 which is not statistically significant.

Implications for Science Teaching

Based on this research, it appears that individual Piagetian task scores do not yield fruitful information about the success of students on specific physics concepts. This seems to indicate that specific Piagetian tasks should not be used as a diagnostic tool to predict the success or failure of students on specific physics concepts.

References

Cantu, Luis and Herron, J. Dudley. "Concrete and Formal Piagetian Stages and Science Concept Attainment", Journal of Research in Science Teaching, 1978, 15, pp. 135-143.

Inhelder, Barbel and Piaget, Jean. The Growth of Logical Thinking. New York: Basic Books, 1958.

Lawson, Anton E. "Comment on 'Cognitive level and college physics achievement'", American Journal of Physics, July, 1979, pp. 652.

McKinnon, Joe W. and Renner, John W. "Are Colleges Concerned with Intellectual Development?" American Journal of Physics, September, 1971, pp. 1047-1052.

Piaget, Jean. Genetic Epistemology. New York: W.W. Norton and Co., 1970.

Schneider, Livingston S. and Renner, John W. "Concrete and Formal Teaching", Journal of Research in Science Teaching, 1980, 17, pp. 503-517.

Shayer, Michael and Adey, Philip. Towards a Science of Science Teaching: Cognitive Development and Curriculum Demand. London: Heinemann Education Books, 1981.