Structured Oral Inquiry Improves Thinking

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THE COMMITMENT of the Biological Sciences Curriculum Study (BSCS) to the production of inquiry materials is in accord with the 1961 pronouncement of the National Education Association, which indicated that the common thread of education is the development of the ability to think (Clark, 1968). Through its development of discovery materials BSCS has helped to shift biology instruction from the memorization of a body of established knowledge to the learning of strategies and tactics of inquiry, experimentation, and autonomy.

Most educators agree on the need for inquiry with three main means for discovery: laboratory experiments, demonstrations, and discussions (Sund and Trowbridge, 1967). However, before teachers adopt innovations in discovery methods, research is needed to document the claims for inquiry and to try to settle the arguments raging over the most effective means for discovery and the amount of time students should be allotted to engage in such activities.

One set of structured inquiry materials, the Invitations to Enquiry (Schwab, 1963), is available for use in all biology classes. Does the use of the Invitations result in student gains in critical thinking? Meyer (1969) found no significant gain in critical thinking on the part of a heterogeneous group of pupils who were exposed to the Invitations. Yet one may ask about possible growth in critical-thinking ability in students who seem most likely to participate in solving these orally posed questions; namely, the bright students. The present study focuses on the use of the Invitations and their effect on the critical-thinking ability of high-ability ninth-grade BSCS students.

What is critical thinking? It is perhaps best defined in terms of the Watson-Glaser Critical Thinking Appraisal, which measures a composite of (i) attitudes of inquiry that involve an ability to recognize the existence of problems and an acceptance of the need for evidence to support assertions; (ii) knowledge of the nature of valid inferences, abstractions, and generalizations in which logic is used to determine the accuracy of evidence; and (iii) skills in using the knowledge and attitudes. Because this instrument measures general critical thinking, it has been used to reflect the carryover of such learning. The ability of students to think critically about problems certainly will permit them to make decisions more objectively and will eliminate much trial-and-error learning. By approaching problems with logic, one uses prior learning to the fullest, whereas trial-and-error learning does not permit one to accumulate previous solutions and the knowledge thereby gained.

Hypotheses and Methods

To give direction to the study the following hypotheses were formulated:

1. There is no significant difference in the critical-thinking ability of ninth-grade BSCS students who were exposed to randomly selected Invitations to Enquiry and BSCS students receiving similar instruction without exposure to the Invitations, as measured by the Waston-Glaser Critical Thinking Appraisal, Form YM (WGCTA), while statistically controlling for test scores on WGCTA.

2. There is no significant difference in the critical-thinking ability of ninth-grade BSCS students who were exposed to randomly selected Invitations and BSCS students receiving similar instruction without exposure to the Invitations, as measured by WGCTA, while statistically controlling for IQ.

The study involved all ninth-grade BSCS students in the Ferguson–Florissant School District, Ferguson, Mo. Because the course is open only to the top 10% of the students, the results of this research are applicable only to similar pupils. Data were analyzed by computer. Various factors limited the complete data to 132 of the 225 students enrolled in BSCS.

A table of random numbers (Fisher–Yates) identified two BSCS classes taught by each of three teachers, and a coin flip determined the experimental group. Although the teachers were housed in separate junior high schools, they all followed the same curriculum guide, which sampled content from the Blue, Green, and Yellow BSCS textbooks. Identical material was presented by each teacher to his classes.

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The Invitations were added to the experimental group on Tuesday and Thursday of each week for an eight-week period (March–May 1970). A maximum of 30 minutes was allotted to the consideration of the Invitations on these days. During the study period 20 Invitations were discussed by the classes.

The critical thinking of all students was tested, using the WGCTA, before the start of the study and again following the completion of the eight-week project. The Invitations were randomly selected and were presented in numerical order. Teachers orally presented each problem as they followed the standard guidelines for presenting the Invitations. Data on IQs, obtained from the permanent record of each student, consisted of scores on a Lorge–Thorndyke group test given in grade 6.

Data concerning the mean scores and adjustment for pretest differences on the WGCTA are presented in table 1. The adjustment of the groups for pretest differences resulted in an F ratio of 8.143, which is statistically significant beyond the .01 level of confidence.

Table 1. Covariance analysis and mean scores for BSCS Students. Criterion, WGCTA posttest; covariate, WGCTA pretest.

Source	*df*	*Mean square*	*Adj. F ratio*
Between groups	1	715.082	8.143*
Within groups	129	87.841	

Groups	*Pretest mean*	*Posttest mean*	*Posttest adj. mean*
BSCS and Invitations	65.848	67.924	67.458
BSCS	64.030	62.318	62.785

*Significant at .05 level of confidence $F_{1,129}=3.92$

Findings from the Data; Conclusion

Hypothesis 1 was rejected. There was a significant difference in critical thinking between the experimental and control classes following adjustment for pretest scores.

Comparing pretest and posttest means, the BSCS and Invitations classes (experimental) increased from 65.848 to 67.924 while the BSCS group (control) dropped from 64.030 to 62.318. The published percentile values for freshmen indicate that a raw score of 57 would place a student at the 50th percentile rank. The superiority of the ninth-grade BSCS students included in this study with respect to critical-thinking ability is borne out by their combined pretest average of 64.939, which placed the entire 132-student group at the 78th percentile rank on the WGCTA.

Table 2 presents the analysis of covariance data for ninth-grade BSCS students, using IQ scores as the covariate. Adjusting the WGCTA posttest for the covariate resulted in an F ratio of 13.354, which is statistically significant beyond the .001 level of confidence.

Table 2. Covariance analysis and mean scores for BSCS Students. Criterion, WGCTA posttest; covariate, IQ scores.

Source	*df*	*Mean square*	*Adj. F ratio*
Between groups	1	1260.828	13.354*
Within	129	94.413	

Groups	*Pretest mean*	*Posttest mean*	*Posttest Adj. mean*
BSCS and Invitations	65.848	67.924	68.218
BSCS	64.030	62.318	62.024

*Significant at .05 level of confidence $F_{1,129}=3.92$

Hypothesis 2 was rejected. There was a significant difference between the posttest means of the two groups following adjustment for IQ differences present at the start of the study.

This study found that the use of the Invitations to Enquiry with high-ability ninth-grade students resulted in significant gains in critical thinking in comparison with similar students not using the Invitations. It would seem that teachers wishing to improve critical thinking in their biology students should consider using the Invitations with the brighter students. Further studies are needed to confirm these results with similar students and to identify other students who improve their critical thinking as a result of using the Invitations to Enquiry. In addition, studies are needed in biology classes that make no overt attempt to include the inquiry dimension in structuring the curriculum.

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The Naturalist as Writer

Nature is everywhere; we stare at it blindly. The naturalist opens our eyes. Sometimes, even with our eyes wide open we cannot see, because we do not know. He opens our minds, too. Unlike the physicist or the chemist, the naturalist is committed to words; mathematics, and the disciplines that depend on it, may be important to his understanding of the world but not to his sharing of it. He must be an accurate observer who can describe what he observes precisely. But that is not enough. He must also be a good writer.

Howard Moss, "Fabre" [review], *New Yorker* 48 [14]: 109.