Designing an Extended Discretion Laboratory Investigation

William H. Leonard

WOULD YOU LIKE TO create your own biology laboratory activities that require the students to think out part of the procedure themselves through the exercise of discretion? Are you interested in training your students to deal with uncertainty in the laboratory yet still develop basic biological concepts?

The Extended Discretion (ED) laboratory approach was described in a recent article (Leonard 1980). The article explained the development of the ED approach as a result of research at the Lawrence Hall of Science, University of California at Berkeley. The original article also presents a description of the concept of extended discretion laboratory learning, relationship to learning theory in science education, and a study where the method was shown to be productive for high school biology students.

This article outlines a step-by-step procedure for the biology teacher to design and conduct an extended discretion laboratory activity and it gives a detailed example, lists expected teacher and student behaviors, and discusses the control of student discretion over the school year.

The basic idea behind the ED approach is that students are required to exercise discretion in the use of available resources during the laboratory activity instead of merely following a recipe-like procedure. Because the approach fosters student independence, it has some similarities to biology teaching strategies previously characterized as deductive (Curtis 1950), enquiry (Schwab 1954), discovery (Bruner 1969), and nondirective (Egleston 1973). The ED approach is different from these other approaches in that there are only specified times at which a student can receive teacher assistance (review points), and there is a systematic attempt to control and account for the period of time a student is required to work without teacher assistance (discretionary time demand). In addition, the approach extends the discretionary time demand upon the student from a few minutes at the beginning of the school year to several hours later in the school year.

Procedures for Construction

1. *Select a laboratory concept* that you wish to develop.
2. *Generate the objective* you wish students to attain relative to this concept.
3. *Express this objective in the form of a concrete task* that can be completed in the available period of time. Some appropriate tasks might be obtaining an answer to a factual question, constructing a device to function in a given way, making certain measurements, or preparing a written description of a phenomenon.
4. *Translate the task into behavioral terms* that can easily be understood by the student.
5. *Estimate the possible maximum and minimum times* needed for students to perform the total task.
6. *Divide lengthy tasks into subtasks.* Depending upon their discretionary abilities, some students will be able to complete the task without assistance from the teacher. Many students may be unable to complete the task without intermediate direction or review of current work from the teacher. It is possible that major tasks should be divided into subtasks. Each subtask should constitute a short activity in itself. The student's progress should be reviewed by the teacher at a point where there is a tangible and measurable product. It is often convenient to divide the task into subtasks of approximately the same time demand. The number of subtasks depends on the length of time a student is expected to be able to do work without a review from the teacher (student time-span of discretion), the complexity of the task, and the total estimated time needed to complete the task. For most high school biology experiments of one-period length, no

William H. Leonard is assistant professor of life sciences and instructional coordinator at the School of Life Sciences, University of Nebraska, Lincoln, Nebraska 68588. For further biographic information on him and his photo, see *ABT* 42(6):338.

more than two or three subtasks are necessary. Identify each subtask and describe it in student terms.

7. *Review points.* It is possible to have more than the number of subtask/review points that will be needed by many students. It should be made clear to each student that s/he may ask for a review at the end of each subtask, if s/he wishes. If the student is to plan and conduct an experiment, convenient review points may be: (1) review of plan and hypothesis, (2) review of data, (3) review of report. Reviews can be programmed to be mandatory or at the option of the student.

8. *Establish a list of resources* that will be available to the student at the time his/her task is given. The list should include:

(a) Available time, both class time and total time extention of task.
(b) Space and equipment available.
(c) Prescribed or technical skills needed to complete task, such as how to use the compound microscope, how to estimate number of bacterial colonies, how to test for the presence of starch, etc.
(d) A list of text or other written materials that may be useful.
(e) Available personnel (teacher, lab aide, etc.).
(f) Any other hints, parameters, or directions the teacher wants to prescribe, such as specialized laboratory skills not performed previously by the student. Some of these skills may be taken word-for-word from another source.

9. *Lay out the activity* in the format shown in figure 1, keeping the amount of paper and words distributed to the student at an absolute minimum. (After all, we are trying to allow the student to exercise as much discretion as possible. The more unrequested direction the student is given, the less discretion s/he can exercise.) Insert any information you wish given as "background."

Figure 1 is an example of an ED laboratory investigation as it appeared in handout form to the student.

Investigation 13.2e: Raw Materials for Photosynthesis

Background:

Carbon dioxide enters the leaf from the air and becomes part of the glucose molecule during photosynthesis. Soon after, the glucose is converted to starch and stored in the leaf, roots, and stems. If the holes through which CO_2 enters the leaf (stomata) are plugged, there may be a reduction of starch buildup in the leaf.

Goal:

Test the hypothesis that: (1) blocking the stomata of a leaf with Vaseline, and (2) lack of sunlight, will affect the production of starch in a leaf.

Tasks:

1. Run a trail starch test on a healthy leaf.
   _____ Teacher Review
2. Plan an experiment to test the two above hypotheses.
   _____ Teacher Review
3. Carry out the experiment and collect data.
   _____ Teacher Review
4. Individually write a report that contains:
   (a) data collected.
   (b) conclusions based upon the data that responds to each of the two hypotheses.

   _____ Grade

FIGURE 1. An example of an ED laboratory investigation as it appeared in handout form to the student.

Recommended Role of the Teacher During the Activity

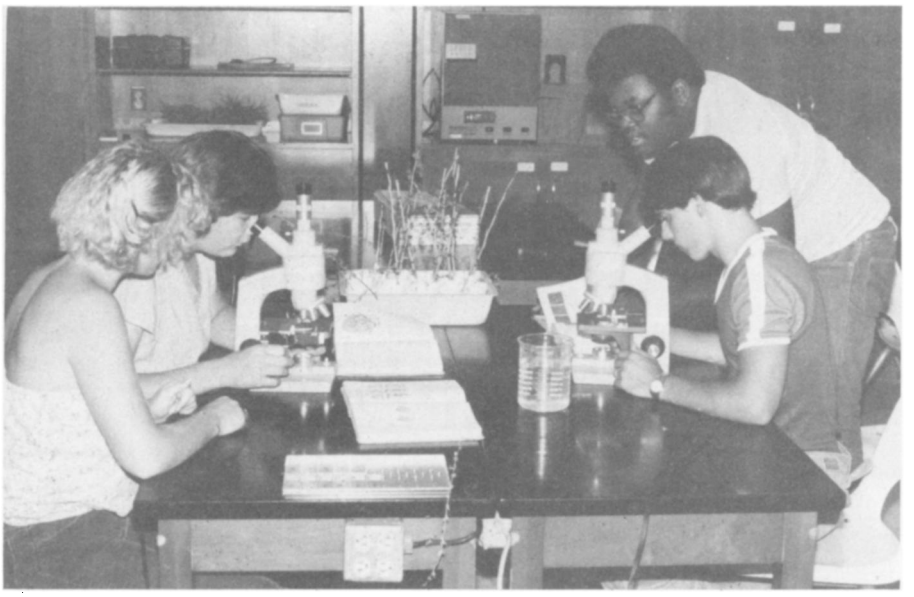
Generally, the fewer decisions the teacher makes for the student, the more discretion the student must exercise. The teacher can be a legitimate resource for techniques, facts or information the student may not have at his/her disposal. However, if the student is to select procedural options, take some sort of action, make plans, or exercise discretion in any other form, the student must *independently* make these decisions.

If it becomes obvious at some point that the student has made an unfortunate decision or cannot make any decision at all, the teacher must make the assumption that the student's discretionary capacity has been exceeded by the discretionary demands of the task; and the teacher must step in and help the student. The teacher help should not, however, involve making the entire decision for the student. The teacher can reduce the discretionary demands by simplifying the task. In a learning situation, this would likely translate into helping the student with part of the decision and letting him/her exercise discretion for the remainder of the decisions needed to complete the task.

A teacher should try not to give reviews at other than specified (pre-planned) review points, and should actually discourage (without appearing negative) optional reviews.

Typically, students want teachers to help and teachers want to help students. (After all, that's teaching, isn't it?) However, the ED approach requires teachers to place a high priority on decision training; they must themselves exercise a great deal of restraint. Most science teachers will seek those students who need help. With the exception of health and/or safety problems in the classroom, it is recommended that the teacher not be on the alert to help students and not initiate help of any kind unless it is sought by the student. The teacher should be available as a resource for technical answers and for specified reviews only. As cruel as it sounds, how else will the student take risks and independently exercise his/her discretionary abilities?

The teacher's role then becomes one of (1) giving technical information—often frequently during the beginning of an investigation and during the interpretation of results, (2) reviewing the progress of the student at the student's request, and (3) occasionally peering at the class to check



Students at work in a laboratory using the Extended Discretion (ED) approach.

for potentially hazardous, disruptive, or negatively productive activities.

Expected Student Behaviors

Students can be told that the objective is for them to make decisions themselves and that the role of the teacher is to promote student independence. They can even be told that the fewer reviews they require, the higher will be their grade—providing, of course, that they make correct or constructive decisions that allow them to complete the task successfully.

Once the stage is set, typical student behaviors include: (1) sitting at desk and simply mulling [thinking], (2) sitting at desk and sketching on paper, (3) discussion with one or more students, (4) requesting information from the teacher, (5) consulting references, (6) manipulating equipment, and (7) seeking and/or receiving a review of progress from the teacher.

Because many alternatives exist for the successful completion of a task, student laboratory reports are likely to be quite diverse. Generally, reports will follow a scientific format (Goal, Hypothesis, Procedures, Data, Results or Conclusions); but within these categories, hypothesis and procedures can vary widely.

Typically, there is evidence of more student energies in the report of an ED lab than, for example, in a *BSCS Green Version* or *Modern Biology* laboratory activity report, where student procedures and reporting are more prescribed.

Control of Discretionary Demand over Time

To be able to control discretionary demand, review points on early laboratory investigations should be only 10 to 15 minutes apart. This is much shorter than for most commercial biology laboratory investigations, which are about 40 minutes. *Gradually* throughout the year the frequency of review points can be reduced and the time between reviews increased. Thus the responsibility upon the student increases through the school year. An example of beginning, midyear, and end of the school year task analyses is shown in figure 2.

September:	Goal A	
	Subtask 1	(10 min)
	Subtask 2	(15 min)
	Subtask 3	(10 min)
	Subtask 4	(15 min)
January:	Goal B	
	Subtask 1	(30 min)
	Subtask 2	(25 min)
	Subtask 3	(50 min)
June:	Goal C	(3 days)

FIGURE 2. The responsibility of the student increases throughout the year as shown.

Summary

The salient components of this laboratory instructional approach are:

- A prior assessment of individual student discretionary capacity in various areas.
- A task statement to the student.
- A list of resources including time.
- Opportunity for the student to exercise discretion.
- Provision for review or help only at specified times at or near the student's current discretionary capacity.

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- Controlled discretionary demand throughout the school year: a gradual increase in time between reviews with gradually increased student responsibility up to or beyond his/her measured maximum.

By having experiences in increased responsibility for the learning process, the student will also experience increased uncertainty. One goal is to correspondingly increase the student's ability to exercise discretion when dealing with uncertainty. I invite you to generate and conduct your own Extended Discretion laboratory activity and to communicate to me your observations of differences in student responses.

The exercise of discretion is so important in one's success outside of school that training in discretion, if possible, certainly should be explored. The biology laboratory seems an excellent opportunity for students to develop to their fullest discretionary abilities. The biology teacher can make an important long-range contribution to the student by providing the student frequent opportunities in the laboratory to deal with uncertainty through the exercise of discretion.

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