The Influence of the Invitations to Enquiry

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A teacher devised classroom study designed to evaluate teaching and learning methods.

The *Invitations to Enquiry* are one of several teaching aids brought forth in the past decade to aid the high school biology teacher in teaching biology as inquiry. As reported by Joseph J. Schwab the *Invitations to Enquiry* are designed to "... bring to the student small samples of the operation of enquiry." As expressed by Schwab, to teach biology as enquiry the biology student must be shown that knowledge arises from the interpretation of data and that the interpretation and search for data progress on the basis of concepts and assumptions that change as knowledge grows.

The *Invitations to Enquiry* present to the biology student samples of biological data from which the student is expected to participate in enquiry by drawing conclusions from the given data, or proposing new hypotheses based on the gained knowledge or proposing hypotheses to account for the data given. By reading, teacher directed class discussion and student participation many examples of the processes of biological investigation become familiar to the student.

This article contains the results of a year long study in which an assessment was made of the effectiveness of the *Invitations to Enquiry* in promoting the understanding of science, critical thinking ability, and academic achievement in biology.

This study was conducted using 46 first year high school biology students enrolled in two of the writer's BSCS Yellow Version classes at Niles Township High School, North Division, Skokie, Illinois. The two classes studied were heterogeneous groups of regular track biology students that did not differ significantly in their vocabulary comprehension, mathematics comprehension or IQ scores.

Before the first day of school one class was randomly designated to be the experimental group and receive the presentation of the "invitations." Each class during the course of the year would meet with the instructor 40 minutes on 3 days of the week and 80 minutes on the other 2 days. An attempt was made to control the type of subject material that was presented to each class. Identical laboratory exercises and laboratory write-ups were assigned to each class. In addition, the quizzes and examinations administered throughout the year were identical.

Schwab suggests that the various "invitations" be presented in one or all of the following manners. (1) As independent learning experiences being covered during a certain period each week. (2) In conjunction with related laboratory exercises or (3) In conjunction with classroom work with the "invitation" selected to match the subject under study.

It was decided to present the experimental class with one "invitation" each week for the duration of the school year. No attempt was made to correlate the subject of the "invitation" with the classroom topic under study. Each "invitation" was presented as a separate entity and no special attempt was made to relate it to the current classroom topic. However, as the school year progressed many of the "invitations" presented were naturally discussed in a context related to a class studied biological topic. In the course of the school year a total of thirty-one "invitations" were presented to the experimental class. As listed in the *Biology Teachers' Handbook,* the "invitations" presented to the experimental group were taken from group I,

Simple Enquiry; group II, The Conception of Cause in Biological Enquiry; and group III, Quantitative Relations in Biology.

In order to assess the student's understanding of science the Test on Understanding Science (TOUS), Form W, was used as the instrument of evaluation. *The Watson-Glaser Critical Thinking Appraisal*, Form Zm, was used to measure critical thinking ability. The *BSCS Comprehensive Final Examination* was chosen as the test of biological achievement. The students in both control and experimental groups were given the battery of three tests as pre-tests during the first three days of class. The tests were administered again as post-tests at the close of the school year.

The following null hypothesis was investigated in this study: There is no significant difference in the end of year performances on tests of biological achievement, critical thinking ability and understanding of science of high school biology students whether taught with the *Invitations to Enquiry* or taught without the use of the *Invitations to Enquiry*. All comparisons were measured by the Test.

As expressed in Table I the pre-test performances on all three tests by the experimental and control classes as measured at the beginning of the school year were not significantly different. Similarly as shown in Table II the post-test performances on the three tests as recorded at the close of the school year did not differ significantly.

Table III summarizes the results of comparing the mean pre-test scores with the mean post-test scores of the experimental class and Table IV compares the mean pre-test and mean post-test scores of the control class. Both the experimental and control classes scored significantly higher on the post-tests than on the pre-tests in all three tests given.

There was a very significant gain in biological achievement by both classes. The level of confidence here for both classes was at .001. There was also a significant gain by both classes on the *Watson-Glaser Critical Thinking Appraisal*. In this case the confidence level was .05 for the experimental class and .001 for the control class. A significant gain in performance was also registered by both classes on the TOUS test. A confidence level of .01 was determined for the experimental class and .05 for the control class. Consequently, our null hypothesis can be accepted as these data show that the effects of using the "invitations" as independent learning experiences in the experimental class resulted in no significant difference between the experimental and control classes in biological achievement, critical thinking ability or the understanding of science.

In this study it was impossible to isolate any specific effect that the use of the "invitations" as a teaching tool had on the learning behavior of the biology students involved. However, the analysis of the *Invitations to Enquiry* as a teaching tool deserves more study. This study was quite limited in that only two classes and one biology teacher were involved. Experimentation should be conducted on a broader scale using more students and teachers. It is quite apparent that the method of using the "invitations" by the individual teacher is a tremendous variable in itself. In future studies more sophisticated attempts should be made to control the teacher's methods of presenting the "invitations." By using only one teacher in this study it is impossible to assess the possibility that desirable teaching techniques fostered by the teaching of the "invitations" to the experimental class may have been transferred to the control class. In future studies it also might be useful to more extensively assess the student's understanding and ability to interpret quantitative data. In this study the *BSCS Comprehensive Final Examination* tested this factor only to some extent. Since it is apparent that the *Invitations to Enquiry*—group III confronted the experimental class with aspects of quantitative biology that were not presented to the control group, a testing instrument with more validity in regard to the understanding of quantitative aspects of biology might be used in a future study.

Table I
Comparison of the Group Means Matched on Pre-Test Scores

	$\bar{x}$	t	p
BSCS Comprehensive Final Examination			
Experimental Class	19		
Control Class	18	.90	.1
Test on Understanding Science			
Experimental Class	30		
Control Class	30	1.8	.1
Watson-Glaser Critical Thinking Appraisal			
Experimental Class	57		
Control Class	58	.38	.1

Table II
Comparison of the Group Means Matched on Post-Test Scores

	$\bar{x}$	t	p
BSCS Comprehensive Final Examination			
Experimental Class	28		
Control Class	26	1.5	.1
Test on Understanding Science			
Experimental Class	35		
Control Class	33	1.1	.1
Watson-Glaser Critical Thinking Appraisal			
Experimental Class	63		
Control Class	64	.41	.1

Table III
Comparison of the Experimental Group Pre and Post Test Mean Scores

	pre-test $\bar{x}$	post-test $\bar{x}$	t	p
BSCS Comprehensive Final Examination	19	28	5.3	.001
Test on Understanding Science	30	35	2.6	.01
Watson-Glaser Critical Thinking Appraisal	57	63	2.1	.05

Table IV
Comparison of the Control Group Pre and Post Test Mean Scores

	pre-test x	post-test x	t	p
BSCS Comprehensive Final Examination	18	26	5.1	.001
Test on Understanding Science	30	33	1.8	.05
Watson-Glaser Critical Thinking Appraisal	58	64	3.0	.001

■ REFERENCES

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HERDING SALMON WITH SOUND

Low frequency sound has been suggested as a means of herding salmon, and other fish that migrate between fresh and salt water, around hydroelectric dams which menace the fish on the downstream trip. Throbbing underwater vibrators placed in the path of migratory fish have forced the fish to detour into bypass channels set up in a series of experiments.

The vibrator guidance system is based on the avoidance response of fish to low frequency sound, according to John G. VanDerwalker of the Bureau of Commercial Fisheries, Columbia Fisheries Program.

Young fish migrating downstream after hatching in inland rivers are particularly menaced by the dams, the scientists said. The experiments were conducted with chinook salmon and steelhead trout. The site of the first study was an irrigation canal in eastern Oregon. Steelheads were migrating down the canal, which was divided into two channels, one 10 feet wide, the other half that width. Vibrators were installed in the larger channel, the route taken by most of the migrating trout.

When the vibrators were turned on, VanDerwalker said, 77% of the fish turned into the smaller channel. The number of steelheads swimming through the five-foot channel was more than halved when the vibrators were silent, the scientist reported.

Following this field study, researchers turned to a two-phase investigation of the effect of the vibrators on chinook salmon under laboratory conditions.

"The objectives of these experiments were to determine the frequency range in which the fish would respond, to measure the intensity necessary to elicit a response, and to describe the characteristics of the response," VanDerwalker explained.

Fish observed in the first phase of the study were sealed in a laboratory tank attached to a vibrator. The fish were held in the tank for several minutes, allowing them to become acclimated to conditions before sound was turned on.

Once the vibrator was operating, VanDerwalker said, fish in the tank appeared to lose their equilibrium, swimming head down, on their sides, and belly-up. Other fish attempted to escape from the vibration by swimming rapidly until exhausted, or nosing persistently against the sides of the tank.

The second phase was designed to test the effects of the vibration on a fish in a floating channel of water. Two hundred fish were released in a rectangular channel and subjected to various sound waves, including pulsed sound and continuous waves.

"All responses noted were avoidance responses," VanDerwalker reported.

RHEUMATOID ARTHRITIS AND HISTIDINE

Laboratory evidence has been unearthed at Downstate Medical Center, State University of New York (Brooklyn) indicating that a common chemical factor, found in almost every food we consume, may play a vital role in the onset of rheumatoid arthritis.

The chemical is histidine, which occurs in milk, meat, grains and a variety of vegetables. It is an amino acid, a component of protein.

Dr. Donald A. Gerber of Downstate's Department of Medicine presented laboratory findings indicating that if individuals have abnormally low concentrations of histidine in their systems, a chemical chain-reaction may take place leading to active rheumatoid arthritis.

Dr. Gerber's study, performed on the blood and urine of more than 100 patients, indicates that histidine exerts a unique blocking effect that prevents the chemical chain reaction from starting.

In simple terms, Dr. Gerber's research shows that a reaction takes place in patients only when histidine concentrations are low. If there is inadequate histidine, minute quantities of copper within the patient's system are left free to cause alterations in protein.

Histidine prevents the reaction by binding copper, Dr. Gerber said. It is this binding, Dr. Gerber feels, which is critical in preventing arthritis symptoms.