



Research to Practice: Applying What We Know To Improve Mathematics and Science Education

Network Connections Conference
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November 8, 2005

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Data Sources:

- Inside the Classroom National Observation Study
- Cross-site Evaluation of the Local Systemic Change Initiatives

Also:

- Emerging Consensus on Effective Professional Development

Organization of the Presentation

- What do we know about the strengths and weaknesses of “typical” mathematics/science instruction?
- What do we know about effective professional development?

Part I:

What do we know about the strengths and weaknesses of “typical” mathematics/science instruction?




Looking *Inside the Classroom*

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Among the Questions Addressed by the *Inside The Classroom* Study:

1. How does mathematics/science instruction “look” in the nation’s classrooms? To what extent are mathematics/science portrayed as inert collections of facts and algorithms, as opposed to dynamic bodies of knowledge continually enriched by conjecture, investigation, analysis, and proof/justification?


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2. Are students actively engaged in pursuing questions of interest to them, or simply “going through the motions,” whether they are doing individual “seatwork” or working in groups?

3. To what extent do mathematics and science lessons engage students intellectually with important mathematics and science disciplinary content?
4. Is teacher-presented information accurate? Do teachers display an understanding of mathematics/science concepts in their dialogue with students?

5. When teachers ask questions, are they posed in a way that is likely to enhance the development of student conceptual understanding?
6. Are adequate time and structure provided for student reflection and sense-making?
7. To what extent is there a climate of respect for students' ideas, questions, and contributions? Are students encouraged to generate ideas, questions, and conjectures?

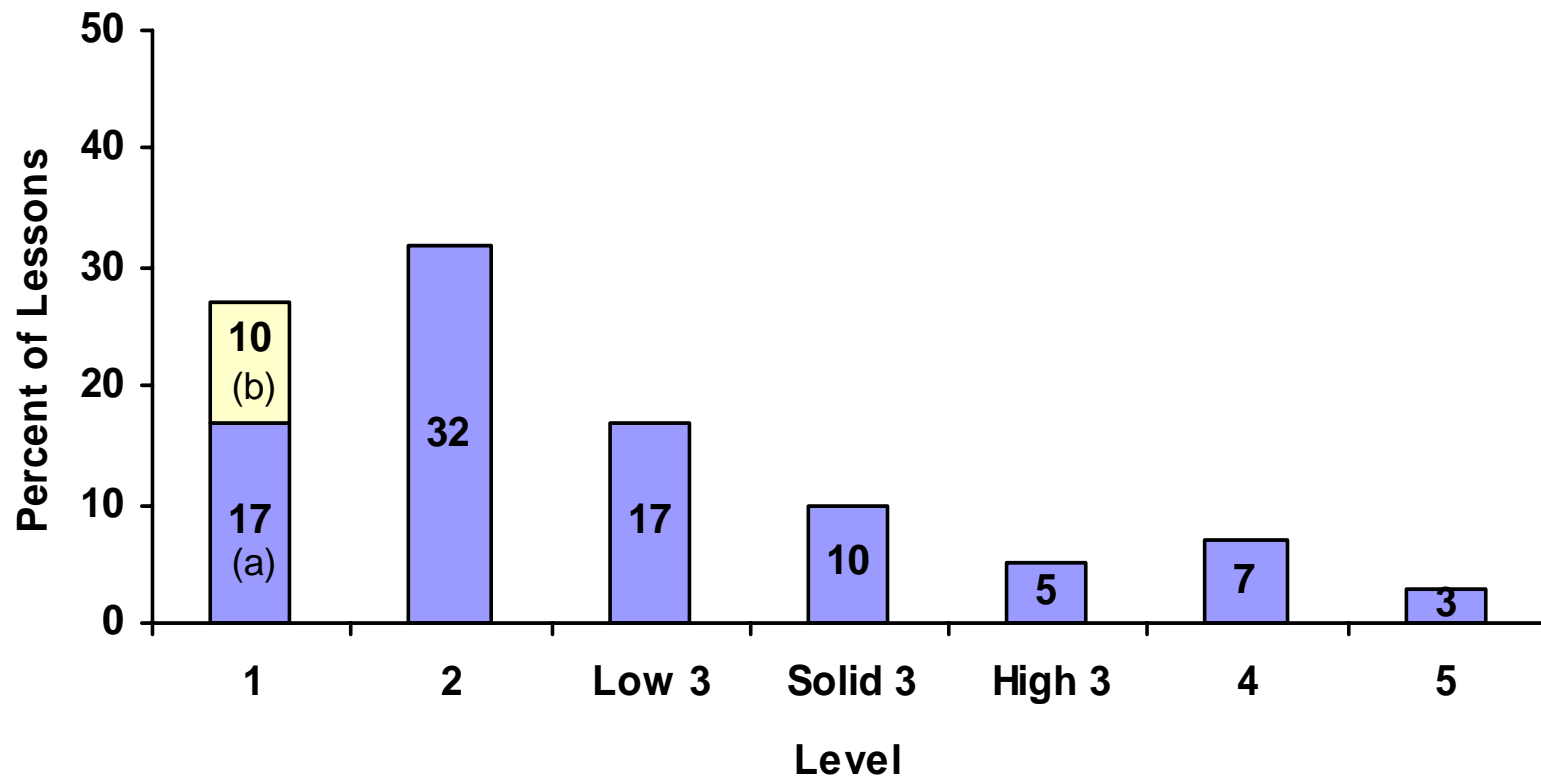


Nationally Representative
Sample of 364 Lessons
(K–12, Mathematics and
Science)

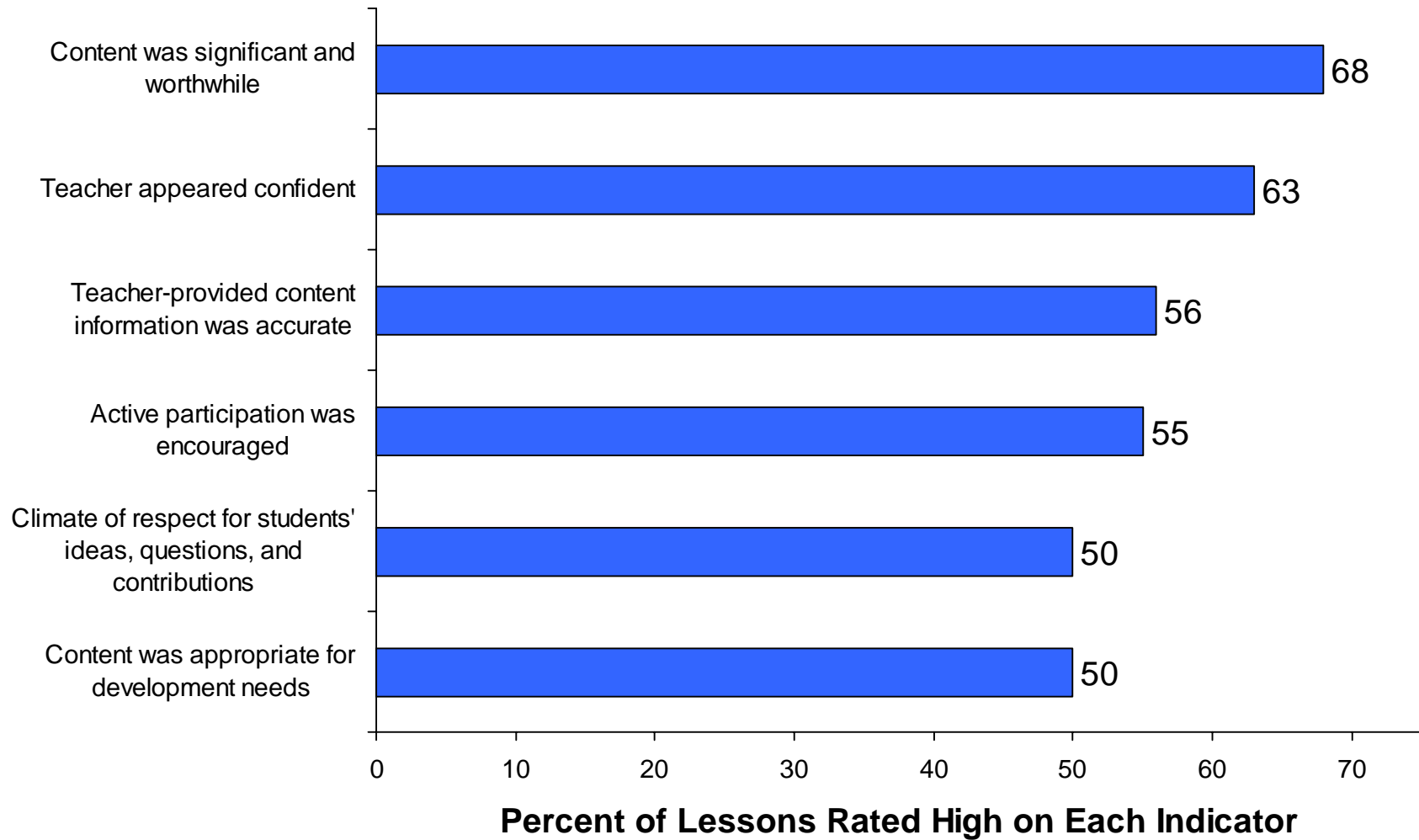


What percent of
mathematics/science lessons
nationally are “high quality”?

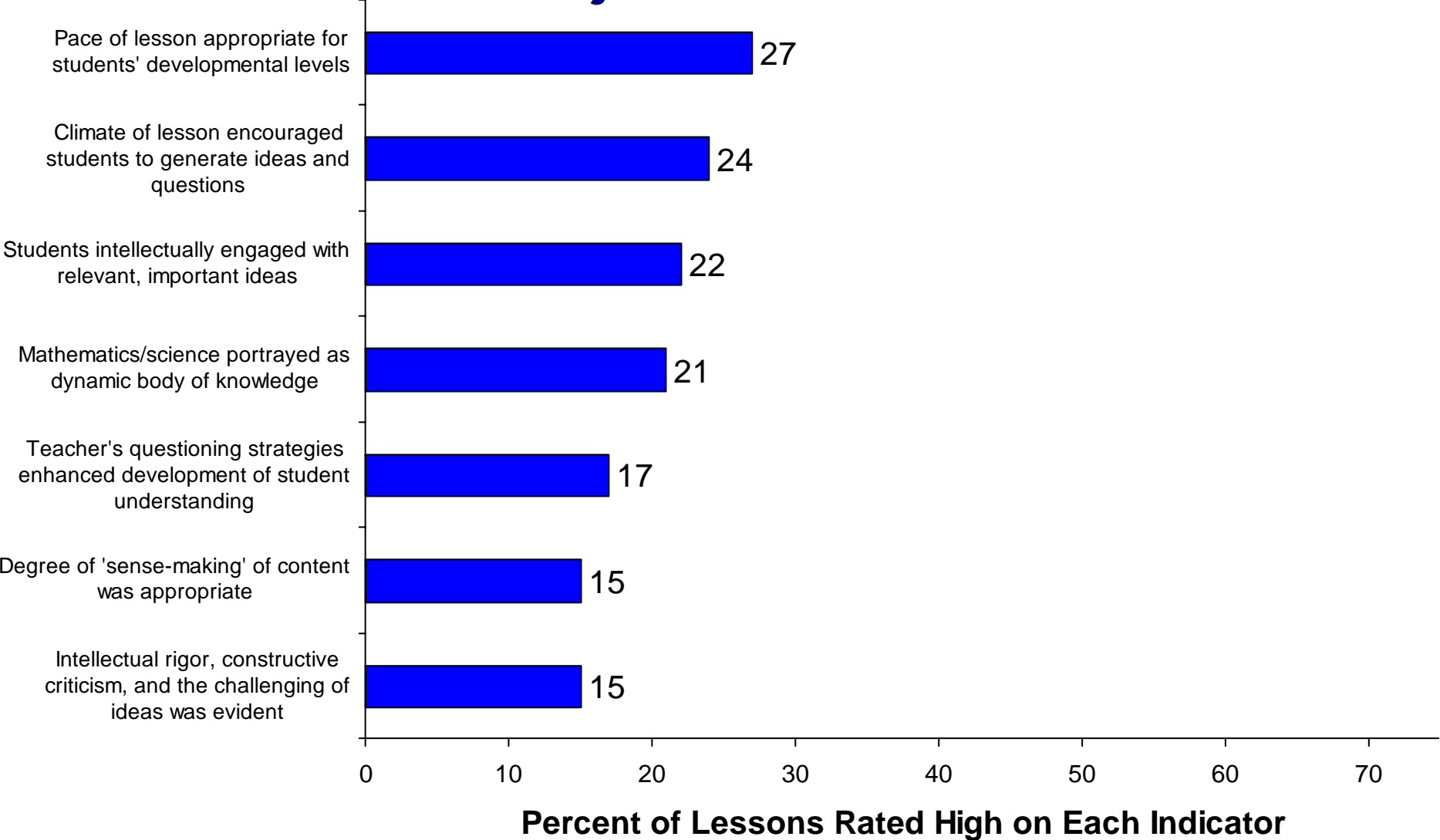
Capsule Ratings: K-12 Mathematics and Science Lessons



Inside the Classroom National Observation Study Relative Strengths




Inside the Classroom National Observation Study Major Weaknesses



Key Elements of High Quality Instruction

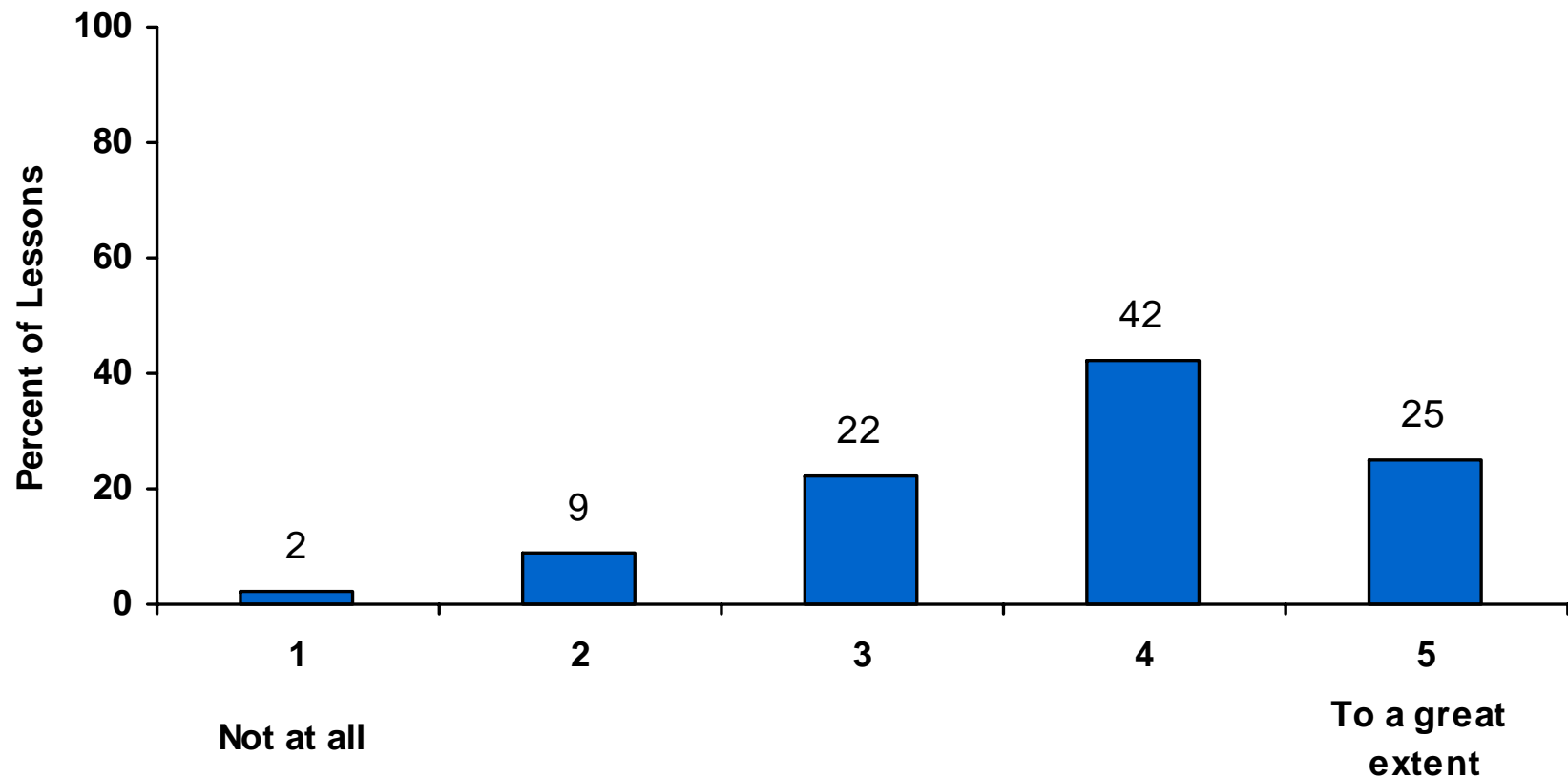
- Engage students with the mathematics/science content;
- Create an environment conducive to learning;
- Ensure access for all students;
- Use questioning to monitor and promote understanding; and
- Help students make sense of the mathematics/science content.



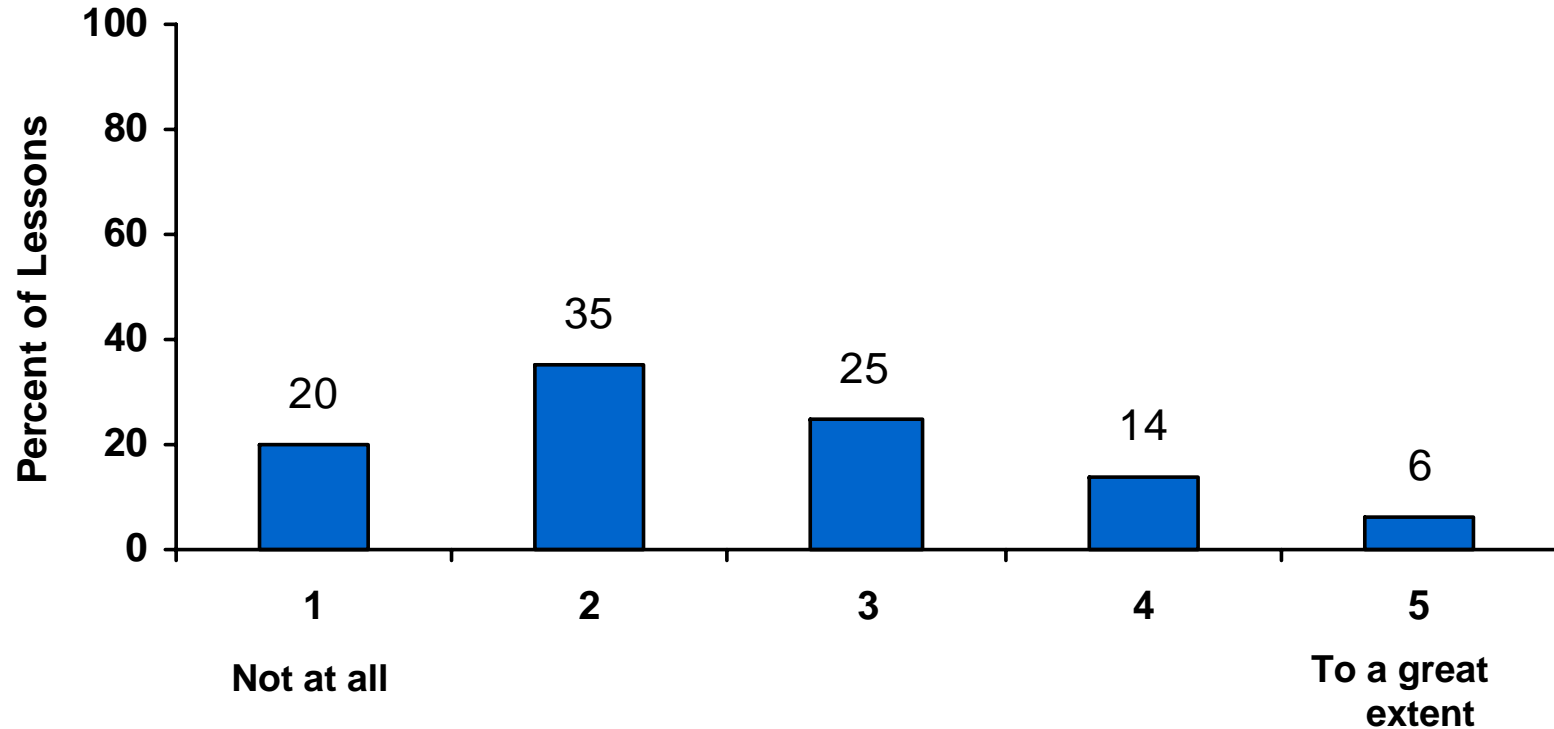
Engaging Students With Mathematics/Science Content

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Mathematics/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 117 in your textbook
- We're at IV.B. 2a in your lecture notes outline
- Today we're doing activity 12; get your materials and begin working in your table groups.

In Contrast:

- As an introduction to the relationship between form and function in living things, the teacher in a 4th grade science class handed out a tail feather and a magnifying glass to each pair of students, and asked them 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.

- The teacher started a mathematics lesson in a 3rd grade class by anchoring the content in the students' prior work with graphs, and then moved quickly to comparing the coordinate system to mapping and directions. To help make the comparison more real, she asked the students to close their eyes and began to talk through an example to show how following specific directions lead to an exact spot. She stated: "Go out this door. Turn right. Go through the double set of doors. Go a few feet further. Whose room is to the right?" The class in unison called out the name of the teacher who teaches in that room.

Portraying Mathematics/Science as a Dynamic Body of Knowledge


Not!!

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."

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In Contrast:

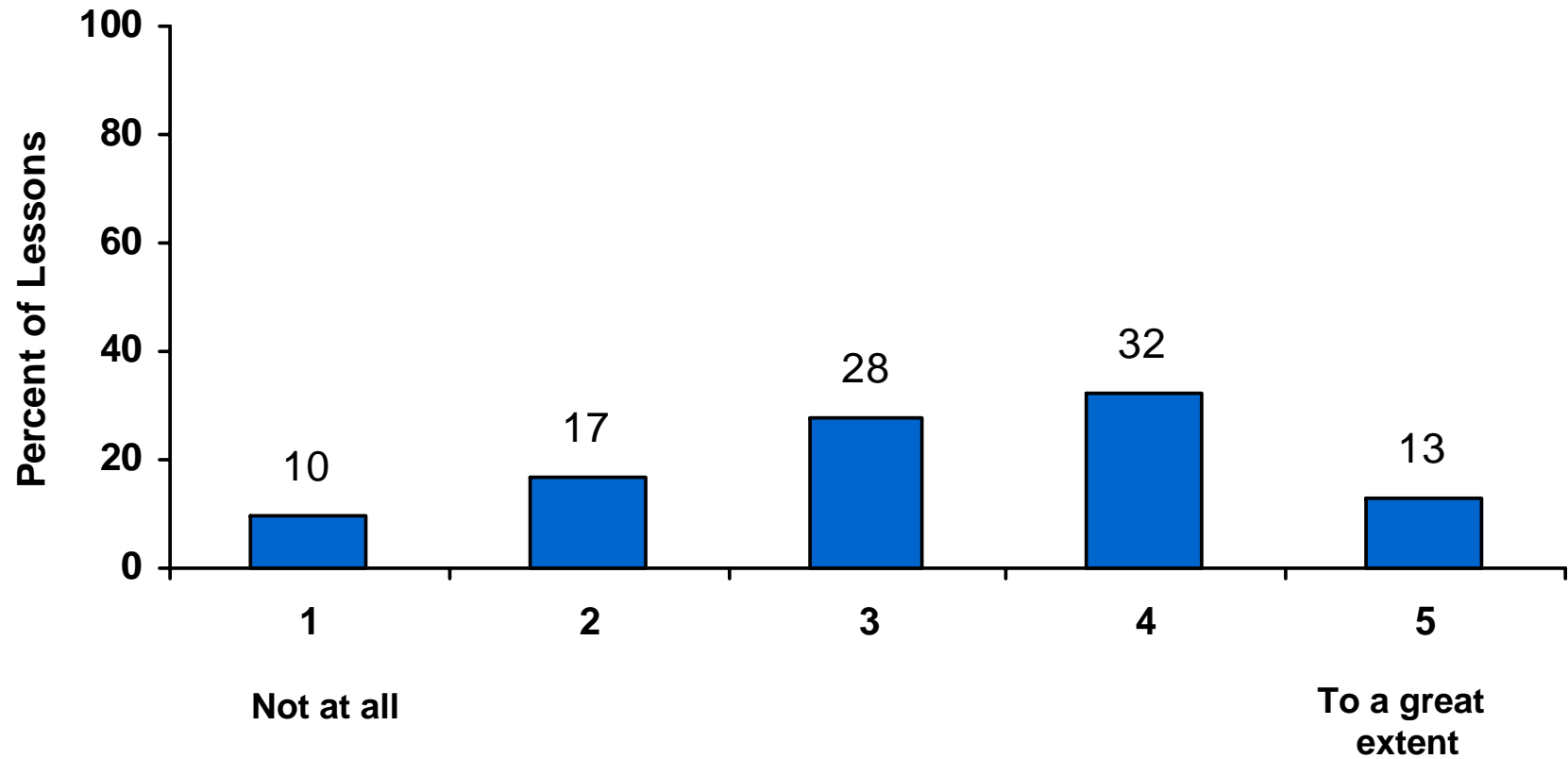
A 6th grade science lesson consisted of a teacher-led discussion of the process of sedimentary rock formation. By drawing upon the experiences and prior knowledge of the students, the teacher helped the students devise a model of how sedimentary rock is formed. For example, the teacher asked students, 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.



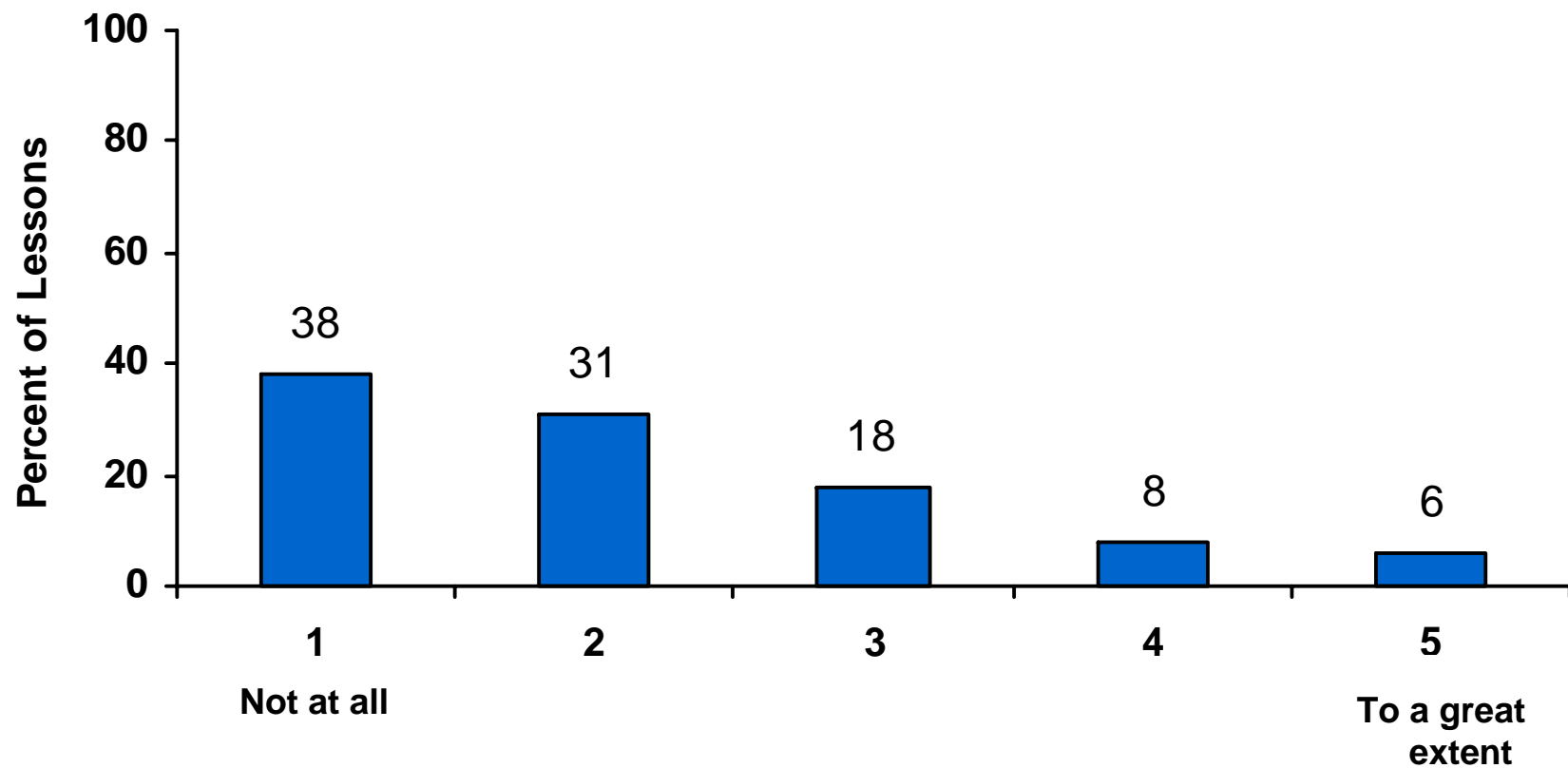
Creating an Environment Conducive to Learning

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



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



Cross Tabulation of Climate of Respect and Intellectual Rigor

		Percent of Lessons		
		Intellectual Rigor, Constructive Criticism, and Challenging of Ideas Are Evident		
		Low	Medium	High
Climate of Respect for Students' Ideas, Questions, and Contributions	Low	26	1	0
	Medium	24	3	1
	High	17	14	13

Respectful and Rigorous


- Students in a high school geometry class were clearly comfortable participating and going to the board to work on problems. Said the observer: "The teacher called on volunteers as well as non-volunteers, and the teacher and students were respectful of each other's thoughts. One particular example that stands out was when a student offered an answer that was slightly off-base and confusing to many others in the class. The teacher responded with, 'Right idea, let's clean it up a bit.' The class remained supportive as students offered suggestions for ways to clean the answer up, building on the first student's answer rather than totally dismissing it. Although the work on the board was to be individually completed, the culture was such that students assisted, and benefited, from their neighbors. The rigor of this lesson was very high, and most of the teacher's questions caused students to really think about the mathematics. The teacher seemed able to relate to the students, and overall the classroom seemed to be a good environment in which to learn."

Respectful, But Lacking in Rigor

- 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

- The observer of a 9th grade Pre-Algebra class reported that comments like “Stop talking,” “Settle down,” and “Am I disturbing you or something?” were used to interact with students throughout the lesson. “The teacher focused less on participation and more on control....There was no rigor and no opportunities for trying to talk about or make sense of any ideas. ...The teacher did not seem to trust the students to do the computations in their heads—at four times during the lesson he told them to use the calculators and not to trust their own thinking.”



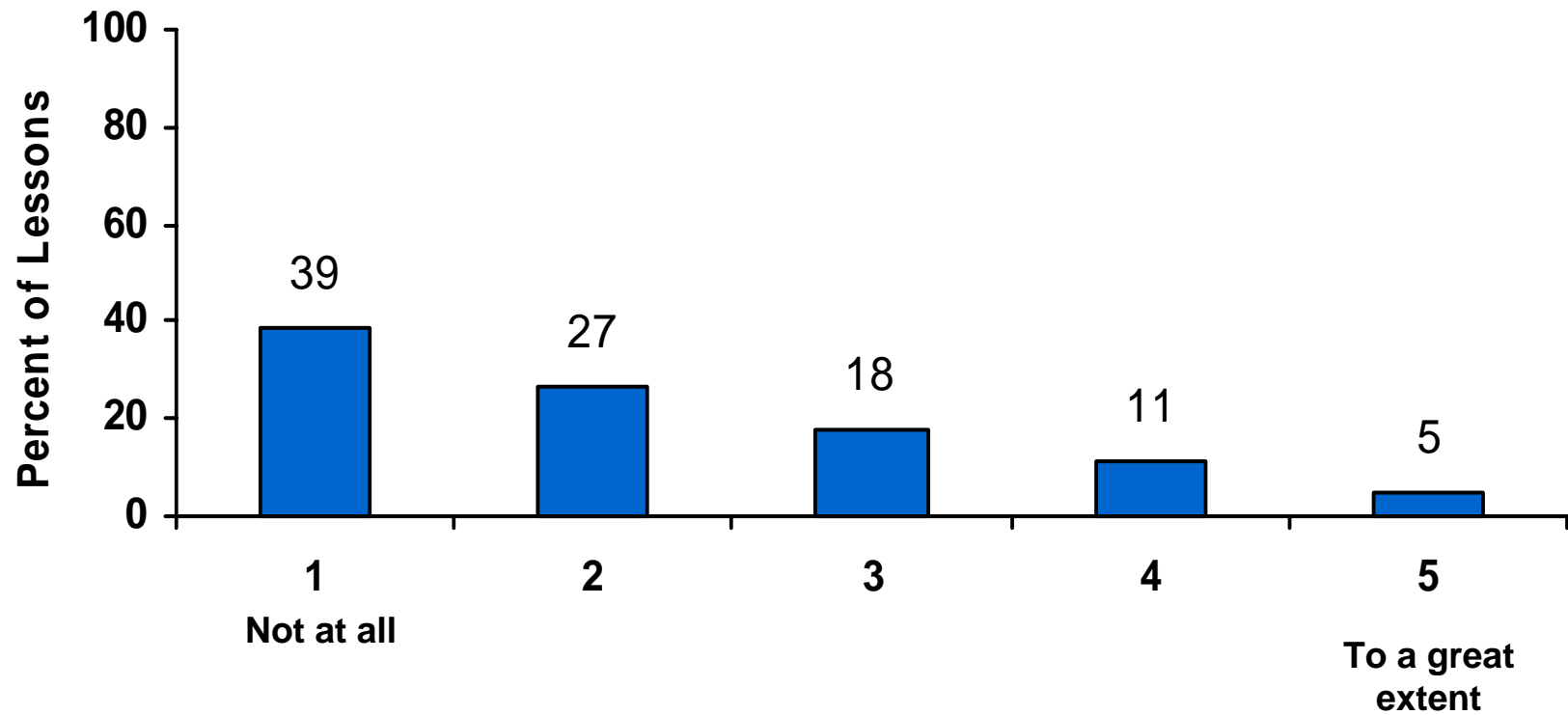
Helping Students Make Sense of the Mathematics/Science Content

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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”

The observer reported that questions asked of students in a 12th grade mathematics class tended to be low-level and leading. The students were given the following system of equations:

$$\begin{aligned}6x + 5y &= -2 \\5x - 4y &= 31\end{aligned}$$

The following "discussion" occurred:

Teacher: "What do we want?"

Students: "x and y"


Teacher: "What do I need to do to get x and y?"

Students: "Get rid of the first matrix."

Teacher: "What do I need to do to get rid of it?"

Students: "Multiply by the inverse."


Said the observer, "discussions during this lesson were much more about identifying steps to do than about justifying the steps by considering conceptual underpinnings."



Sometimes teachers
answer their own
questions

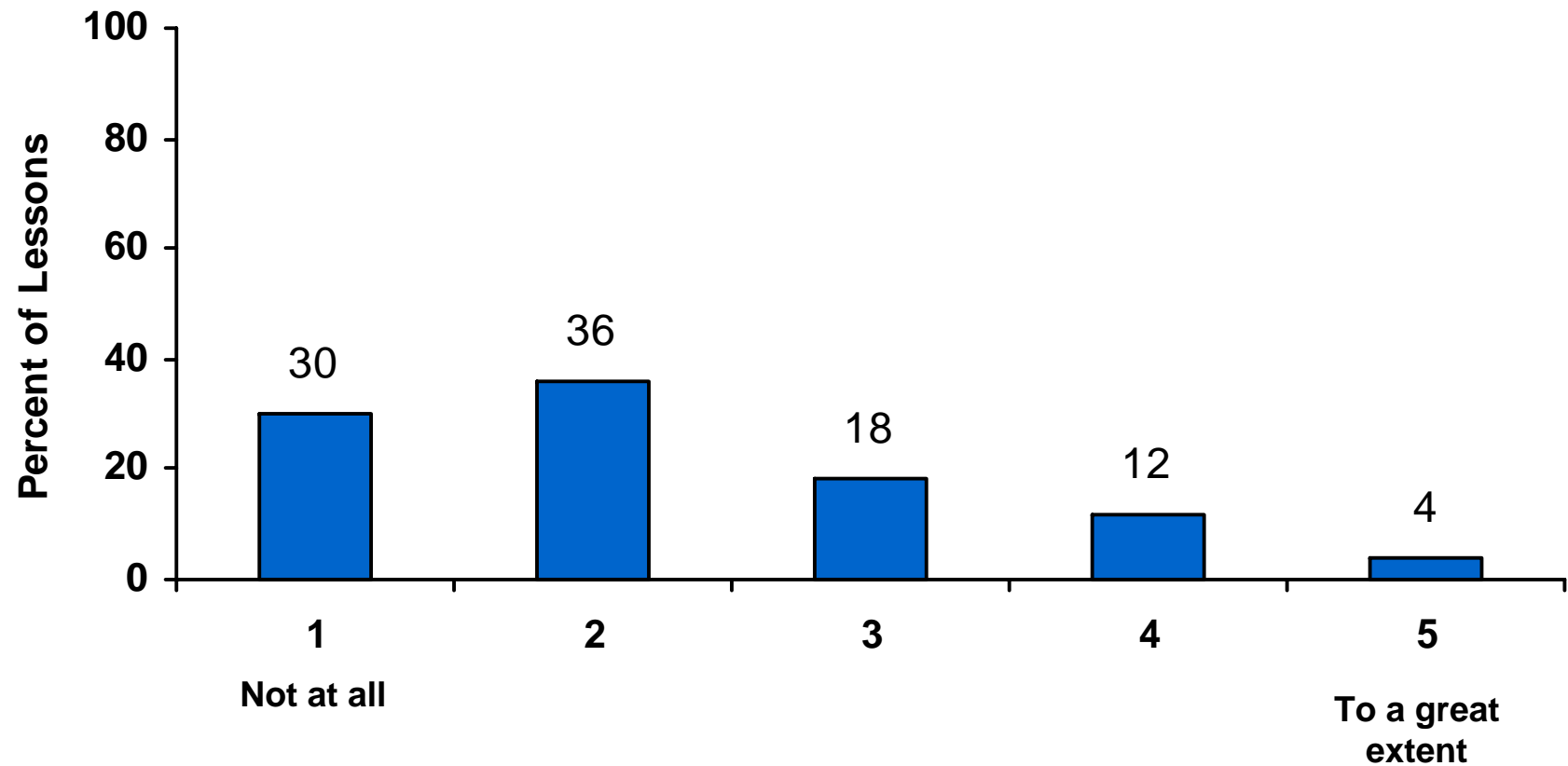
In Contrast:

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?"



Inadequate attention to “sense-making”

Degree of Sense-Making Is Appropriate for This Lesson



The purpose of a 4th grade mathematics lesson was to extend the students' knowledge to multiplying single-digit numbers by dollar and cents amounts, e.g., $\$3.42 \times 7$. The teacher indicated that she wanted "to get students used to using decimal points and dollar signs." As students completed problems on the board, she would answer with a simple, "Correct" or ask questions to guide them to their errors such as, "Where's your decimal" and "What's 6 times 3 plus 3?" Students would hurriedly correct their work and upon receiving the confirmation that the work was correct, erase it immediately. Very few of the seated students had the opportunity to even see the work of the students at the board. The teacher sought no input from the students in terms of pointing out others' errors and seemed to be only interested in the correct answer.

In Contrast:

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.

Closing Thoughts on Mathematics/Science Instruction Piece

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

<http://www.horizon-research.com/insidetheclassroom/reports/>

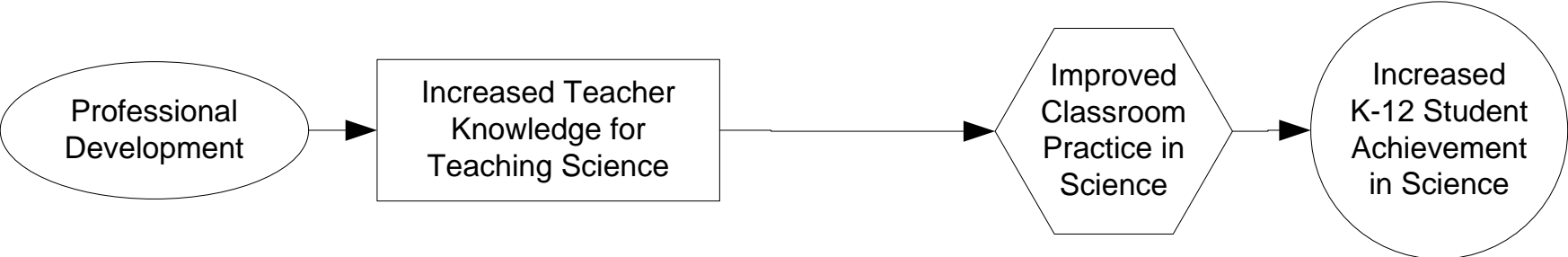
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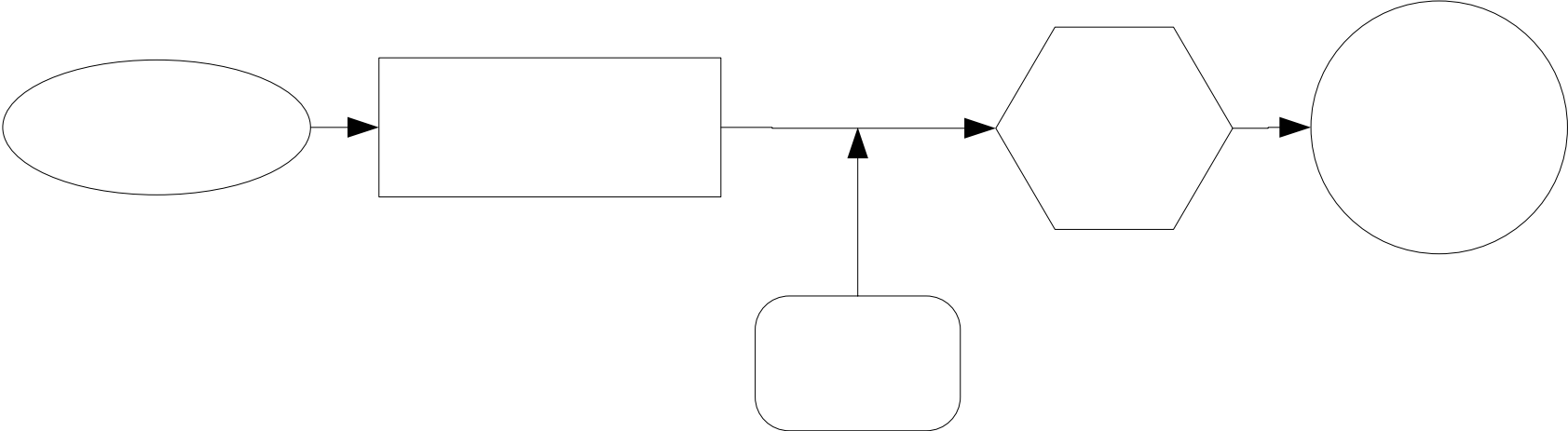
Comments? Questions?

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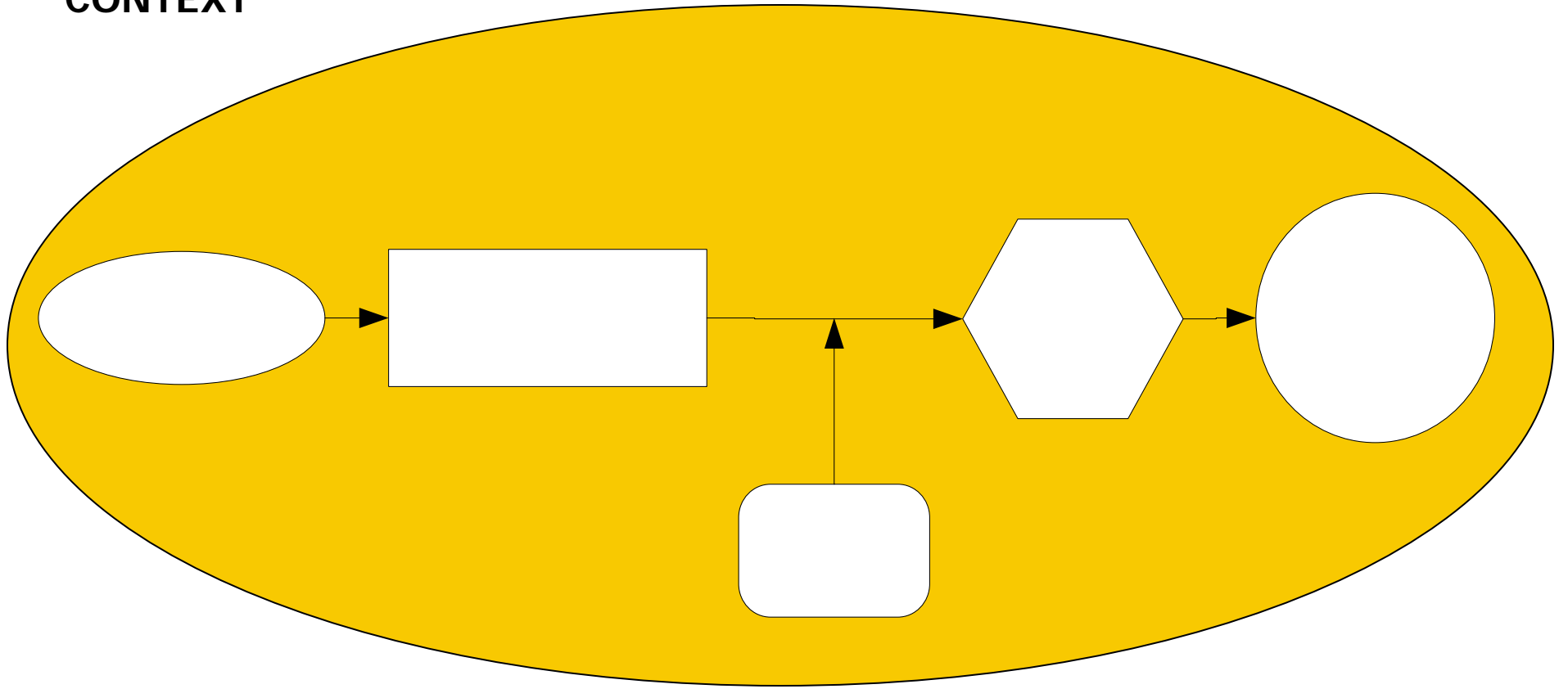
Part II

What do we know
about effective
professional
development?





CONTEXT



Two key questions about Professional Development

- What knowledge and skills do teachers need for effective classroom practice?
- What types of professional development meet teachers' learning needs to create the necessary knowledge and skills, facilitate their transfer to classroom instruction, and result in improved student learning?

Writing about reform professional development:
“These principles and beliefs seem reasonable. Yet we know as little about what teachers learn in these kinds of forums as we do about what teachers learn in traditional staff development and in-service. Our readiness to embrace these new principles may, in fact, be rooted in a desire to escape collective bad memories of drab professional development workshops rather than in sound empirical work. But replacing our old conceptions of professional development with new makes sense only if the new ideas are held up for rigorous discussion and evaluation. New is not always right.” (Wilson and Berne, 1999)

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Professional Development: The Consensus View (Elmore, 2002)

- Focuses on a well-articulated mission or purpose anchored in student learning of core disciplines and skills
- Derives from analysis of student learning of specific content in a specific setting
- Focuses on specific issues of curriculum and pedagogy
 - Derived from research and exemplary practice
 - Connected with specific issues of instruction and student learning of academic disciplines and skills in the context of actual classrooms

- Embodies a clearly articulated theory or model of adult learning
- Develops, reinforces, and sustains group work
 - Collaborative practice within schools
 - Networks across schools
- Involves active participation of school leaders and staff
- Sustains focus over time—continuous improvement

- Models effective practice
 - Delivered in schools and classrooms
 - Practice is consistent with message
- Uses assessment and evaluation
 - Active monitoring of student learning
 - Feedback on teacher learning and practice

Local Systemic Change (LSC) Projects

- Designated instructional materials
- 130 hours of professional development
- Target all teachers, not just volunteers
- Address the “system” constraints and incentives

When we go into classrooms: how deep are changes in practice?

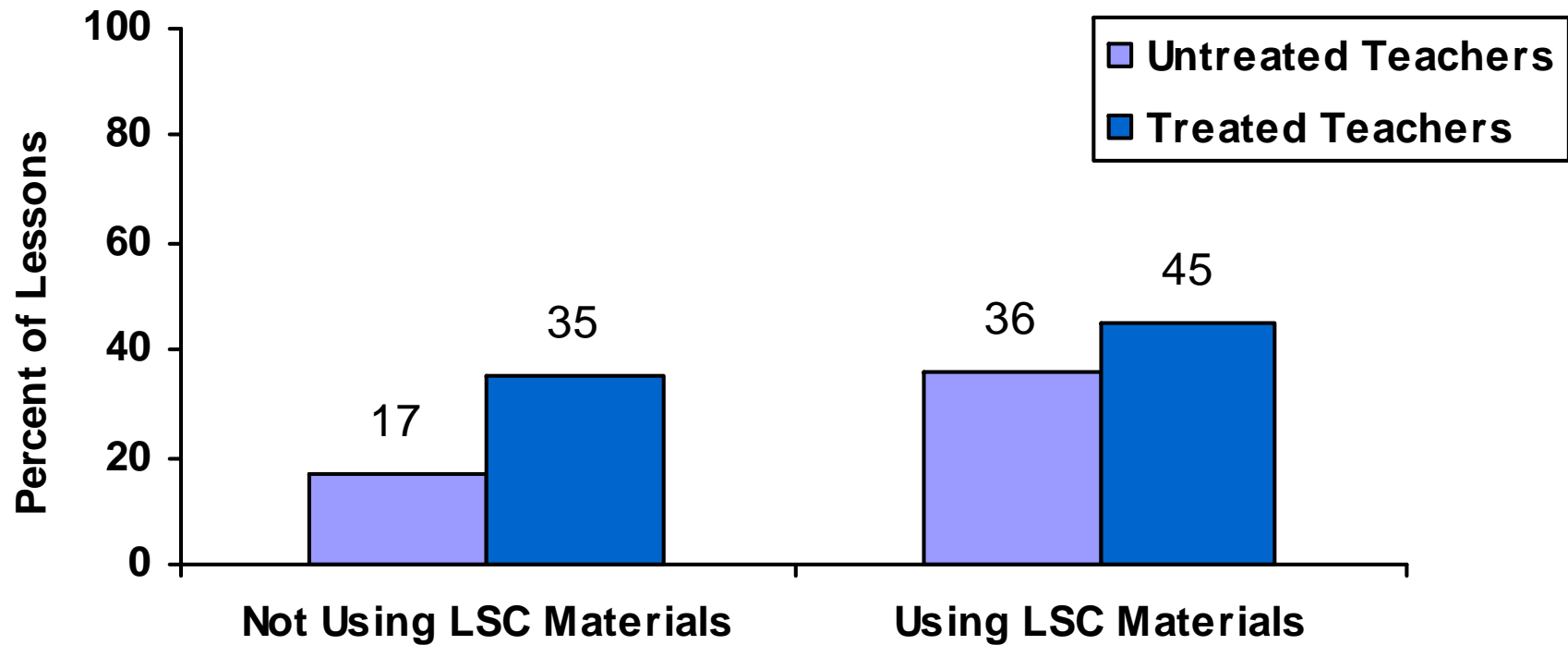
- Lessons taught by teachers using standards-based instructional materials, with PD on those materials, incorporated some specific strategies from PD.
- But PIs reported that even these lessons typically fell short of current vision on areas such as the use of higher order questioning, and making sense of data.

(Pasley, 2002)

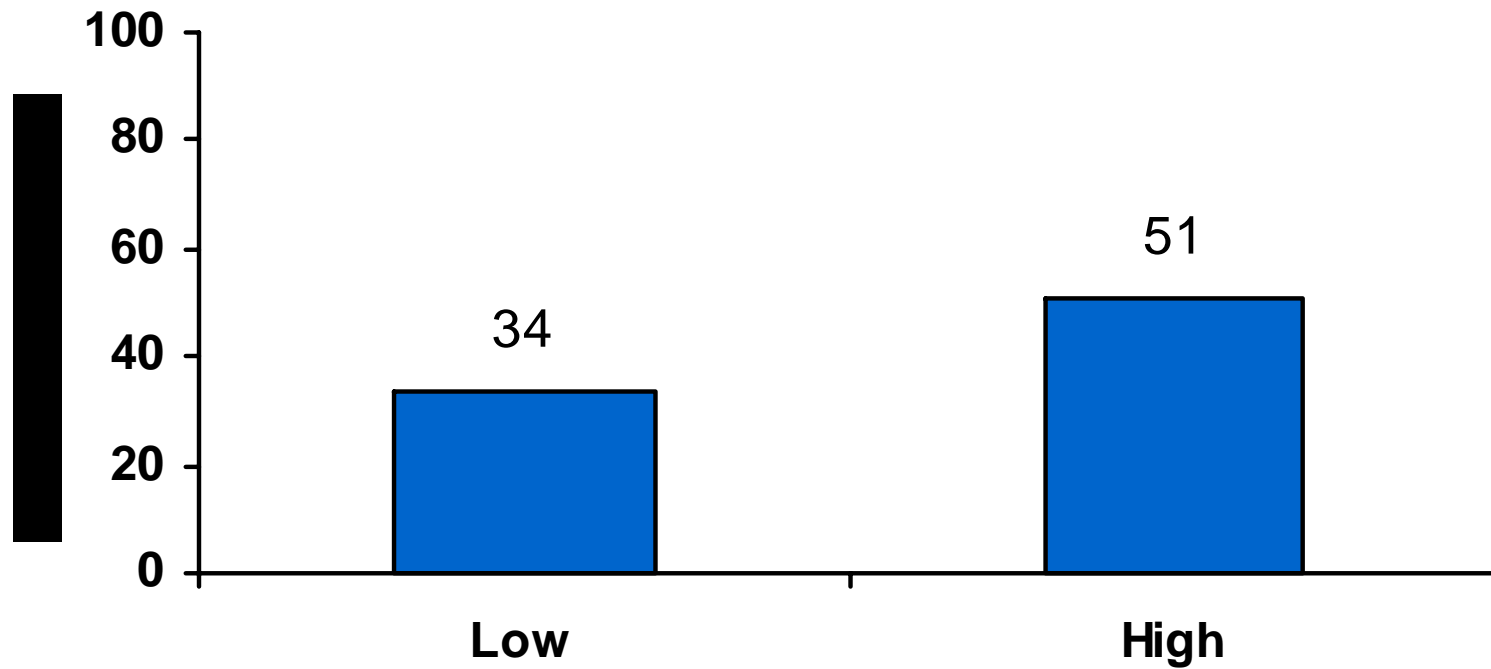
"In all three lessons observed, teachers did not demonstrate that they understood the content or how the concepts in the lessons they were teaching fit into the concepts in the unit. They tended to zero in on the minutiae of a particular lesson and apparently did not recognize how the lessons fit into the bigger picture of the unit.

The issues demonstrated in the observations are difficult to address within the format of the professional development program. Teachers need to change their perceptions of themselves as teachers, their own ideas of learning, and their understanding of how students learn mathematics."

Highly-Rated Lessons, by Use of LSC-Designated Materials and Treatment



Highly-Rated Lessons, by Adherence to LSC-Designated Materials





Mechanical Use

Creative Use

Purposeful Use

TE-MAT

Teacher Education Materials Project


WWW.TE-MAT.ORG



An online database of reviews of
materials for K-12 mathematics and
science professional development

providers

National Science Foundation Grant
#: ESI 9619139



www.te-mat.org

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Closing Thoughts on Professional Development

Professional development needs to be designed to achieve a particular purpose or set of purposes

Coherence doesn't happen by accident

- Need to look at articulation, K–12
- Need to help teachers understand the mathematics and science big ideas AND how the student activities relate to those ideas
- Professional development is easier when all of the teachers at a grade level (or in a course) are using the same instructional materials
- Need to provide incentives for teachers to engage in long-term professional development aligned with their needs
- Need to make sure principals share (and support) the same vision of effective mathematics/science teaching



Comments? Questions?

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