LEIB-IRA: Preliminary Report

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A review of numerous high school biology textbooks and accompanying laboratory activities indicates that considerably greater emphasis is now being placed on laboratory experiences than in the past. This trend is partly the result of the currently accepted and advocated need for greater student involvement in the process of inquiry. With a wealth of information already available on the need for student involvement, it is now necessary to consider what the extent of this involvement should be and the kinds of problems that should concern the student.

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The need for guidance in how to promote student inquiry and to establish inquiry guidelines for teachers, teacher educators, curriculum developers, and evaluators resulted in the publication, in 1969, of *Inquiry Objectives in the Teaching of Biology,* ed. by Richard M. Bingman. Developed jointly by the Mid-continent Regional Educational Laboratory (McREL), Kansas City, Mo., and the Biological Sciences Curriculum Study (BSCS), Boulder, Colo., this document identifies six major inquiry factors common to all forms of biologic inquiry: problem formulation, hypothesis formulation, study design, execution of the design, interpretation of data, and synthesis of knowledge.

Of these factors, only execution of the design and interpretation of data receive emphasis in most recommended laboratory activities. A few relatively recent innovations do provide instruction in certain other inquiry factors but generally in a highly structured manner; that is, the students respond to predetermined questions and do not pursue a problem of their own choice. Also, these innovations are generally used with entire classes, and the selected topic may have little appeal for many of the students.

Purposes of LEIB and IRA

Inquiry Objectives in the Teaching of Biology (IOTB) provided the guiding perspective for defining factors needed to develop student competency in the laboratory and enabled McREL to develop the 1970 instructional-strategy documents, by Jimmy R. Stothart, under the general title *Laboratory Explorations in Biology (LEIB).* This strategy is aimed at developing skills and attitudes through which students can attack their own problems in an open or less-structured manner through original or self-selected designs. At present four Laboratory Explorations have been developed: *LEIB I,* "Populations"; *LEIB II,* "Biogenesis"; *LEIB III,* "Respiration"; and *LEIB IV,* "Biological Clocks." Additional topics are being considered.

LEIB is intended to develop skill in each of the inquiry factors as the student initiates, plans and executes a complete inquiry activity. These instructional devices are being developed as an integral part of the Inquiry Role Approach (IRA), described in a 1971 McREL document, by Bingman, titled *Learning Through Inquiry: a Social Design.* IRA is a classroom instructional system in which the students work as individuals and in small and large groups. IRA teacher response to the *LEIB* has been enthusiastic: "*LEIB* turned on one of my classes, which until now had been quite disinterested in Blue Version" and "The kids insist on our opening the labs on weekends for them to do their work" are representative comments.

Student Options

LEIB begins by presenting the student with a structured situation containing one or more dis-

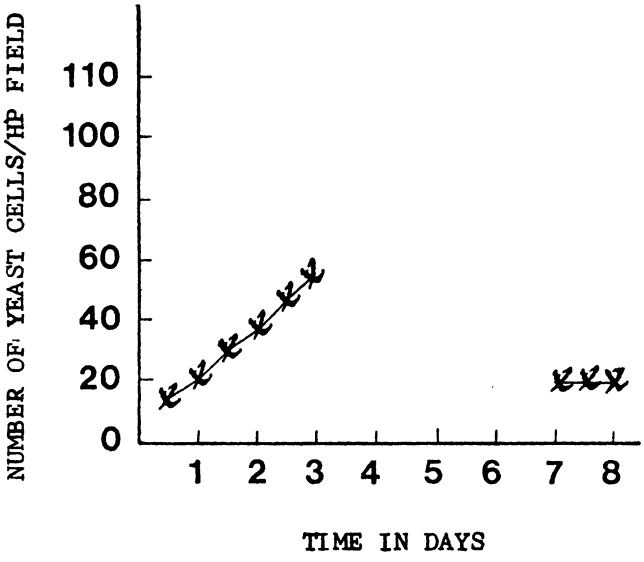

Fig. 1. Graph of a yeast population. The graph contains discrepancies for the student to identify and explain.

crepancies, which he examines and subsequently questions: see fig. 1.

Next the student is given a list of possible steps he could take in the planning phase of an investigation. He is to decide on the order in which he will use these steps or whether or not he will use them at all. The steps would require him to (i) state the problem, (ii) develop an hypothesis, (iii) review related literature, and (iv) design a study.

The student is allowed to change the sequence of steps or to replan as necessary during the investigation. Since *LEIB* is an instructional strategy, guidance is given on how one might carry out each of these steps. The amount of guidance varies in successive Laboratory Explorations, to provide the opportunity for each student to become more competent in each of the inquiry factors. For example, in the case of formulation of hypotheses as presented in *LEIB I,* it is expected that the student will make general explanatory statements but not necessarily in the form of well-structured working hypotheses. In *LEIB II* he is given more guidance, and it is expected that he will formulate the hypothesis in accordance with the criteria of a well-stated hypothesis. In *LEIB III* and *LEIB IV* the student is given less guidance in hypothesis formulation.

On completion of a Laboratory Exploration the student receives instruction in each of the six factors of inquiry and is given the freedom to initiate and complete an inquiry of his own.

Appraisal of Effectiveness

An analysis of students' written and oral reports of *LEIB I* and of classroom observations by McREL staff members resulted in agreement that classes of students who investigated a problem of their own choosing relative to yeast problems demonstrated the following inquiry skills on one or more occasions (see *IOTB,* chapter 3, for the explanation of the symbols):

Identified a situation that a biologist would question	I A 1
Selected and ordered the steps to take when investigating a problem	I B 1
Selected a problem that is capable of solution	I B 2 a
Stated the problem in researchable terms	I C
Generated hypotheses about critical elements in the problem	II B
Used available related literature	I B 1
Identified and accounted for the variable when planning the experimental design	III A 1
Selected from the possible variables the one most relevant to the hypothesis	III A 2
Controlled each variable	III A 3
Designed an experiment in order to collect wanted data	III C
Selected appropriate sampling techniques	III C 2 a
Included in the experimental design methods that minimized random and systematic error	III C 5
Predicted the kinds of information that resulted from the design	III D 1
Followed the plan for collecting and using data	IV A
Used tools properly	IV B
Recorded data accurately	IV C
Used various means to present the data in order to bring out different features	V D
Identified the assumptions made during the investigation	V A
Used results of other studies when interpreting data	V B
Employed deductive and inductive reasoning to make generalizations	V C
Identified new questions or problems that arose from the solution of the problem	VI D 1
Examined data to determine their relevance to the hypothesis and the problem	V E
Formulated conclusions that were based on available evidence	V G

LEIB I was used in 33 Inquiry Role Approach classes of Blue Version biology involving approximately 1,000 heterogeneously grouped students in high schools in Kansas and Missouri and in some honors classes in Jefferson Parish, Louisiana.

Teacher and Student Reactions

Teacher reactions to the four Laboratory Explorations have been gratifying, and evidence of growth in inquiry skills is consistently reported. Examples of teachers' views are the following:

"We now see additional opportunities to teach inquiry skills in conjunction with the regular laboratory investigations. For example, mini-*LEIBs* can evolve from the discussion of the results of these investigations."

"It's not unusual for students to report: 'We have botched this thing. We'd like to do it again *now*.'"

"Several offshoot problems developed during *LEIB I*. One group's yeast culture was contaminated with a protozoon. They then studied culture techniques for this protozoon."

"One of the greatest advantages is that the student has to go back, restudy, and relearn skills previously taught."

Name _____

		Possible points	*My evaluation*
I. Identifies, states clearly the problem, and realizes it is soluble		5	
II. Review of literature (amount, relevancy, etc.)		5	
III. Hypothesis—stated to show it is testable, is related to the problem		5	
	Subtotal	**15**	
IV. Design of study and execution of study (testing of the hypothesis)			
A. Variables and controls		5	
B. Provides for replication		5	
C. Efficient plan that is followed and involves all team members		5	
D. Uses tools properly and revises procedures when results indicate the need (i.e., notices mistakes and corrects them)		5	
	Subtotal	**20**	
V. Data-collecting			
A. Uses simplest technique to collect		5	
B. Valid sampling (stirring more than one drop, etc.)		5	
C. Drawings (show budding, size differences)		5	
D. Mathematical calculations accurate		5	
E. Identifies sources of error		5	
F. Distinguishes between random and systematic error and introduces techniques to eliminate		5	
G. Records in orderly way daily, and later processes data for interpretation		5	
H. Records findings (both expected and unexpected) and significant relationships		8	
	Subtotal	**43**	
VI. Interpreting findings (discussion and conclusion)			
A. Identifies assumptions		5	
B. Uses research, experience, etc. to interpret findings		5	
C. Uses deductive and inductive reasoning as influenced by readings, data, etc.		5	
D. Uses various means of presenting data and bringing out different features		5	
E. Examines data in relation to problem and hypothesis		5	
F. Identifies conflicts, discrepancies		5	
G. Draws tentative, concise conclusions and avoids overgeneralizations		5	
H. Relates findings to varied personal interests and the world at large		5	
I. Applies knowledge to new situations—makes predictions		5	
J. Recognizes new problems		5	
	Subtotal	**50**	

Team evaluated: _____ *Grand total* _____

Fig. 2. *LEIB* evaluation form developed by students. It has been edited, lightly, for publication here.

"One of the major problems is how to evaluate student research."

Problems in using the Laboratory Explorations have been identified and procedures for resolving them are being developed. Presently techniques of evaluating student performance are being examined, as are methods of presenting the completed investigation.

As is characteristic of the Inquiry Role Approach, student involvement in all phases is being encouraged. For example, one class was given the BSCS–McREL document and asked to develop a scoring system. Because the students had worked in groups of four to conduct the investigations, they decided to present group reports to the class in seminar fashion. The reports were scored by each student in the class; then the scores were averaged. This average score was, in turn, averaged with the teacher's rating score to obtain a final score for each report. The students within each group decided how to distribute the points among themselves. The score sheet developed and used by the students is shown in fig. 2. This scoring sheet is a first attempt of students in one heterogeneous class to develop an evaluation scheme. In using this sheet (or similar forms) students are beginning to establish criteria for giving a certain number of points for each inquiry behavior. Student development of evaluative criteria is in itself a means of evaluating student growth.

Quintessential Science

It is said of the naturalist Jean Henri Fabre that at age seven, trying to discover how light enters the human body, he closed his eyes and opened his mouth. Disappointed, he reversed the process.