

Development and Use of Content-Specific
Assessments of Teacher Knowledge
-or-
How Do You Know If They're Learning What
You Want Them to Learn?

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Horizon Research, Inc.

Workshop for State Leaders and Evaluators of Teacher
Professional Development

April 25, 2008

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Session Overview

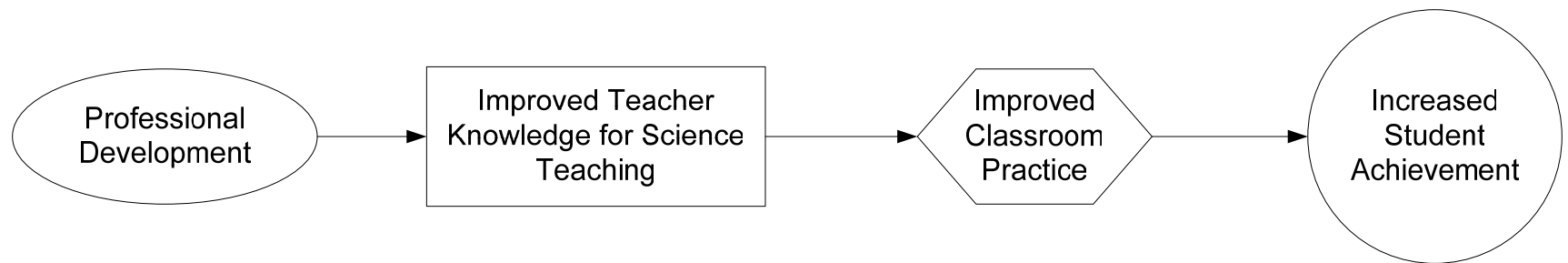
- Orienting to the work
- Assessments in mathematics
- Assessments in science
- Question-and-answer



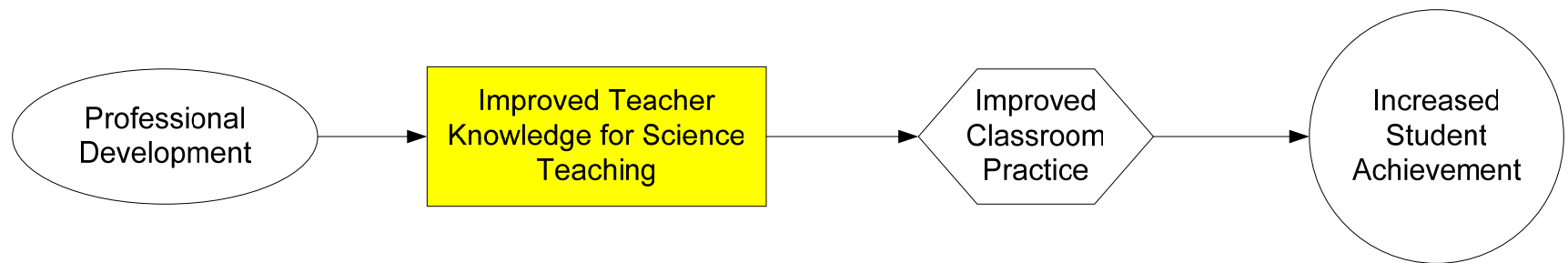
Orienting

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The PD Logic Model

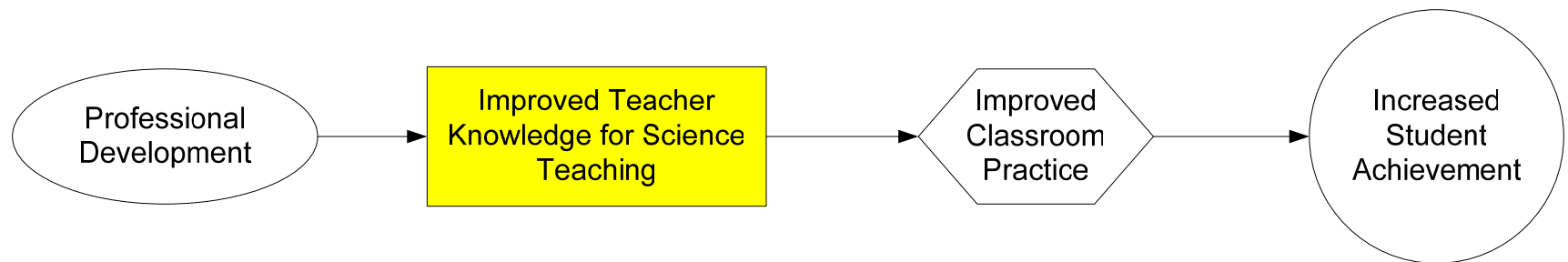


The PD Logic Model



The Problem

Dissatisfaction with what we know about impacts on teacher content knowledge



Why is Assessing Teacher Learning Hard?

- Lack of well-established instruments
- Professional development culture
- Lack of agreement on what “it” is

Domains of Teacher Knowledge

- Disciplinary content knowledge
- Representing ideas
- Student thinking about the content
- Strategies to diagnose the thinking of a particular group of students
- Sequencing ideas for students
- Content-specific strategies that move students' thinking forward



What's Available

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Existing Tools: Mathematics

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Learning Mathematics for Teaching (LMT)

Assessments for elementary and middle grades teachers

- Content Scales:
 - Number and operations
 - Patterns, functions, and algebra
 - Geometry
- Knowledge domains:
 - Specialized content knowledge
 - Knowledge of content and students
 - Knowledge of content and teaching
- Each scale has a pool of multiple choice items
- For more information:
<http://sitemaker.umich.edu/lmt/home>

Learning Mathematics for Teaching

Sample Items

Specialized Content Knowledge (Division)
Knowledge of Content and Students
(Multiplication)

Knowing Division

What is $2 \div 2/3$?

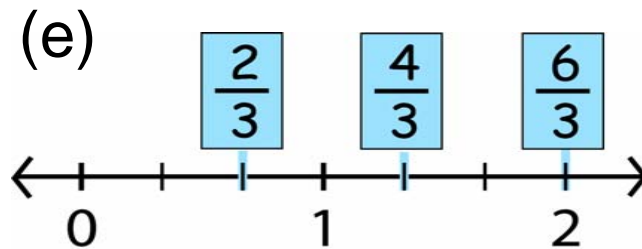
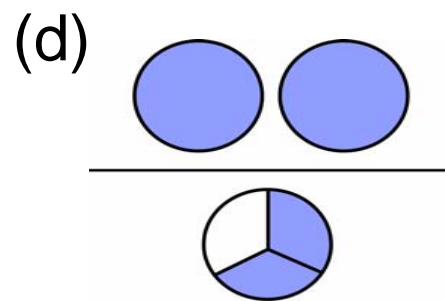
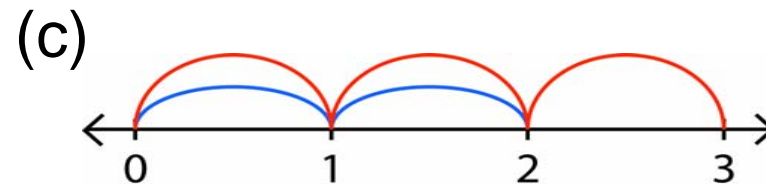
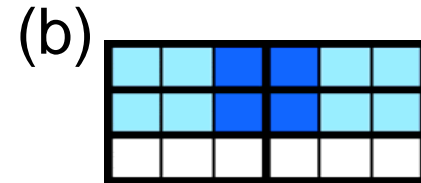
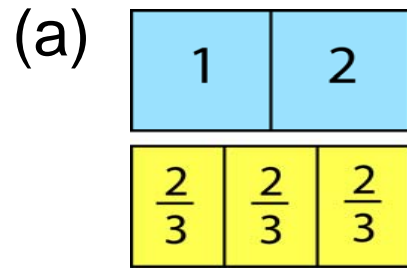
- (a) $4/3$
- (b) $1/3$
- (c) 3
- (d) $2/3$



Sample LMT Items

Knowing Division for Teaching

Which of the following can be used to represent $2 \div \frac{2}{3}$?



Knowing Multiplication

$$\begin{array}{r} \text{Multiply:} \quad 49 \\ \quad \quad \quad \times 25 \\ \hline \end{array}$$



Sample LMT Item

Knowing Multiplication for Teaching

How was each answer produced?

What might lead a student to make these errors?

(a)

$$\begin{array}{r} 49 \\ \times 25 \\ \hline 405 \\ 108 \\ \hline 1485 \end{array}$$

(b)

$$\begin{array}{r} 49 \\ \times 25 \\ \hline 225 \\ 100 \\ \hline 325 \end{array}$$

(c)

$$\begin{array}{r} 49 \\ \times 25 \\ \hline 1250 \\ 25 \\ \hline 1275 \end{array}$$

Diagnostic Teacher Assessments in Mathematics and Science

- Assessments for elementary and middle grades teachers
- Content scales:
 - Number/computation
 - Geometry/measurement
 - Probability/statistics
 - Algebra
- Knowledge types:
 - Type I-Rote memory
 - Type II-Conceptual understanding
 - Type III-Problem solving/reasoning
 - Type IV-Mathematics knowledge for teaching
- Each form has 20 items, 10 multiple choice, 10 open-ended
- For more information: <http://louisville.edu/edu/crmstd/>

Diagnostic Teacher Assessments in Mathematics and Science

Sample Mathematics Items

Conceptual Understanding
(Number/computation)

Mathematics Knowledge for Teaching
(Probability/statistics)

Sample DTAMS Item

Conceptual Understanding

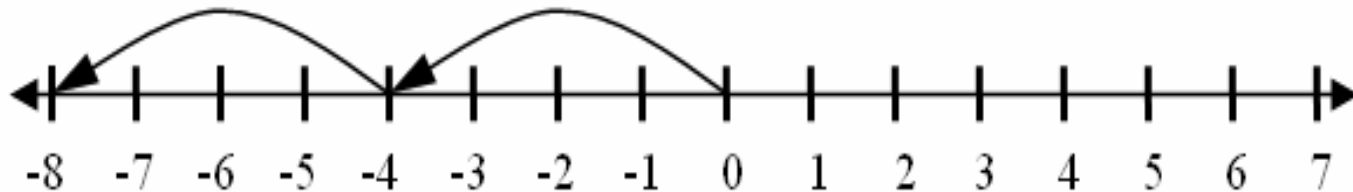
The drawing below best represents which of the following expressions?

a. -4×-2

b. 4×-2

c. 2×-4

d. -4×2



Sample DTAMS Item

Mathematics Knowledge for Teaching

You are demonstrating a probabilistic event to third-grade students. You use a spinner to determine the choice of two colors, red or green. The students record the outcomes of 11 spins. Each time, the pointer landed on **green**.

How would you explain this outcome to the students?

Knowledge of Algebra for Teaching

- Assessments for teachers of algebra
- Content scales:
 - Expressions, Equations, and Inequalities
 - Functions and their Properties: Linear and Non-linear
- Algebra knowledge for teaching:
 - Knowledge of school algebra
 - Advanced knowledge of mathematics
 - Teaching knowledge
- Just completed analysis of validation study of two parallel forms
- For more information:
<http://www.msu.edu/~kat/index.htm>

Knowledge of Algebra for Teaching

Sample Items

Advanced Knowledge of Mathematics

Teaching Knowledge

Sample KAT Item

Advanced Knowledge of Mathematics

For which of the following sets S is the following statement true?

For all a and b in S , if $ab = 0$, then either $a = 0$ or $b = 0$.

- i. the set of real numbers
- ii. the set of complex numbers
- iii. the set of integers mod 6
- iv. the set of integers mod 5
- v. the set of 2×2 matrices with real number entries

A. i only

B. i and ii only

C. i, ii and iv only

D. i, ii, iii and iv only

E. i, ii, iii, iv, and v



Sample KAT Item

Teaching Knowledge

A student solved the equation

$$3(n - 7) = 4 - n$$

and obtained the solution $n = 2.75$.

What might the student have done wrong?



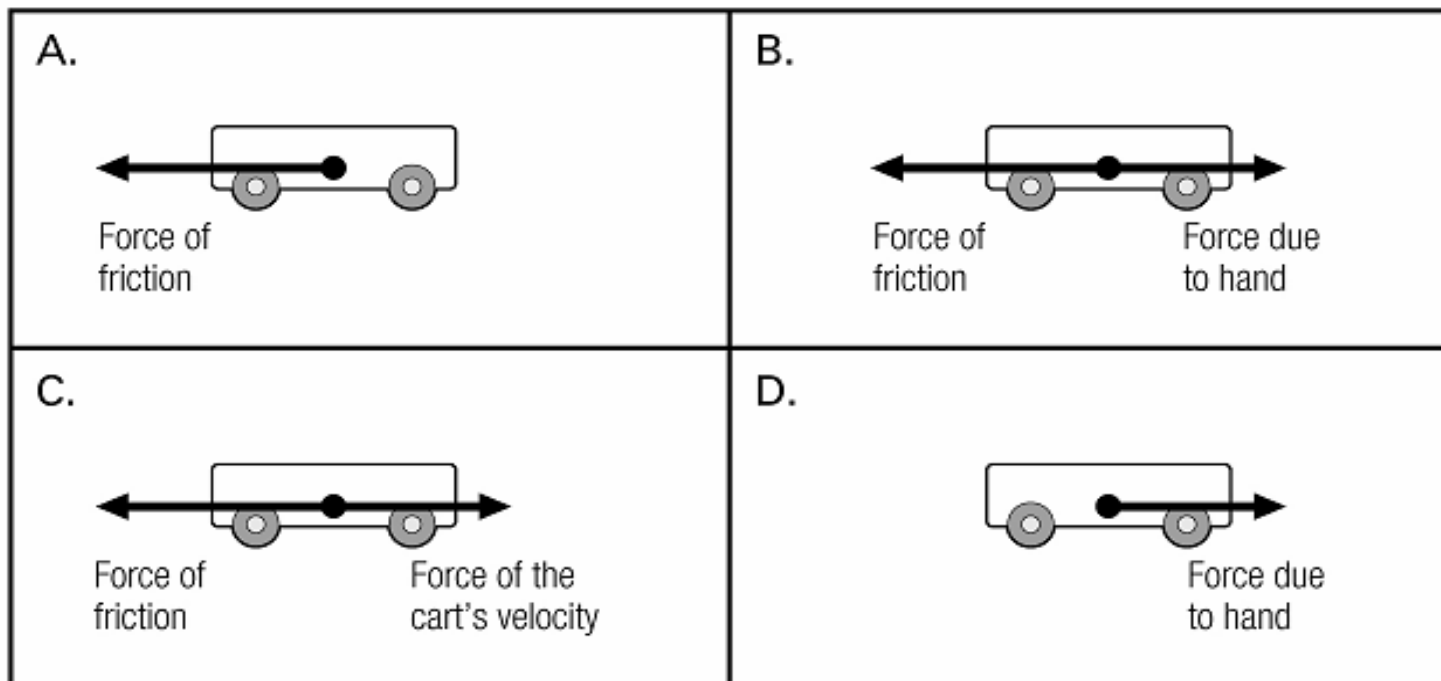


Existing Tools: Science

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In a unit on force and motion, students have been pushing small carts across their tables to the right and observing the motion. The teacher asks the students to draw a diagram showing all the **horizontal** forces on a cart once it leaves the student's hand and is rolling across the table. (A)

Which one of the following force diagrams is correct?



Domains of Teacher Knowledge

- Disciplinary content knowledge
- Representing ideas
- Student thinking about the content
- Strategies to diagnose the thinking of a particular group of students
- Sequencing ideas for students
- Content-specific strategies that move students' thinking forward

Diagnostic Teacher Assessments in Mathematics and Science

- Assessments in life, earth, and physical science (one in each area) for middle grades teachers
- Knowledge domains:
 - declarative knowledge
 - scientific inquiry and procedures
 - schematic knowledge
 - pedagogical content knowledge (PCK)
 - science, technology, and society knowledge
- Each form has 20 multiple choice and 5 open-ended
- Straight content (except for PCK)
- Available on fee basis; \$7 per teacher for scoring
- Contact Bill Bush at U of L: bill.bush@louisville.edu
http://louisville.edu/edu/crmstd/diag_sci_assess_middle_teachers.html

Sample Items

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Sample Multiple Choice Item

If a constant net force greater than zero is applied to a ball, what would you observe?

- A. Not much, because a “net” force is always weak.
- B. The ball will go at a constant speed in a straight line.
- C. The ball speeds up, slows down, or changes direction.**
- D. The ball will eventually explode or disintegrate.

Sample Open-ended Item

After a lab that involved magnetism and compasses, a student writes that a magnet can't function on the Moon because there are no magnetic poles on the Moon as there are on Earth. Identify this student's misconception and describe an appropriate strategy to counteract this misconception.

MOSART: Misconception Oriented Standards-based Assessment Resource for Teachers

(NSF Grant No. 0412382)

- Over 1,000 items on K-12 earth science and physical science content
- Distractors based on published misconceptions
- Each test is 20 m-c items
- Same tests for teachers and students
- Available at no cost
- Contact Phil Sadler

http://www.cfa.harvard.edu/smgphp/mosart/about_mosart.html

MOSART Tests

K-4 Physical Science

K-4 Earth Science

K-4 Astronomy/Space Science

5-8 Physical Science

5-8 Earth Science

5-8 Astronomy/Space Science

9-12 Chemistry

9-12 Physics

9-12 Earth Science

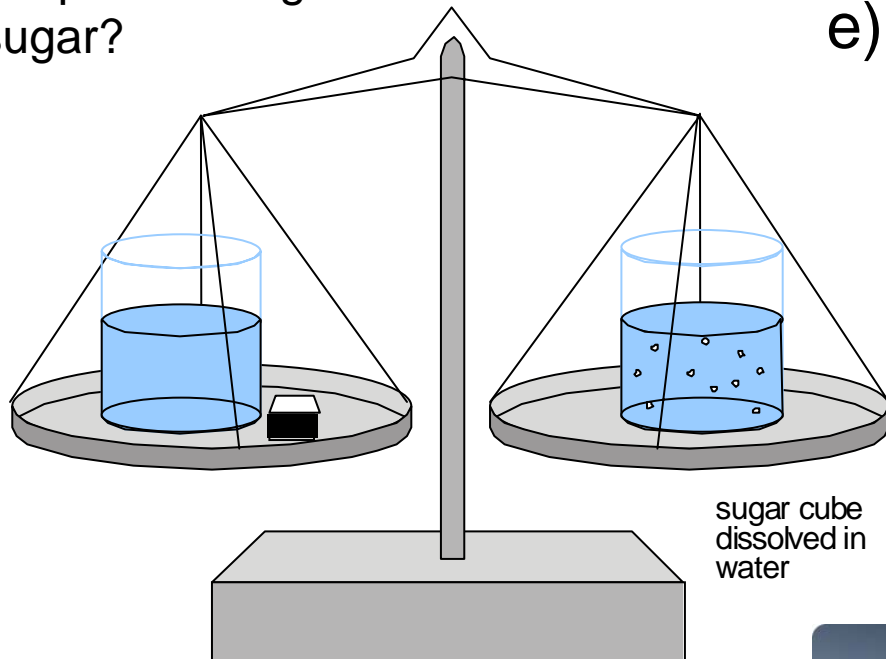
9-12 Astronomy/Space Science

Sample Item

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Which answers do your Middle School students give?

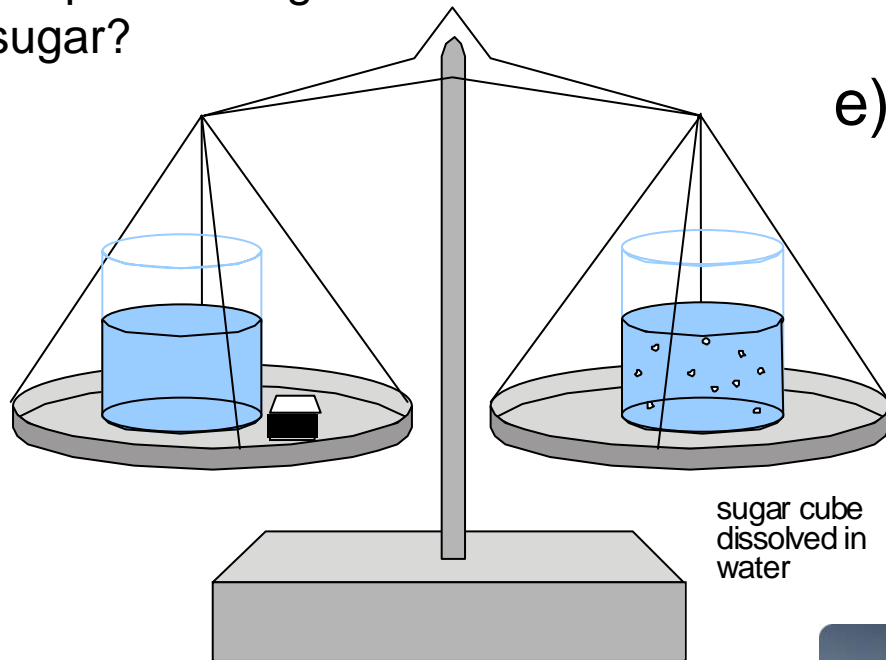
Sue balances a cup of water with a sugar cube outside the cup with another cup of water with a sugar cube in it on a scale. After the sugar cube dissolves, what will happen to the pan holding the dissolved sugar?



- a) Move up.
- b) Move down.
- c) First move up and then down.
- d) The pan will not move.
- e) There is not enough information to answer the question.

Answers after taking a MS Physical Science Course

Sue balances a cup of water with a sugar cube outside the cup with another cup of water with a sugar cube in it on a scale. After the sugar cube dissolves, what will happen to the pan holding the dissolved sugar?



- a) Move up. 28%
- b) Move down. 22%
- c) First move up and then down. 8%
- d) The pan will not move. 37%
- e) There is not enough information to answer the question. 6%



ATLAST

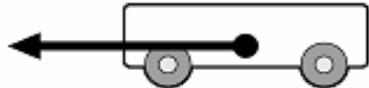



Assessing Teacher Learning About
Science Teaching

(NSF Grant No. 0335328)

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In a unit on force and motion, students have been pushing small carts across their tables to the right and observing the motion. The teacher asks the students to draw a diagram showing all the **horizontal** forces on a cart once it leaves the student's hand and is rolling across the table. (A)

Which one of the following force diagrams is correct?

<p>A.</p>  <p>Force of friction</p>	<p>B.</p>  <p>Force of friction</p> <p>Force due to hand</p>
<p>C.</p>  <p>Force of friction</p> <p>Force of the cart's velocity</p>	<p>D.</p>  <p>Force due to hand</p>

Common Features of All Items

- All are multiple choice
- All are keyed to a specific idea⇒
- All are set in the context of work that teachers do⇒

Target Ideas for Cart Item

1. A force is a push or pull interaction between two objects, and has both strength and direction.
2. The force of friction acts to oppose an object's motion. ⇨



Sample Items

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In a lesson on plant growth, a teacher is discussing plants' use of light energy from the Sun. During the discussion, one student says, "Plants need the light to grow, but they don't change the light at all. It's like when you're reading a book, and you need the light to help you read."

Which one of the following ideas about the role of light energy in photosynthesis does the student seem to be missing? (B) ⇨⇨

- A. Light energy is changed into sugars in the process of photosynthesis.
- B. Light energy is changed into another form of energy in the process of photosynthesis.
- C. Light energy is the energy source for the process of photosynthesis.
- D. None. The student seems to have an accurate understanding of the role of light energy in the process of photosynthesis.

Level 2 Item Features

- Address teachers' ability to analyze student thinking *using science content knowledge* ⇒
- Cannot be answered without content knowledge
- Only one answer choice is “content-correct” *and* relevant to the instructional context
- Fairly high cognitive load

Common Errors Made With Level 2 Items⇒

- Teachers look for common student thinking rather than the thinking of *these* students
- Teachers look for a correct statement
- Teachers try to answer the student item
- Teachers look for familiar wording – e.g., “equal and opposite”
- Teachers need options that allow them to hold naïve conceptions

Sample Item

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In a class discussion, a teacher asks his students to describe Earth's plates. One student says, **"There are thousands of plates that are moving and causing changes to Earth's surface."**

Based on this statement, which one of the following should the teacher do next to further this student's understanding of Earth's plates? (B) ⇨⇨

- A. Discuss the types of geological features plate movement can cause.
- B. Have students outline the boundaries of the plates on a map.
- C. Introduce students to the specific ways in which plates move.
- D. Demonstrate how the plates move as a result of convection.

Level 3 Item Features ⇨

- Address teachers' ability to *make instructional decisions* using science content knowledge
- Cannot be answered without content knowledge
- Only one answer choice is “content-correct” *and* relevant to the instructional context
- High cognitive load

Common Errors Made With Level 3 Items ⇒

- Teachers see all activities/questions as “best”
 - Lack of content knowledge
 - High cognitive load
- Context is important
 - Focus on logistics
 - Unfamiliar scenario/equipment
- Teacher beliefs

Availability and Use

- Freely available
- Uses to date:
 - Pre-test only (needs assessment)
 - Pre-test, post-test
 - Pre-test, post-test, delayed post-test
 - Pre-test, post-test with control group



Development and Use of Content-Specific Assessments of Teacher Knowledge

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Discussion