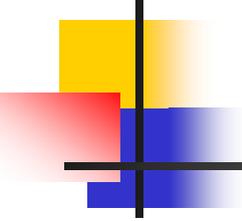
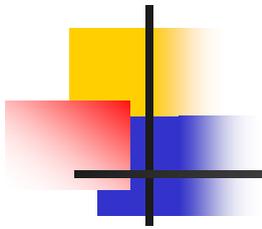


Quality Science Instruction: The Vision and the Reality

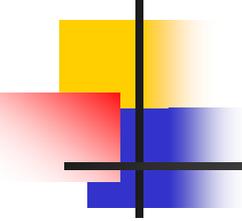
**Iris R. Weiss
June 25, 2007**



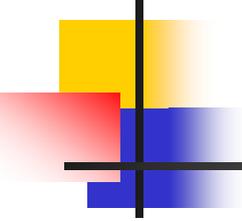
Quality Science Instruction: The Vision



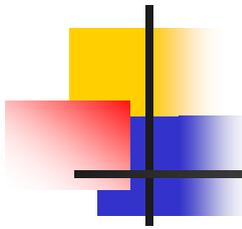
Students are engaged intellectually with important science disciplinary content.



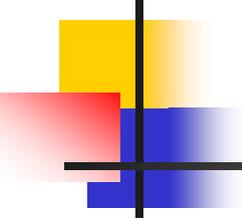
Science instruction portrays science as a dynamic body of knowledge continually enriched by conjecture, investigation, analysis, and proof/justification.



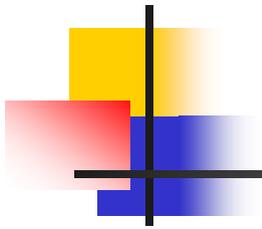
Students are actively engaged in pursuing questions of interest to them, rather than simply “going through the motions.”



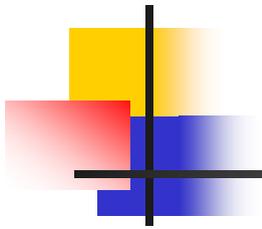
There is a climate of respect for students' ideas, questions, and contributions. Students are encouraged to generate ideas, questions, and conjectures.



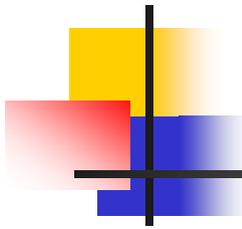
Teachers present accurate science information and display an understanding of science concepts in their dialogue with students.



Teacher questions are posed in a way that is likely to enhance the development of student conceptual understanding.

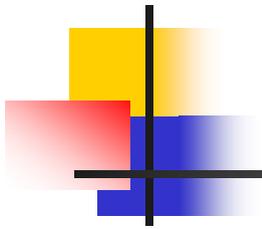


Adequate time and structure are provided for student reflection and sense-making.

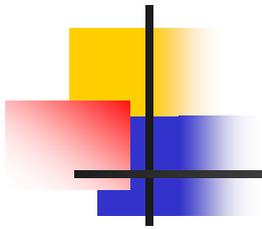


“Capsule” Rating Scale

- Level 1: Ineffective instruction
 - a. “passive learning”
 - b. “activity for activity’s sake”
- Level 2: Elements of effective instruction
- Level 3: Beginning stages of effective instruction (low, solid, high)
- Level 4: Accomplished, effective instruction
- Level 5: Exemplary instruction

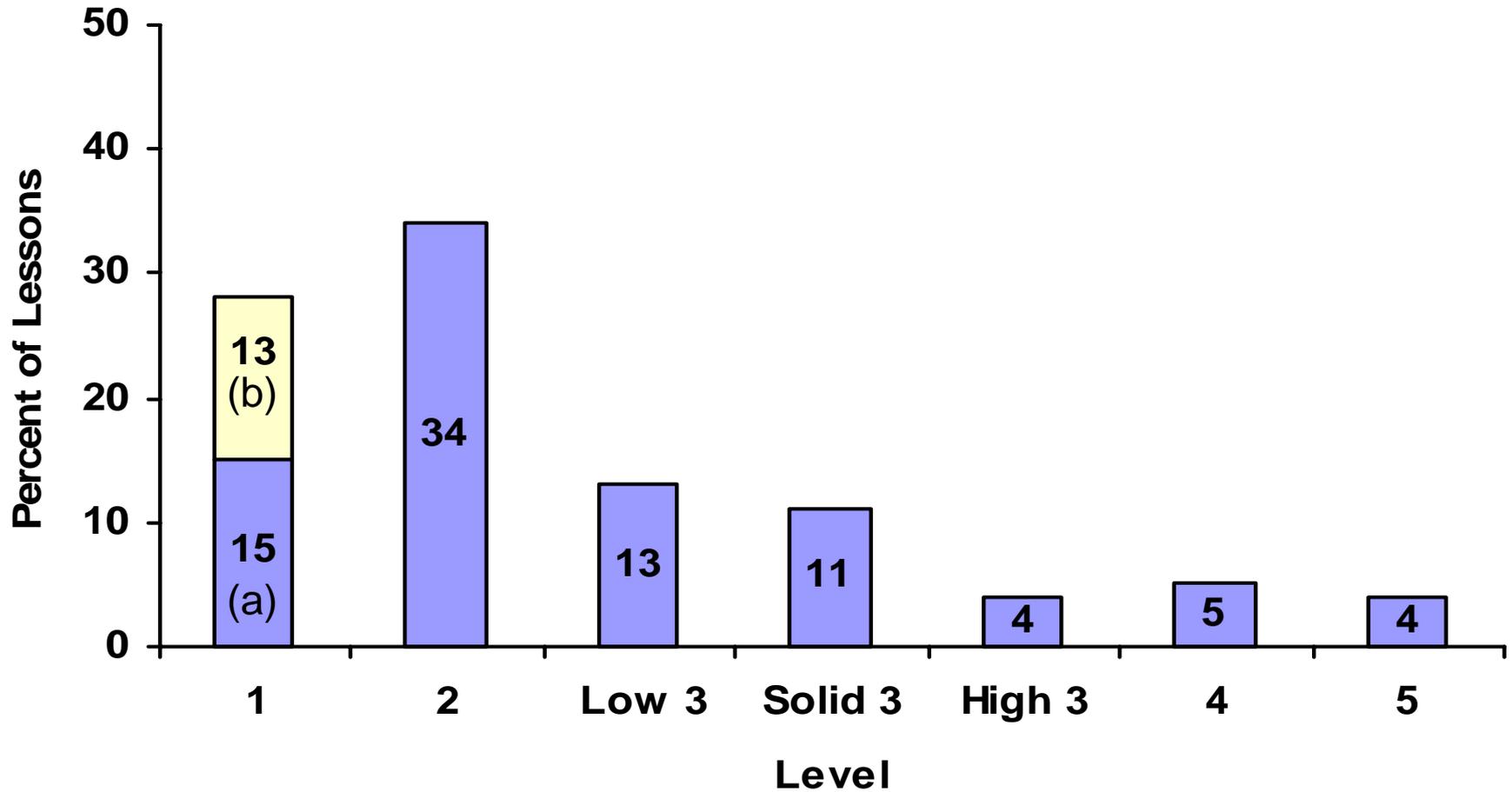


Quality Science Instruction: The Reality

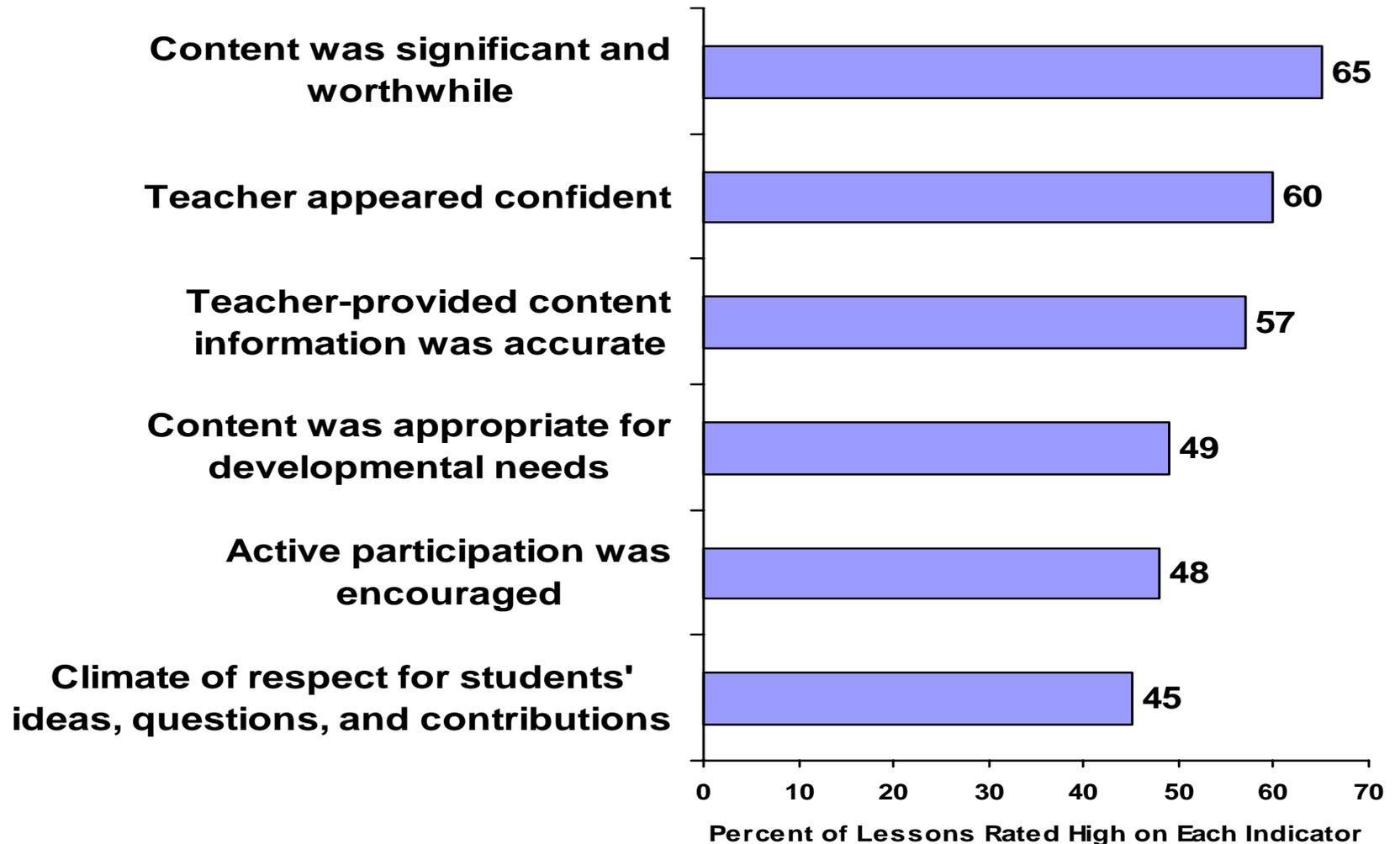


What percent of K–12 science lessons would you predict were rated as high quality?

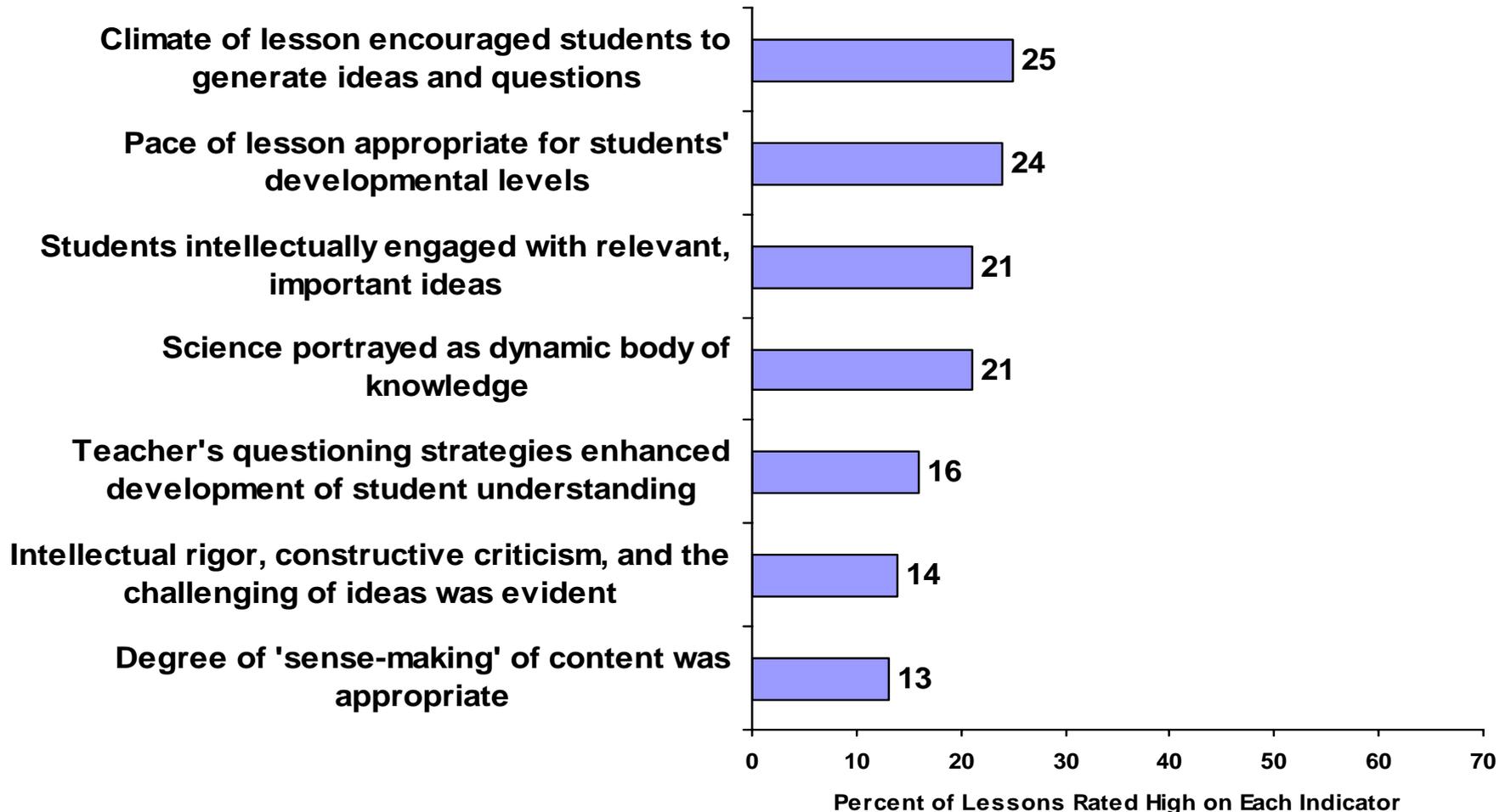
Capsule Ratings: K-12 Science Lessons

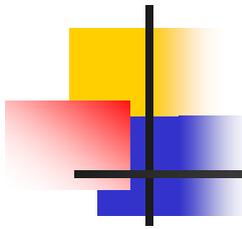


Relative Strengths of K–12 Science Lessons



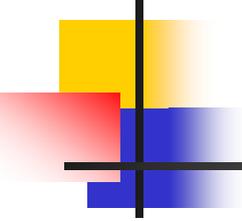
Areas Where K–12 Science Lessons Are Rarely Strong





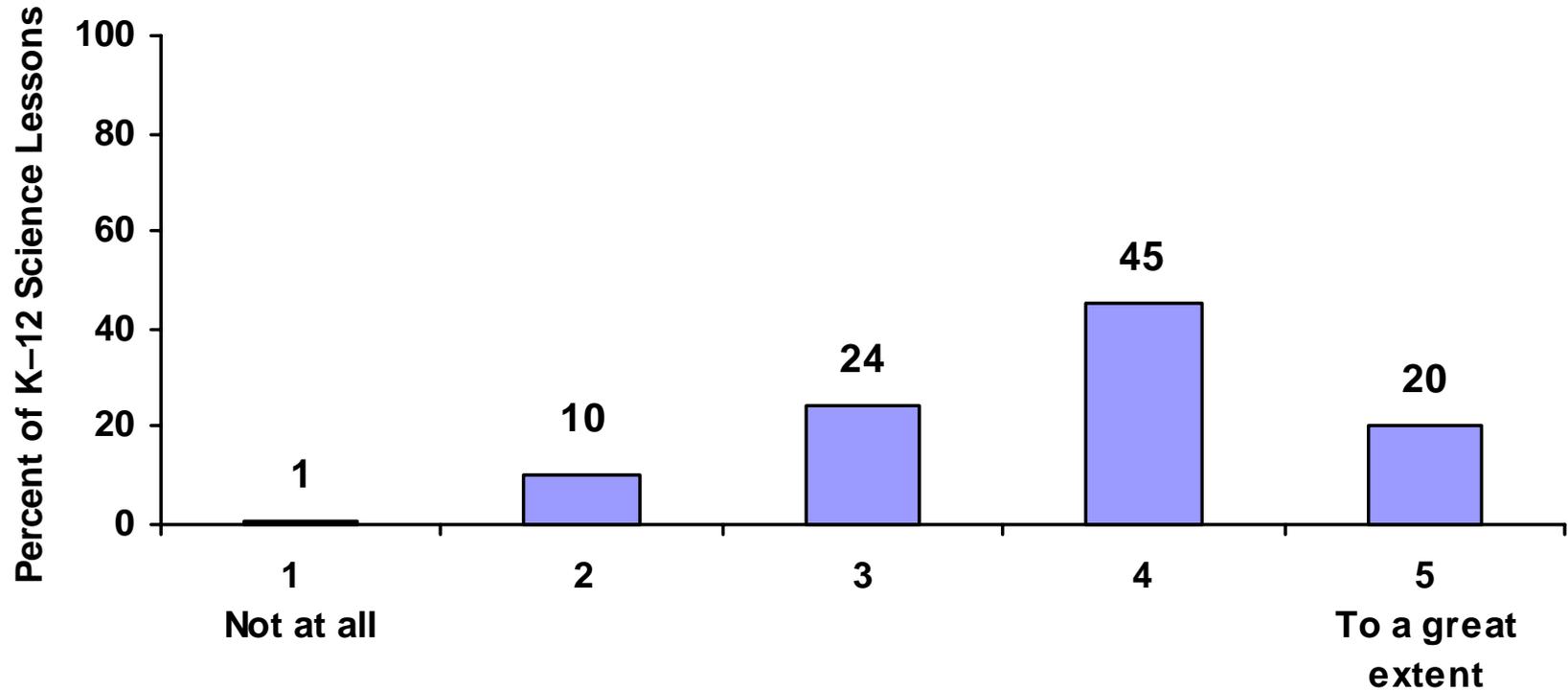
Key Elements of High Quality Science Instruction

- Engage students with the science content;
- Create an environment conducive to learning;
- Ensure access for all students;
- Use questioning to monitor and promote understanding; and
- Help students make sense of the science content.

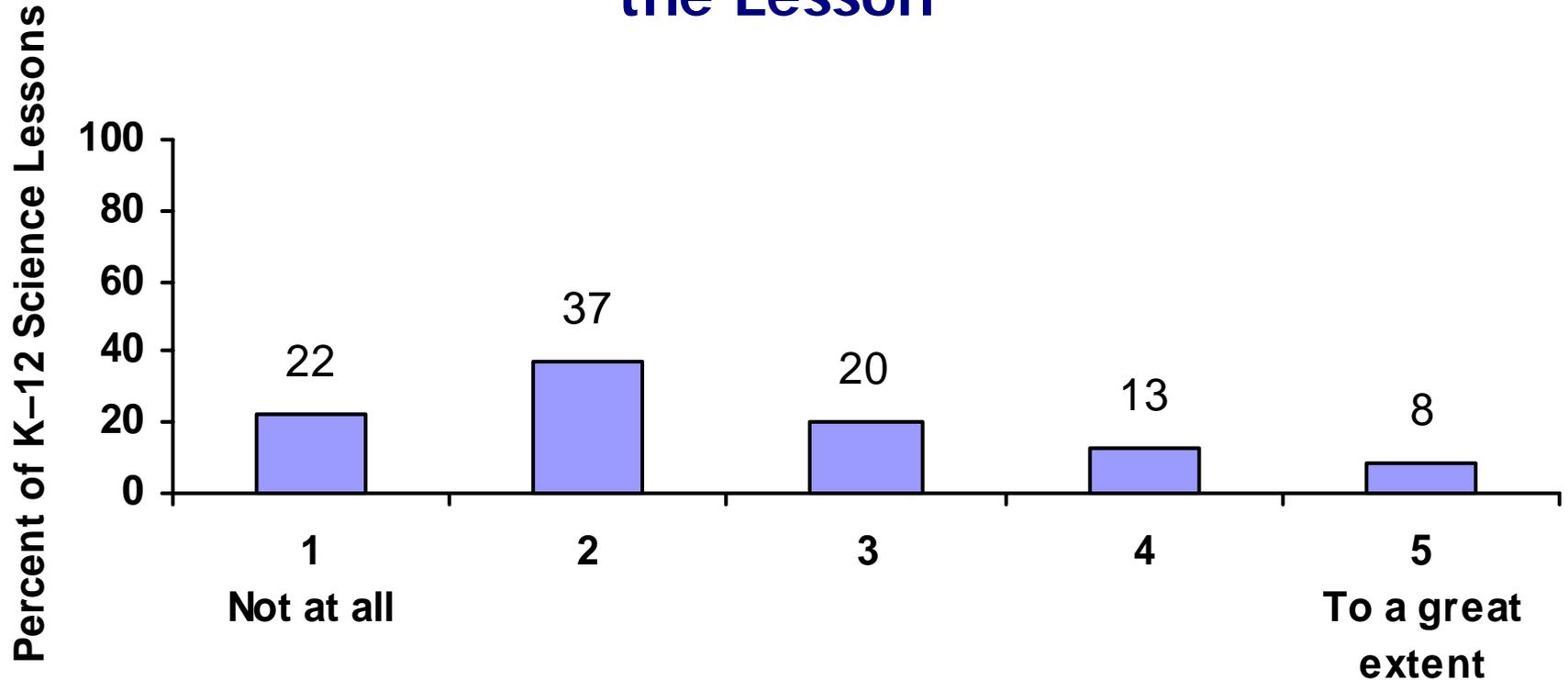


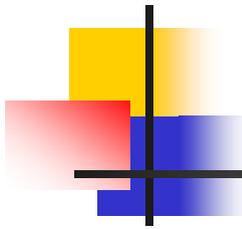
Engaging Students With Science Content

Science Content Is Significant and Worthwhile



Students Are Intellectually Engaged with Important Ideas Relevant to the Focus of the Lesson



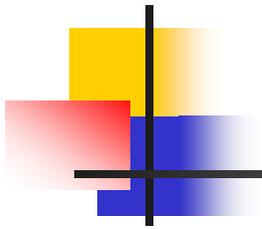


Many Lessons “Just Started”

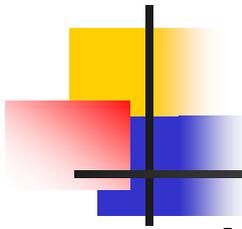
- Turn to page 178 in your book

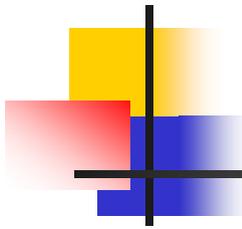
or

- We're at V.B. 2a on the outline of Newton's Laws



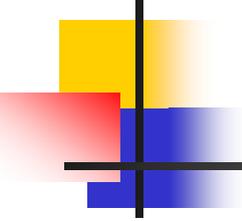
In Contrast...

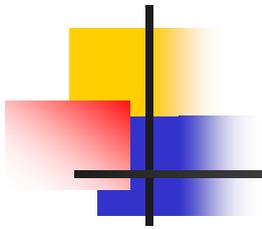
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- In a 4th grade science lesson, as an introduction to studying the relationship between form and function, the teacher handed out a tail feather and a magnifying glass to each pair of students. Students were asked to examine the feather, pull the barbs apart, and look for the hooks. They then pulled the feather between their fingers, making the barbs stick back together. The teacher then handed out a down feather and they repeated their investigations.



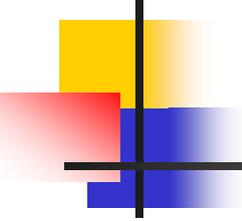
Portraying Science as a Dynamic Body of Knowledge

Not!!!

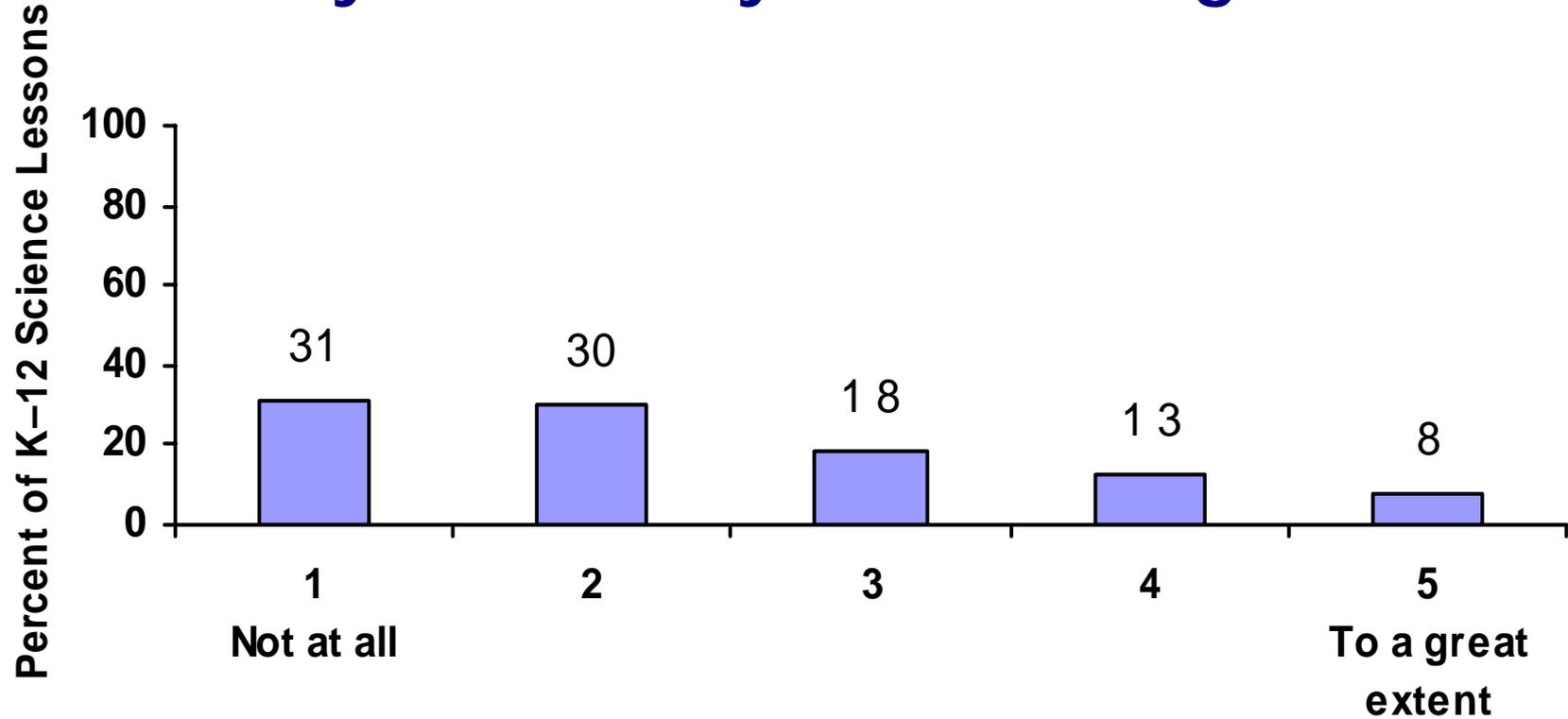
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- An 8th grade science lesson was designed to give the students a great deal of factual information on Newton's Third Law of Motion. The students copied notes from the blackboard for half of the lesson, and the next half of the lesson was spent with the teacher asking them to recall information from the notes. The observer wrote: "The lesson was designed in a way that allowed the students to be very passive, interacting little with each other or the content. The students spent a great deal of time hurriedly copying the notes; only those students who were called on by the teacher during the review time were required to think about the content, and even that was at the basic level of recalling facts they had just written down."

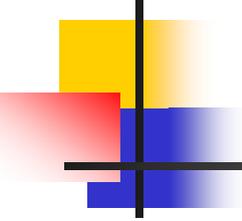


In Contrast...

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- A 6th grade science lesson consisted of a teacher-led discussion of the process of sedimentary rock formation. By drawing upon the experiences and prior knowledge of the students, the teacher helped the students devise a model of how sedimentary rock is formed. For example, the teacher asked students, if they broke a vase, what they would need to fix it. The students decided that not only would they need glue, they would also need something to push the pieces together. The teacher then asked the students, “Where might the force come from [to push sand together to make sandstone]?” The teacher probed students until they considered possible sources of the pressure. This lesson emulated the scientific process of using observable data and knowledge of basic scientific principles to create a model of an unobservable process.

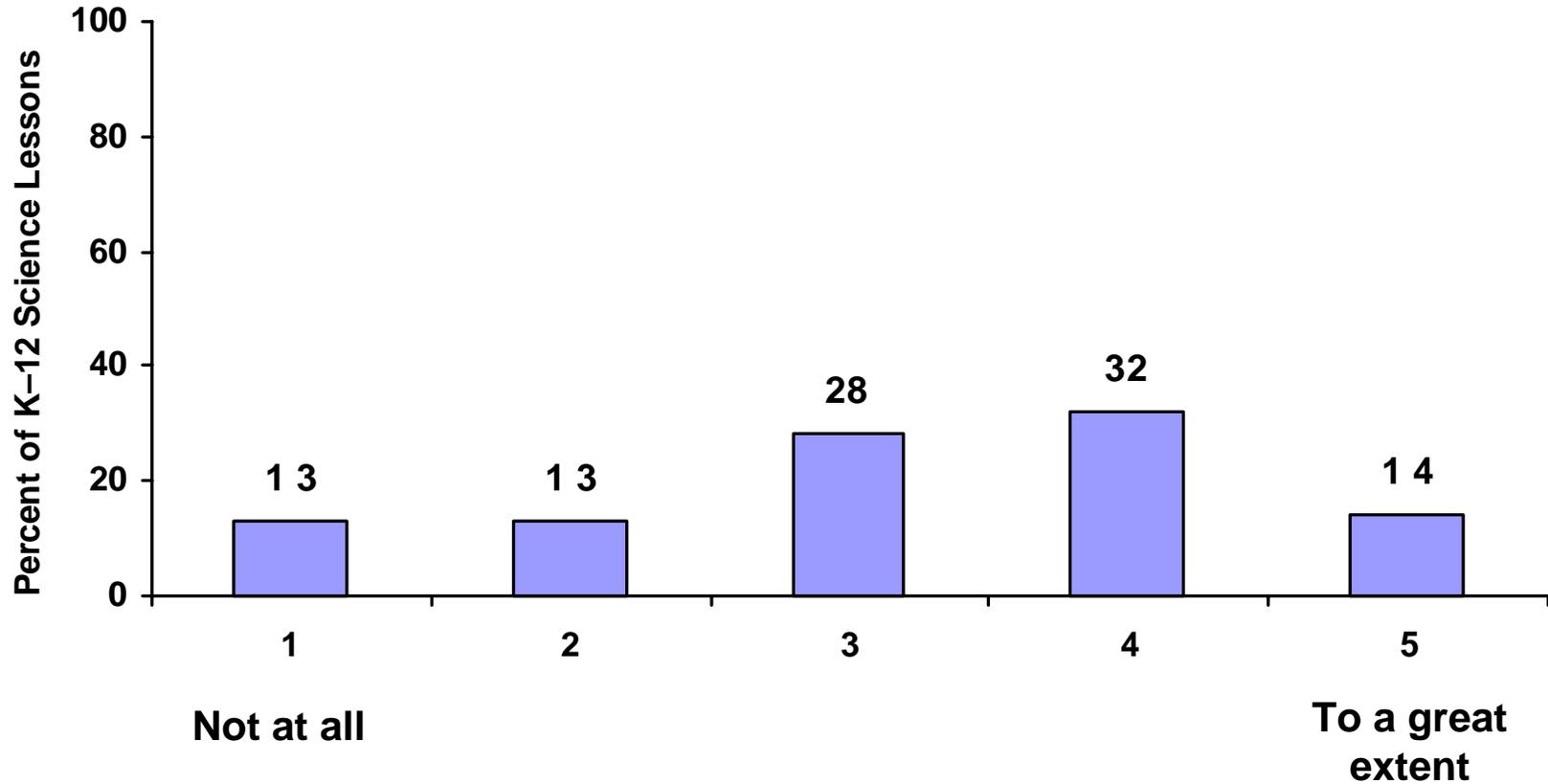
Science Portrayed as Dynamic Body of Knowledge



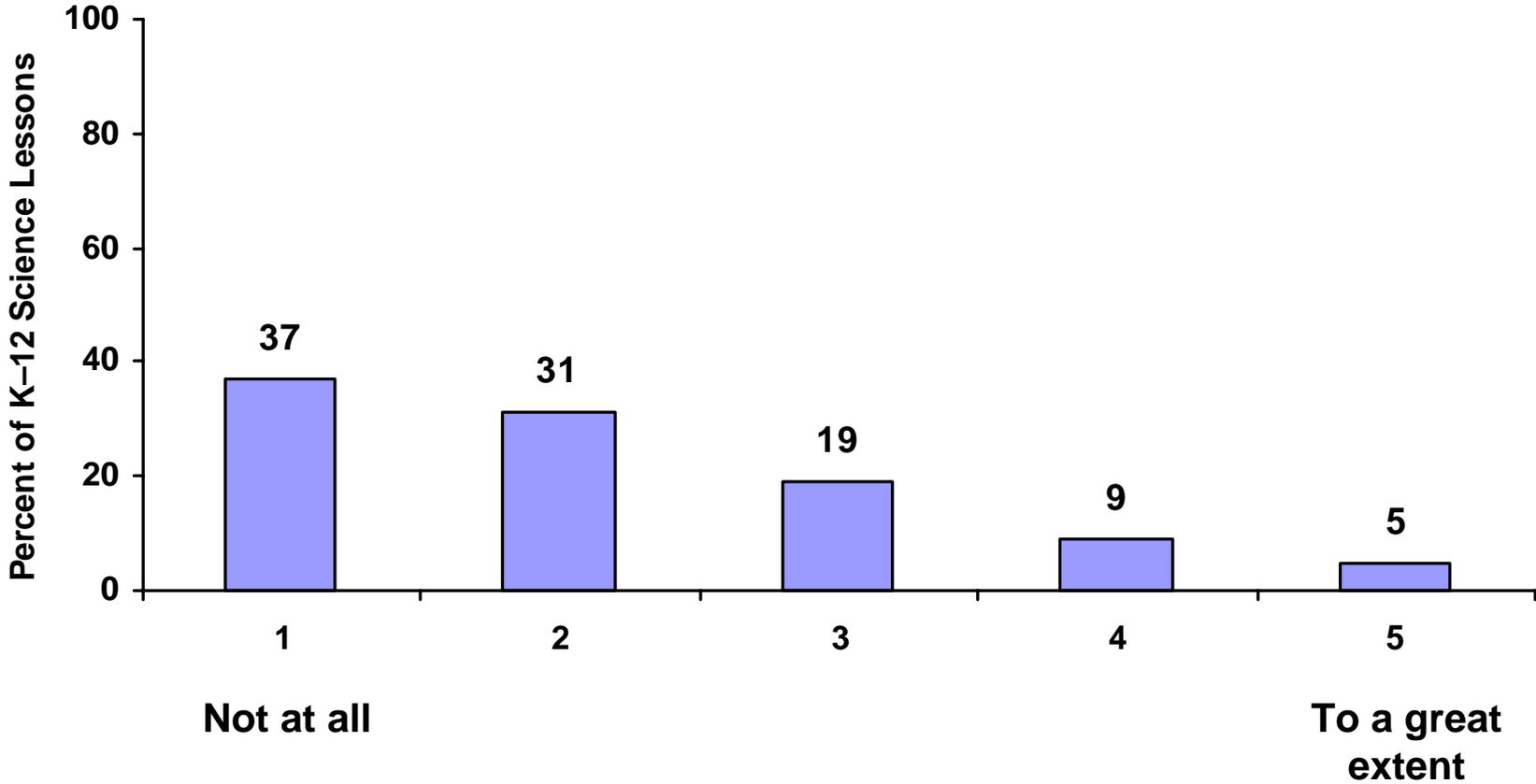


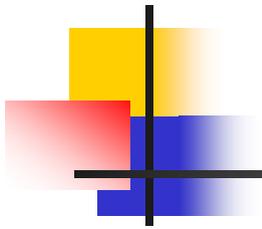
Creating an Environment Conducive to Learning

Climate of Respect for Students' Ideas, Questions, and Contributions

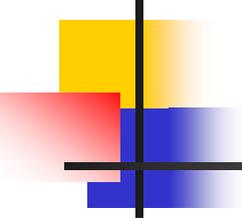


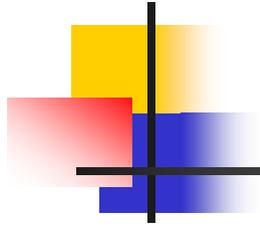
Intellectual Rigor, Constructive Criticism, and Challenging of Ideas Are Evident



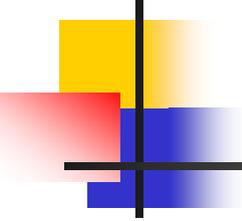


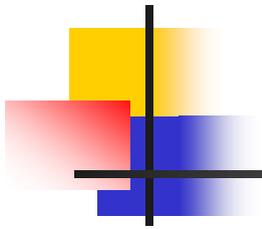
Respectful and Rigorous

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- Students in a 5th grade science class worked extremely well in pairs, offering constructive criticism of each other's findings. The observer described an example where one student concluded that a rubber band conducted electricity, but her team-mate pointed out that she had accidentally touched the wire to one of the clips, completing the circuit. The pair of students then tried the experiment again, taking care to touch only the rubber band, and found that the rubber band was not a conductor. "The teacher eagerly answered questions, and encouraged exploration. There was—pardon the pun—an air of electricity and excitement in the room, and the students had to be shooed away from their activities for recess. It would be hard to imagine a classroom more conducive to learning."

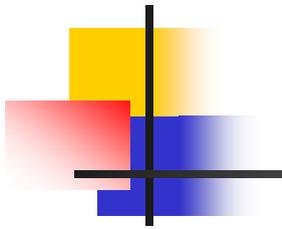


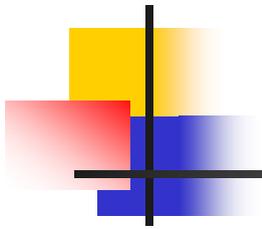
Respectful, But Lacking in Rigor

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- The observer reported that “emotionally, the culture of this 9th grade science class was good. The teacher had a warm relationship with the students, and it seemed clear that there was great deal of mutual respect. Intellectually, however, the culture in this classroom was very weak. Science was presented as facts and formulas to memorize, with no requirement that things make sense or even be internally consistent. Students were asked to respond to the teacher’s questions but did not interact with each other, or propose new ideas for the class to discuss.”

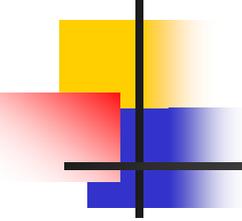


Lacking in Respect for Students

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- The observer noted that the culture in a high school biology classroom was one of an authoritarian teacher and uninspired students. About half the class was entirely disengaged for the entire block period, and several did not even fill out the worksheet during the time allotted. Students remained silent during work time and apologized when they gave a wrong answer. On three different white boards the teacher had written: "If anyone writes with my pens again you will pay the price."

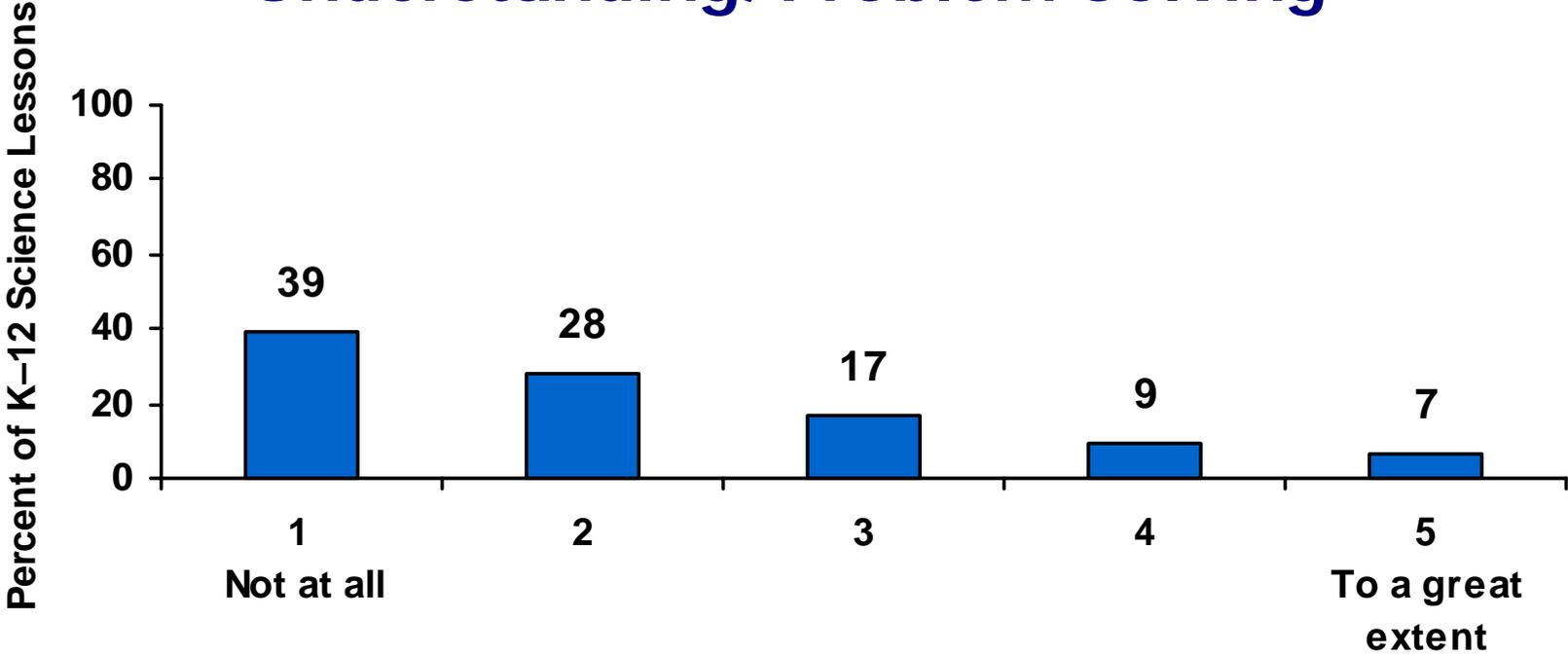


Helping Students Make Sense of the Science Content



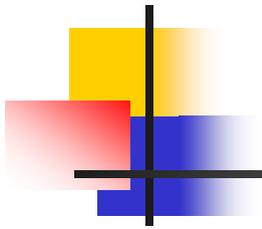
Questioning to encourage
students to think more
deeply

Teacher's Questioning Enhanced Development of Student Understanding/Problem Solving

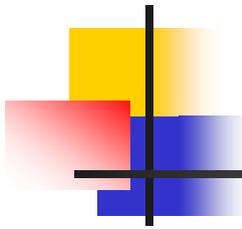


How would you rate the following question and answer session that took place in a 6th grade science lesson on weather and the atmosphere?

- Teacher: "The first layer is the what?"
- Students: "Troposphere"
- Teacher: "How many layers are there?"
- Students: "Four"
- Teacher: "What happens in the troposphere?"
- Student: "It rains"
- Teacher: "What happens in that layer?"
- [Students unsure]
- Teacher: "w, w, w..."
- Student: "Water?"
- Teacher: "What have we been studying?"
- Student: "Weather."
- Teacher: "What are four forms of precipitation?"
- Students: "Rain, snow, sleet, hail"

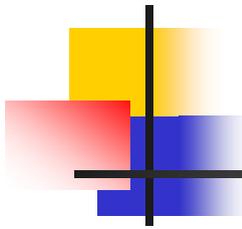


Sometimes teachers
answer their own
questions



In Contrast:

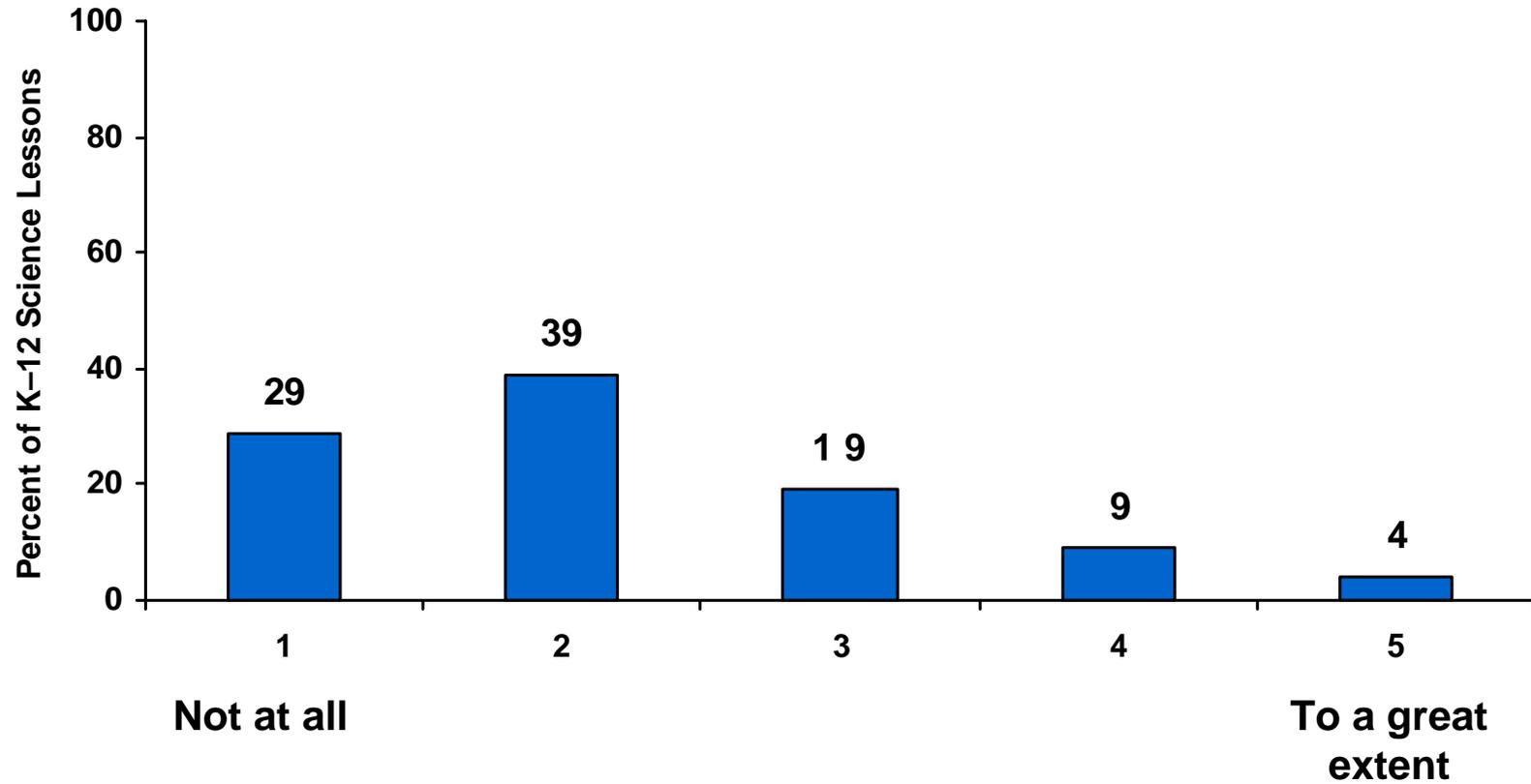
- As the students in a 10th grade science class were examining the results of their experiment, the teacher asked questions that pushed them to examine their results further and to provide evidence for their conclusions. Examples of questions asked by the teacher are: “How could we test if there is still sugar in the reservoir?” “Why didn’t it [the iodine indicator] reach equilibrium?” and “How do you know?”



MAJOR Weakness:

Inadequate attention to
“sense-making”

Degree of Sense-Making Is Appropriate for This Lesson



The teacher guided a 3rd grade class through the completion of a science worksheet by referring the students to a particular question, telling them to turn to a specific page in their textbook and look for the answer, asking one student volunteer to read the answer from the book, then writing the answer on an overhead transparency copy of their worksheet. The observer reported the following conversation as an example:

Teacher: "Let's look at lesson two. Turn to page E16.

Fill in the blank. Look on the page. Matter is made of...what?"

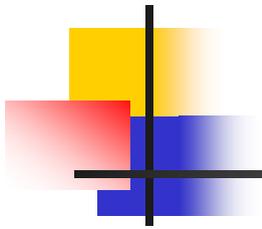
Student 1: "Atoms."

Teacher: "Adding heat changes a solid to a what?"

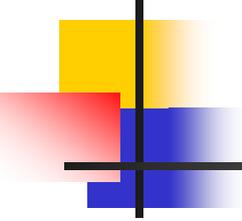
Student 2: "Liquid."

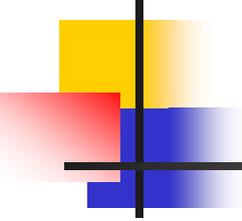
Teacher: "Good. Now read number three."

At the completion of the worksheet, the teacher then went over the questions and answers to summarize the content in the lesson. The students were instructed to keep their worksheets for the next lesson.



In Contrast...

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- The teacher in a high school human anatomy and physiology class began a lecture by drawing a diagram of a nerve receptor, connected by a nerve fiber to (eventually) the brain. He explained the concept of a threshold for a receptor, noting that stimuli could be either sub-threshold, threshold, or super-threshold, stressing that only after the threshold is reached does the receptor respond to the stimulus and send a signal to the brain. He spent most of the remainder of the lesson explaining that receptors vary in threshold and, “Your brain recognizes the highest threshold receptor stimulated.” The teacher gave the example of caution signs being made of certain colors because the receptors for those stimuli have the lowest threshold, and of an artist using certain colors to create light and draw a person to a particular part of a painting.

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- Choice of instructional strategy doesn't appear to be as important as some have suggested.
 - The key to quality science instruction appears to be providing students an opportunity to engage with important science concepts and ensuring that they in fact make sense of these concepts.