Modification of Multiple-Choice Assessment Items Based on Student Feedback‡

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Abstract

Project 2061 is creating assessment items targeting the learning goals recommended by AAAS's *Benchmarks for Science Literacy* (BSL, 1993) and the NRC's *National Science Education Standards* (NSES, 1996). One of our topics is force and motion at the middle school level. Our item development process includes pilot testing and student interviews. We will describe how this feedback is used to modify the items. Examples will include modifications to vocabulary, context, and distractors. In addition we will describe the use of this feedback to modify item design tools.

Forces: Balanced/Unbalanced

Typical Item

An object is speeding up. Which of the following statements about the forces acting on the object is true?

A. Balanced forces are acting on the object.
*B. An unbalanced force is acting on the object in the direction of its motion.
C. An unbalanced force is acting on the object in the direction opposite to its motion.
D. No forces are acting on the object.

Student Feedback

25% of students think that speeding up/slowing down depends on whether the force is balanced/unbalanced.

"It is moving faster so it would have to be balanced forces."
"If the forces were balanced it would not be moving."
"If it was unbalanced it would slow down."

Modified Clarification Statement

The words "balanced" and "unbalanced" were added to the clarification, so that they could be used in assessment. The clarification statement now says,

"If an unbalanced force acts on an object in the direction of its motion, the object's speed will increase."

In addition, "unbalanced" and "balanced" are carefully defined via the following statements:

"Two forces acting on an object at the same time in opposite directions are equivalent to a single force that is weaker than the stronger of the two individual forces and in the same direction as the stronger of the individual forces. This single force is an unbalanced force."

"Two forces of the same strength acting on an object at the same time in opposite directions will cancel one another. In this case, the forces on the object are balanced."

Note that for assessment a maximum of two forces can act on an object at the same time, and the direction of each force must be along the object's line of motion.

Forces: "In Direction of Motion"

Typical Item

An object is moving. A force acts on the object in the direction of the object's motion. What will happen to the object's motion while this force acts?

A. The object's motion will depend on the type of force.
B. The object's speed will stay the same.
*C. The object will speed up.
D. The object will slow down.

Student Feedback

30% of students think that the force is coming from the direction of the object's motion.

"[The object won't speed up] because if it hit something it tends to slow down"
"It will not speed up because something is in its way preventing it from speeding up"
"If a force hits it from the way it's heading, the object would slow down, stop, or go the other way."

Modified Clarification Statement

To assess students' understanding of the direction of a force relative to the object's motion, the following sub-idea was added to the "Forces" key idea:

"If an object is initially at rest, and moves because it is pushed or pulled, the pushing or pulling force is in the same direction as the object's motion."

Vocabulary: "Diminishes"

Original Item

A ball is kicked straight up. The ball's speed decreases as it moves upward. Why does the ball's speed decrease?

A. Because the ball gets heavier as it gets farther away from the ground.
B. Because the force of the kick diminishes as the ball moves upward.
C. Because the force of the ball's motion decreases.
*D. Because the force of gravity is in the opposite direction to the ball's motion.

Student Feedback

42% of students indicated that they did not understand the word "diminishes."

Modified Item

Replace the word "diminishes" with "runs out," which is comprehensible and mimics misconception wording.

Mathematical Operations

Original Item

A person walks 5 miles in 2 hours. Which of these calculations gives the person's speed?

A. 2 hours divided by 5 miles
*B. 5 miles divided by 2 hours
C. 5 miles divided by 1 hour
D. 5 miles times 2 hours

Student Feedback

40% of students felt that choice A could not be correct because:

"You can't divide 2 by 5 without getting a negative number"
"5 can't go into 2"
"No if you divide 2 by 5 you would get an uneven number"

These students are rejecting the distractor for the wrong reason. This reduces the item's diagnostic value.

Modified Item

We will ask students to choose the value, not the calculation. We will test students to see if they will accept speeds less than 1 if presented as a fait accompli.

A person walks 5 miles in 2 hours. What is the person's speed?

A. 0.2 miles per hour
B. 0.4 miles per hour
*C. 2.5 miles per hour
D. 10 miles per hour

Modified Clarification Statement

New Sub-Idea for Key Idea "Motion"

"An object's speed can be calculated by dividing the distance it travels in a given time interval, by that time interval."

Vocabulary: Horizontal

Original Item

At an ice rink, a person hits a hockey puck with a hockey stick. What are the horizontal forces acting on the puck while it is touching the stick? Note: ignore friction and air resistance.

A. The force of the puck's motion
*B. The force of the stick
C. The force of the puck's motion and the force of the stick
D. There are no horizontal forces on the puck

Student Feedback

20% of students indicated that they did not understand the word "horizontal."

Modified Item

At an ice rink, a person is hitting a hockey puck with a hockey stick. Which of the following are forces acting on the puck while it is touching the stick?

A. The force of the puck's motion
*B. The force of the stick on the puck
C. Both the force of the puck's motion and the force of the stick on the puck
D. Neither the force of the puck's motion nor the force of the stick on the puck

Caveat

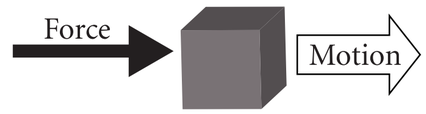
Though we removed the word "horizontal" from this item, we believe that assessment of middle school students should include the word "horizontal," and we may use it in other items.

NCTM's Principles and Standards for School Mathematics uses the words "horizontal" and "vertical" in the Geometry standard for grades 3-5.

Comprehensibility: Speed Table

Original Item

In the drawing below, the arrow labeled "FORCE" represents a force acting on an object. The length of the arrow represents the strength of the force, and the direction of the arrow shows the direction of the force. The arrow labeled "Motion" shows the direction of the object's motion.



Every second, starting when the clock reads "0 seconds," the speed of the object is measured. Which row of the table could be a correct representation of the object's speed between 0 seconds and 6 seconds?

Clock	0 sec	1 sec	2 sec	3 sec	4 sec	5 sec	6 sec
*Row A	10 mi/hr	11 mi/hr	12 mi/hr	13 mi/hr	14 mi/hr	15 mi/hr	16 mi/hr
Row B	10 mi/hr	10 mi/hr	10 mi/hr	10 mi/hr	10 mi/hr	10 mi/hr	10 mi/hr
Row C	10 mi/hr	10 mi/hr	10 mi/hr	13 mi/hr	13 mi/hr	13 mi/hr	13 mi/hr
Row D	10 mi/hr	11 mi/hr	12 mi/hr	13 mi/hr	12 mi/hr	11 mi/hr	10 mi/hr

Student Feedback

Pilot Testing

Across several different items, 25-30% of students indicated overall confusion. Sample reasons for confusion:

"All these rows and seconds."
"The speed chart."
"I don't know what you are referring to as a row."

Interviews

When the interviewer said to students, "First look at each row of the table and tell me what it means, then try to answer the question," students thought the item was straightforward.

Without that scaffolding, students were often confused.

Hypothesis

Students were overwhelmed by the amount of information in the table and did not try to understand it.

Solution

Guide students' eye along rows of table by shading alternate rows.
Use 12-hour time, rather than starting at arbitrary "0 seconds."
Record the speed every minute, rather than every second, to avoid confusion with m/s.

Modified Item (Modified Speed Table)

Speed of Object

Time	9:00 AM	9:01 AM	9:02 AM	9:03 AM	9:04 AM	9:05 AM	9:06 AM
Row A	10 m/s	11 m/s	12 m/s	13 m/s	14 m/s	15 m/s	16 m/s
Row B	10 m/s	10 m/s	10 m/s	10 m/s	10 m/s	10 m/s	10 m/s
Row C	10 m/s	10 m/s	10 m/s	11 m/s	12 m/s	12 m/s	12 m/s
Row D	10 m/s	11 m/s	12 m/s	13 m/s	12 m/s	11 m/s	10 m/s

Plausibility

Original Distractor (see original version of item above)

Row C	10	10	10	13	13	13	13

Student Feedback

Students rejected this distractor because the speed changed abruptly, and they thought this was implausible.

Desired reasoning: speed should change the entire time that the force acts (for this item, from 0 seconds to 6 seconds).

Modified Distractor

Speed changes for several seconds (so the choice is plausible), but not the entire 6 seconds (so the choice is still wrong).

Row C	10	10	10	11	12	12	12

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