SIMPLIFYING *Inquiry* INSTRUCTION

Assessing the inquiry level of classroom activities

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Inquiry instruction is a hallmark of the current science education reform efforts. Science teachers know that inquiry is important, yet most teachers lack a practical framework of inquiry to inform their instruction.

Defining inquiry and assessing how much inquiry is supported by a particular activity or lab can be difficult and confusing. This article presents a simplified explanation of inquiry and provides a rubric that will enable science teachers to determine whether an activity is inquiry based and, if so, to assess the level of inquiry it supports. Additionally, the framework presented will allow teachers to easily adjust the level of inquiry in an activity and increase the amount of inquiry in their science instruction.

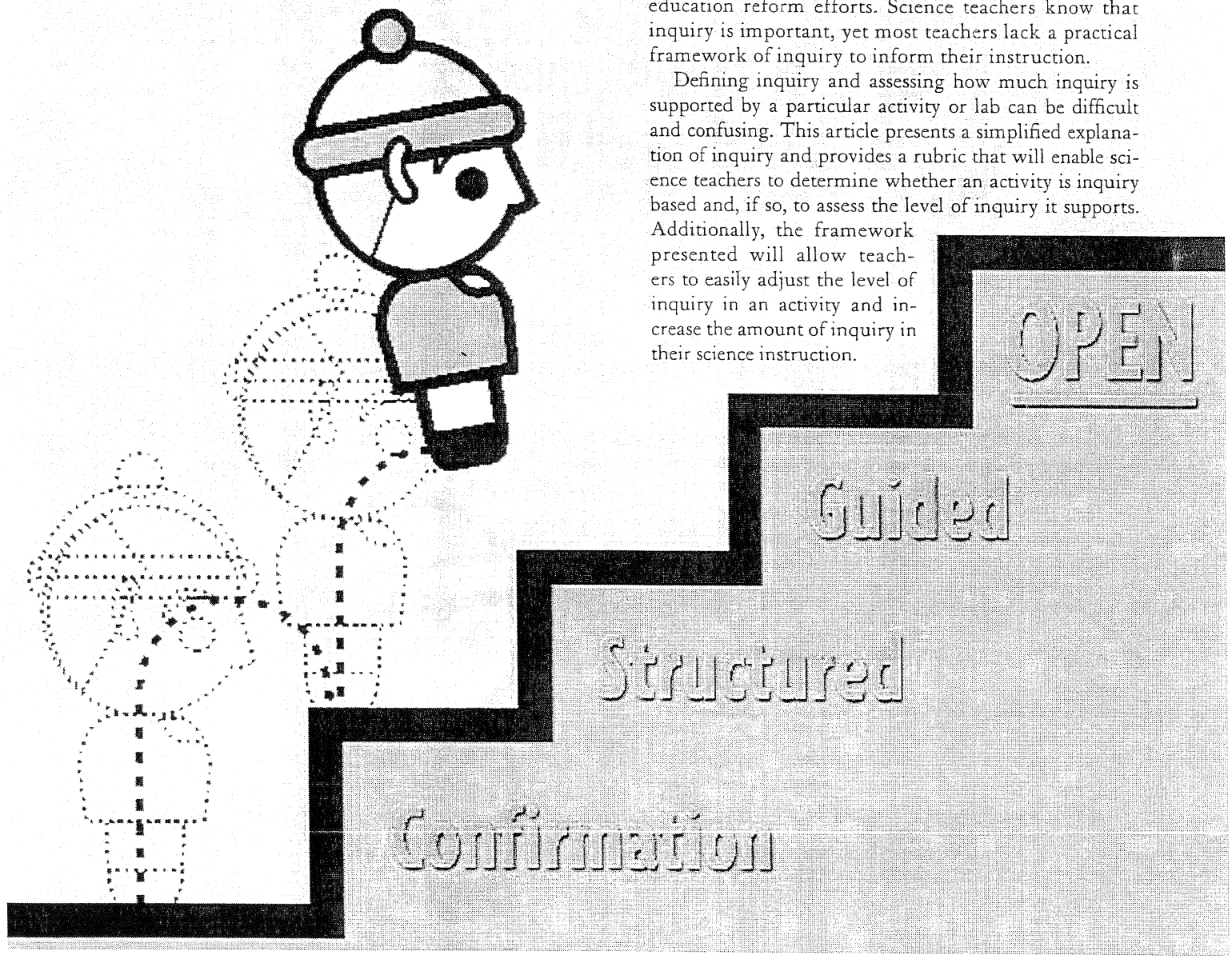

FIGURE 1

Teacher inquiry self-check.

Which examples constitute inquiry?		
1a. Students complete a Moon phase calendar by ◆ cutting out photographs of the Moon in different phases, ◆ mounting them on a monthly calendar on the proper date, and ◆ labeling each of the eight major Moon phases.	**1b.** After completing a pre-assessment activity on students' knowledge of Moon phases, a student asks about the correct order of Moon phases. The teacher challenges students to determine the sequence of phases by observing the Moon and recording their observations for one month.	**1c.** The teacher begins with the question "Does the Moon rise and set at the same time every night?" Following a brief discussion of the question, the teacher demonstrates the rising and setting of the Moon for several sequential evenings using a computer simulation. The teacher then facilitates a class discussion in which the class concludes that the Moon rises and sets about 50 minutes later each evening.
2a. Students define and describe the El Niño effect by using text and images they find on the internet.	**2b.** Students go to the library to find newspaper accounts describing the impact of El Niño on the California coast. They then summarize what they find in a two-page written report.	**2c.** Students select a location in the U.S. then search the Internet for monthly temperature data of this location for the most recent El Niño year. Students then compare monthly temperature data for the El Niño year to the average temperature data for the past 50 years in order to assess the impact of El Niño on that particular location.

the student. The salient feature of this model is the question, "How much information is given to the student?"

Using this framework as a guide, lab activities can be designed at varying levels of inquiry, depending on wording and presentation. This model allows the teacher to tailor inquiry lessons to the particular readiness levels of the class. For instance, a Level 1 activity can become a Level 2 by having students complete it prior to learning the targeted concept, and a Level 2 activity can be revised easily to Level 3 simply by removing the procedural directions.

Complexity

The degree of complexity in an inquiry activity also varies, depending on the level of openness and the cognitive demands required (Figure 3). The simplest, Level 1, is sometimes referred to as a confirmation activity. At this level, students are provided the question and procedure, and the expected results are known in advance. For instance, lab activities presented at the end of the chapter to verify a concept that has already been taught fall into this category.

In a Level 2 activity (structured inquiry), students investigate a teacher-presented question through a prescribed procedure. Both Level 1 and 2 activities are commonly referred to as "cookbook labs," because they include step-by-step instructions, but Level 2 activities answer a research question. The difference between a Level 1 and Level 2 activity can be a matter of timing—a confirmation lab can become a structured inquiry lab simply by presenting the lab before the target concept is taught. Note that the majority of laboratory investigations in most textbooks are written at Level 1 or Level 2. Including low-level inquiry activities in the curriculum is not necessarily a problem, as long as they are not used to the exclusion of higher levels. After all, students are able to take greater ownership of their own learning, make authentic decisions, and construct meaning for themselves at the higher levels of inquiry.

A Level 3 activity (guided inquiry), again, features a teacher-presented question but leaves the methods and solutions open to students. This level of inquiry requires students to design or select the procedure to carry out the investigation. Students typically get very little practice in designing their own investigations; therefore, guided inquiries have the potential to take student engagement and ownership of the lab to a new level. Furthermore, guided inquiry activities can be easily created from cookbook labs simply by removing the step-by-step directions and requiring students to come up with their own methods for answering the research question. The teacher should approve student procedures before the investigation is conducted and be sure that proper safety guidelines are followed.

Problems, solutions, and methods are left to the student in a Level 4 activity (open inquiry). Science fair projects are perhaps the most common form of Level 4 inquiries in science classrooms. Students investigate

FIGURE 2

Modified version of the four-level model of inquiry.

How much information is given to the student?

Level of inquiry	Question?	Methods?	Solution?
1	✓	✓	✓
2	✓	✓	
3	✓		
4			

Continuum of Scientific Inquiry

Level 1—Confirmatory
Problem area, methods of instruction, and "correct" interpretations are given or are immediately obvious from either statements or questions in the students' laboratory manual or textbook. Includes activities in which students simply observe or experience some unfamiliar phenomena or learn to master particular laboratory technique.

Level 2—Structured Inquiry
Laboratory manual proposes problems and describes ways and means by which the student can discover relationships he/she does not already know from manual texts.

Level 3—Guided Inquiry
Problems are provided, but methods as well as solutions are left open.

Level 4—Open Inquiry
Problems, as well as the solutions and methods are left open. The student is confronted with the "raw" phenomena.

Refs:
Herron, M.D. (1971). The nature of scientific enquiry. *School Review, 79*(2), 171- 212.
Schwab, J. J. (1964). Structure of the disciplines: Meanings and significances. In G. W. Ford & L. Pugno (Eds.), *The structure of knowledge and the curriculum* (pp. 6-30). Chicago: Rand McNally.

Evaluating an Activity's Level of Inquiry

What is given to the student?

Level	Problem?	Procedure?	Solution?
1			
2			
3			
4			

Name_____

Inquiry Level Quiz

Assess the inquiry level (1-4) of each of the following activities. Use "0" if the activity does not support inquiry.

Inquiry	Given to Ss	Description
1	Question, Methods, Solution	**Confirmation**—*Students confirm a principle through an activity in which the results are known in advance.*
2	Question, Methods	**Structured inquiry**—*Students investigate a teacher-presented question through a prescribed procedure.*
3	Question	**Guided inquiry**—*Students investigate a teacher-presented question using student designed/selected procedures.*
4	—	**Open inquiry**—*Students investigate topic-related questions that are student formulated through student designed/selected procedures.*

Lab Activity A

Inquiry Level:_____

The students are provided - with live Daphnia, thermometers, depression slides, and compound microscopes. Water baths maintained at 5, 20, and 35 degrees Celsius have been provided at five lab stations around the room. The students are instructed to expose a sample of their Daphnia to one of the water baths for two minutes and then count the heartbeats of one Daphnia for one minute. This procedure is to be repeated for each of the three temperatures (the students have already been shown how to count the heartbeats of a Daphnia). After the collection of data, the students are asked to plot the number of heartbeats per minute versus temperature on a sheet of graph paper and state a conclusion about the relationship between these two variables.

Lab Activity B

Inquiry Level:_____

The students are provided with live Daphnia, thermometers, depression slides, and compound microscopes. They are asked to determine the number of heartbeats per minute for one of the Daphnia. The students are then asked to find out if different temperatures influence the heart rate of Daphnia and to explain how other variables could account for the differences observed.

Lab Activity C

Inquiry Level:_____

The teacher explains to the students that temperature has a general effect on the heart rate of invertebrates. Higher temperatures tend to increase the heart rate while lower temperatures decrease the heart rate. One rule states that the heart rate doubles for every 10 degrees increase in temperature. A cold-blooded animal like the Daphnia is directly influenced by the environmental temperature. With this information, the students are instructed to "break up" into their laboratory groups and verify the stated relationship between heart rate and temperature for the specific temperatures of 25, 35, and 45 degrees Celsius. These students already know how to set up water baths and determine Daphnia heart rates.

Lab Activity D

Inquiry Level:_____

Live Daphnia, hot plates, nicotine solution, 5% alcohol solution, light sources, rulers, thermometers, depression slides, pH paper, balances, graph paper, microscopes, stirring rods, beakers, and ice cubes are placed on the demonstration table at the front of the room. The students are asked to use any (or all) of these materials to investigate the influence of environmental changes on the heart rate of Daphnia and to search for quantitative relationships among the variables investigated.

(Based on an activity by Norman G. Lederman).

Textbook Activity Assessment: Levels of Inquiry (25 pts)

Randomly select 9 lab activities in the science textbook that your CI uses in your EDIS 488 placement. For each activity, indicate 1) whether it is inquiry, and if so, 2) brief description of question and data, 3) what is given to students (Question, Methods, Solution), and 4) what level of inquiry (Herron's Scale) does the activity support? After completing this analysis for all 9 activities, complete the following on a separate page:

1. Describe how you would modify 2 of the activities in order to increase their inquiry level, Be sure to indicate new level (2 paragraphs). 6pts.
2. Write a conclusion in which you evaluate the degree to which your textbook supports inquiry (1 paragraph) 10 pts.

Textbook Title:

Title/Purpose of Activity	Pages	Inquiry? (Y or N)	Question & Data	What is Given to Students?			Inquiry Level
				Q?	M?	S?	
1.			Q: D:				
2.			Q: D:				
3.			Q: D:				
4.			Q: D:				
5.			Q: D:				
6.			Q: D:				
7.			Q: D:				
8.			Q: D:				
9.			Q: D:				