## USING VARIED INSTRUCTIONAL TECHNIQUES: INDUCTIVE and DEDUCTIVE TEACHING APPROACHES

In order to meet the needs of diverse learners in a biology classroom, it is important to vary the approach to teaching the content. One basic dichotomy related to approaches is that of inductive-deductive teaching.

### What Are Inductive and Deductive Teaching?

*Inductive teaching* (also called *discovery teaching* or *inquiry teaching*) is based on the claim that knowledge is built primarily from a learner's experiences and interactions with phenomena. An instructor using an inductive approach begins by exposing students to a concrete instance, or instances, of a concept. Then learners are encouraged to observe patterns, raise questions, or make generalizations from their observations. The teacher's role is to create the opportunities and the context in which students can successfully make the appropriate generalizations, and to guide students as necessary.

Inductive teaching has close ties with the instructional method called the "learning cycle," where phenomena are explored before concepts are named. Inquiry-based teaching, in which students are asked to continually develop and test hypotheses in order to generalize a principle, is another member of the inductive "family."

*Deductive teaching* (also called *direct instruction*) is much less "constructivist" and is based on the idea that a highly structured presentation of content creates optimal learning for students. The instructor using a deductive approach typically presents a general concept by first defining it and then providing examples or illustrations that demonstrate the idea. Examples that do not fit the idea are helpful in confirming the idea. Students are given opportunities to practice, with instructor guidance and feedback, applying and finding examples of the concept at hand, until they achieve concept mastery.

Most “demonstration” or “cookbook” labs are deductive in nature. Students have already been introduced to the idea in their text or in lecture, and the lab serves to show them directly and concretely something that they already know or have been taught conceptually. They know the outcome of the procedure before it is completed. The three osmosis labs starting present a deductive version (demonstration), a transitional deductive/inductive version (structured inquiry), and an inductive version (guided inquiry), all based on the same materials.

**Examples of Inductive and Deductive Ecology Lessons**

The following two examples are meant to illustrate the two approaches.

*Deductive*

During an ecology unit, the instructor presents the concept of resource partitioning. It is defined: Resource partitioning is the dividing up of a key resource (habitat, food) in order to reduce direct competition between species. Examples of the phenomenon (such as a visual depiction of the famous warbler/spruce tree spatial partitioning example) are then shared with students and explained. Then the instructor asks students to apply their understanding by evaluating a new example (such as a wading birds/feeding depths visual depiction) and deciding whether it fits the concept of resource partitioning. The example is discussed, and students are given feedback on their choices and justifications. The teacher decides if additional examples are necessary in order for students to achieve concept mastery.

*Inductive*

During an ecology unit, the instructor provides students with a few visual depictions of ecological scenarios where resource partitioning is shown (the warblers/spruce trees and the wading birds/feeding depths examples, for instance). Students are instructed to observe and describe the examples and to look for any patterns they share. The instructor may ask a guiding question, such as "What are some ways that competition can be minimized?" Students then share their observations and interpretations of the phenomena, hopefully describing the unnamed concept of resource partitioning. After the discussion, the instructor provides the name of the concept for the students.

**The Advantages and Disadvantages of These Approaches**

Neither of these approaches is perfect for all students all of the time; each has advantages, disadvantages, and trade-offs.

Richard Felder (1993) characterizes inductive and deductive preferences as a learning style issue. Some students learn best through an inductive approach; some learn best through a deductive approach. Inductive learners *like* making observations and poring over data looking for patterns so they can infer larger principles. Deductive learners *like* to have the general principles identified and prefer to deduce the consequences and examples from them. These are often the same learners who prefer more structure in general.

From the example about resource partitioning described previously, one can see that the inductive approach could potentially make for a "messier" lesson. Students may draw other meanings from the examples and data provided than what was intended by the instructor. The inductive approach may also take more time and be less "efficient" than a deductive approach. In addition, certain ideas do not lend themselves easily to an inductive technique—teaching about DNA base pairs or photosynthesis, for instance.

Some educators have suggested that deductive teaching can be critically important for students with learning disabilities (Brigham and Matins 1999). This method has a clear and readily apparent structure, is easily paced to accommodate student needs, and is very familiar to students. But deductive teaching has trade-offs; it can be too rigid a form that does not allow for divergent student thinking nor emphasize student reasoning and problem solving.

Mary Bay et al. (1990) found that in a controlled study of science achievement by students with mild handicaps, including learning disabilities, those students taught by an inductive approach showed better long-term retention of concepts than those taught with a deductive approach. The hypothesis is that inductive thinking demands deeper processing.

At the same time, open-ended inductive exercises may pose severe challenges for students with learning disabilities. Such students may have difficulty getting started, understanding their role in the exercise, and staying focused on the activity. In order for these students to succeed when engaged in inductive activities, it is essential that the instructor create clear guidelines for behavior, provide explicit directions from the outset of the activity, and be prepared to offer extra guidance as necessary. Mastropieri, Scruggs, and Butcher (1997) concur and suggest that inductive-based activities for students with learning disabilities, without the supporting structures described here, will result in less effective concept development.

These pros and cons, however, should not steer an instructor away from using one approach or the other; both are important teaching models.

**Ways to Integrate Inductive Teaching**

Since inductive teaching is a less familiar approach to many biology teachers, two additional examples of inductive teaching are offered below.

1. Give students a basic data set in the form of a table or graph that shows a key concept, such as exponential growth. Ask them to observe the data, describe the data, and make some interpretations about the data. After the observations and interpretations have been discussed, introduce the name for the concept (exponential growth) and give them any other additional information deemed appropriate.

2. Play what is called the "inductive game." Provide a prompt in the form of a question or challenge, such as "List as many basic foods that humans consume as you can." Provide one or two examples so students catch on quickly (e.g., eggs, carrots). As the group names foods, record the responses for all to see in a simple table with three columns, leaving the heading for each column blank. The students will see that each response is placed in one of three different columns. (See Figure 3.19 below.)

After several examples have filled all three columns, ask students to propose a classification system for the three-column table; in other words, what concept is the basis for the groupings? Collect and record the suggestions as the class discusses the merits of the various classification schemes proposed. Then write the appropriate name or definition for the groupings in the empty headings of the columns.

In this case, the concept intended to be drawn out of the students was macromolecules: fats, proteins, and carbohydrates. Students will not typically identify the proper name of the concept, but that is not the point. The point is to look for patterns and propose a generalization that is supported by the examples.

Figure 3.19. "Inductive Game" Example.

| **Mystery Heading (proteins)** | **Mystery Heading (fats)** | **Mystery Heading (carbohydrates)** |
|---|---|---|
| Eggs<br>Turkey<br>Yogurt | Olive oil<br>Butter | Potatoes<br>Rice<br>Carrots |

## Examples of Inductive Teaching Labs and Activities in the ***Biology Success!*** Manual

The *Biology Success!* manual contains two activities that are designed to be primarily **inductive**: “Mussel Beach: A Simulation of Evolutionary Change” and “Mendelian Genetics”.

In Mussel Beach, students carry out a data-collecting simulation using beads and pencils, and they are asked to compare the results and draw conclusions before the key concepts are introduced.

In the activity Mendelian Genetics, students are given a structured and concrete experience of Mendelian principles using Legos before the corresponding genetics terms are introduced.

## Examples of Deductive Teaching Labs and Activities in the ***Biology Success!*** Manual

The *Biology Success!* manual contains two activities that are designed to be primarily **deductive**: “Biogeochemical Cycles” and “Designing Controlled Experiments”.

In Biogeochemical Cycles, students are led through a highly structured overview of biogeochemical cycles and then asked to practice writing about one example using a writing template.

In Designing Controlled Experiments, students work through a worksheet that defines and gives examples of key concepts of experimental design. They are then asked to practice using these concepts by designing an experiment of their own.

## Conclusion

Both deductive and inductive teaching approaches should be included in a biology course. Each offers advantages to students with different learning strengths and motivations. Varying the approach to teaching content can help reach a broader number of students with diverse learning needs.

## References

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