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Critical Thinking Development Among Physical Science Students

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INTRODUCTION

The physical science course for nonscience students has the following objectives: subject matter achievement, an understanding of the methods and philosophy of science, and the development of critical thinking ability. Also, courses of this type offer unparalleled opportunities as a public relations medium between the world of science and the educated layman.

It was found that most college freshmen enrolling in the physical science course had little academic experience in the solution of problems requiring critical thinking. However, they were usually quite proficient in work depending mainly upon memorization and seemed to expect questions requiring only this ability. At the beginning of the course they would frequently complain in mild outrage, "The answer to this question isn't in the book." This situation led to a study of teaching techniques that might be expected to encourage the development of critical thinking and finally to methods of measuring this ability.

Critical thinking has been defined as:

"a) An *attitude* of wanting to have supporting evidence for opinions or conclusions before assuming them to be true.

b) *Knowledge* of the methods of logical inquiry which help determine the weight of different kinds of evidence and which help one to reach warranted conclusions.

c) *Skill* in employing the above attitude and knowledge." (1) John Dewey (2), T. H. Huxley (3), Max Black (4), and many others have recognized the similarity between this concept and that of "scientific thinking". It thus seemed pertinent to establish the development of critical thinking as a physical science course objective.

TEACHING METHODS FOR DEVELOPING CRITICAL THINKING

A textbook was adopted which seemed to be in harmony with the objectives of the course. It contained an elementary presentation of the principles and facts of physical science, but withheld most applications for development by the student in the substantial sets of problems that followed each chapter. These problems were of the inductive-deductive type or required interpretation of data. About two-thirds of the problems involved some use of arithmetic.

Several introductory lectures were devoted to helping the student establish a broad perspective in science. They were presented with some of the philosophical ideas and methods of science. The role of logical thinking and mathematics in science was discussed. The structure and methods of formal logic were introduced in one lecture and the students were assigned a few illustrative problems. At intervals during the course, puzzles of the "brain twister" variety were given as recreational exercises.

As might be expected, student proficiency in the solution of textbook and test problems in physical science was greatly improved. But what about critical thinking ability in other areas? Could a transfer of training be expected? Much controversy exists about transfer of training. L. W. Webb in "Educational Psychology" (5) has a brief but comprehensive report on most of the experimental investigations of this problem. These studies indicate that positive transfer, absence of transfer, or negative transfer may occur.

Measuring Critical Thinking Ability

The "Watson-Glaser Critical Thinking Appraisal" was selected to measure student progress. This test has been in use for a thirty year period with some revision. The coefficient of reliability as determined by both the split-half and the inter-form method for several types of groups is about .9. Norms are available for the "presophomore" college population. Of great importance was the fact that neither of the two equated test forms contained problems involving science or mathematics.

The "Critical Thinking Appraisal" is divided into subtests of inference, recognition of assumptions, deduction, interpretation, and evaluation of arguments. There is no time limit, but few students required longer than fifty minutes.

A physical science class of twenty-nine freshman and sophomore students was tested at the beginning and end of a semester. A control group of twenty-three nonscience students at the same class level, but with no physical science course work were similarly tested.

Test Results

Test results from the ninety-nine total items on each of the equated forms revealed that the raw score average of the physical science class was raised from 62.4 to 66.8. Since the probable error of the difference is only 1.4, this is a significant increase. The change in raw score corresponds to an average increase of 13 percentile points on the college norm scale.

The average raw score of the control group was raised from 63.0 to 66.7 or a 10 percentile point increase. This is also a statistically significant gain. (According to the test authors, gains due to increased familiarity with the test amount to only 0.6 points on the average.)

The greater increase of the physical science class score, 13 as compared to 10 percentile points, may not be significant because of the small sample size.

An examination of subtest scores revealed no comparative increase outside the range of probable error for the physical science class except in subtest 3, the section designed to measure ability to reason deductively from given premises. Here the physical science class registered a 10.8 per cent increase in score while the score of the control group was unchanged.

Summary

The development of critical thinking ability was selected as one of the objectives of a physical science course. Problem solving was emphasized in course work.

Tests of critical thinking achievement revealed substantial development in ability for both physical science and control group students. Slightly greater gains were noted for the physical science class, but an investigation of subtest scores indicated a decisive increase in deductive ability as compared to that of the control group.

Additional testing will be required to determine if physical science students make significant gains in other areas of critical thinking.

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