Using Released Items from the Ohio Graduation Tests (OGT) as a Pre-Assessment

Purpose of Article

- Define preconceptions/misconceptions
- Provide examples of how students arrive at misconceptions
- Explain why teachers should pay attention to student preconceptions/misconceptions
- Provide one or two examples of OGT items that could be used to help uncover student preconceptions and misunderstandings
- Suggest a strategy for using OGT data at the district level as a starting point to uncover student preconceptions

Definition of Misconceptions and Preconceptions

Educational research literature contains a variety of terms to describe knowledge that learners bring to the learning environment. The term used by an author may depend upon when the research was accomplished, who did the research, and where the research occurred.

Concern has been expressed with using the term *misconception,* as the term itself may prejudice the researcher or teacher. Not all students' misconceptions are incorrect. Some are incomplete, some are alternative descriptions for natural events, and some are simply naïve.

For the purpose of this paper, the terms *misconceptions*, *preconceptions*, *alternative explanation, naïve theories, nonscientific beliefs,* and *mixed conceptions* will be interchangeable. The underlying meaning of these terms is that learners do not explain the natural world in a way that is congruent with our current scientific knowledge.

How Students Arrive at Misconceptions

> In contrast to the commonly held and outmoded view that young children are concrete and simplistic thinkers, the research evidence now shows that their thinking is surprisingly sophisticated. Important building blocks for learning science are in place before they enter school.
>
> Children entering school already have substantial knowledge of the natural world, which can be built on to develop their understanding of science concepts.

Taking Science to School: Learning and Teaching Science in Grades K-8; Committee on Science Learning, Kindergarten through Eighth Grade; Richard A. Duschl, Heidi A. Schweingruber, and Andrew W. Shouse, editors; National Academy of Sciences 2007; National Academies Press

Children learn science from everyday experience with the natural world that involves scientific principles. To illustrate this point, we will relate an experience with a five-year-old child. Alex believed that his toy cars could only go fast if he pushed them really hard. He believed that in order for them to complete a lap around the race track, he had to keep pushing them.

When asked what would happen if a hill was placed at the beginning of the race track, he was unsure, but he thought the car would fall some distance and then need to be pushed the rest of the way around the track. Through his experiences with the toy car and race track, Alex had begun to think of force as a push or pull. However, he seemed to think that continual force had to be applied to make the car go.

At age five, Alex is starting to develop his personal conceptual mental model for the science concepts addressed by Newton's three laws of motion. His view of force is not uncommon.

> Students believe constant speed needs some cause to sustain it. In addition, students believe that the amount of motion is proportional to the amount of force, that if a body is not moving there is no force acting on it; and that if a body is moving there is a force acting on it in the direction of the motion (Gunstone and Watts, 1985). Students also believe that objects resist acceleration from the state of rest because of friction – that is, they confound inertia with friction (Jung et al., 1981; Brown and Clement, 1992). Students tend to hold onto these ideas even after instruction in high school or college physics (McDermott, 1983).

Benchmarks for Scientific Literacy, American Association for the Advancement of Science, 1993, Oxford University Press

The Annenberg series, "A Private Universe," clearly demonstrates the last sentence from the *Benchmarks* quotation. The opening scene of nascent college graduates incorrectly answering basic science questions emphasizes the resistance and longevity of student misconceptions.

> What is especially concerning about misconceptions is that we continue to build knowledge on our current understandings. Possessing misconceptions can have serious impacts on our learning.

If after high school and college physics courses students hold onto their personal preconceptions, what can educators do? First and foremost we can arm ourselves with knowledge about students' misconceptions and how important addressing these misconceptions is in determining whether our students will learn or not. Eric Jensen states:

> The Value of Prior Knowledge
> - All students will have some prior knowledge even if it's just random or unconscious learning.
> - Prior knowledge is not a mythical concoction. It consists of real, physical brain matter (synapses, neurons, and related, connected networks).
> - Prior knowledge fundamentally influences whether and how a student will gain an accurate or deep understanding of the topic.

- Prior knowledge is personal, complex, and *highly resistant to change*.
- The best way to teach is to understand, respect, and build on the student's prior knowledge.

5-E as Suggested Teaching Model

Second, we can employ teaching methods that assist students in constructing their own knowledge.

> A logical extension of the view that new knowledge must be constructed from existing knowledge is that teachers need to pay attention to the incomplete understandings, the false beliefs, and the naïve renditions of concepts that learners bring with them to a given subject. . . . If student's initial ideas and beliefs are ignored, the understandings that they develop can be very different from what the teacher intends.
>
> *How People Learn: Brain, Mind, Experience, and School John D. Bransford, Ann L. Brown, and Rodney R. Cocking; Committee on Developments in the Science of Learning, Commission on Behavioral and Social Sciences and Education, National Research Council, 1999*

There are many different teaching methods that are constructivist, since the goal of constructivist teaching is to have students construct and build their own knowledge. For the purpose of this article, we will focus on the first part of a five-part learning cycle.

> A recent study conducted by Horizon Research, Inc. concludes that the key factors that distinguish effective science lessons from ineffective lessons are opportunities for the lesson to:
>
> - **Engage students** with content by inviting purposeful student interaction with the dynamic body of scientific knowledge.
> - **Create conducive environments** for learning by providing respectful and rigorous opportunities for individual and group learning.
> - **Ensure access** for all students by differentiating instruction to meet learning needs.
> - **Use questioning** to monitor and promote understanding by posing questions to encourage students' reflecting, planning, monitoring and self-evaluating.
> - **Help students make sense** of the content by facilitating students' intellectual work and conceptual connections among ideas, explorations and explanations.
>
> *Ohio Department of Education, Standards Based Education*

Since the focus of this article is on students' preconceptions, our discussion will be limited to engagement activities. In particular, our focus will be on possible uses of released OGT items as ways to begin conversations with learners about their preconceptions. For our purposes, *engage* may be defined this way:

> ***Engage:*** Set up motivating conditions to initiate and sustain students' engagement in inquiry. Use standards-based questions, demonstrations, discrepant events, and perplexing case-based or technological-design scenarios to strategically capture and channel student thinking. Help students access a learning cycle at multiple entry points. Select and design motivators to help students access the prescribed concepts, skills and cognitive demands described by the *Ohio Academic Content Standards, K–12 Science*.
>
> *Ohio Department of Education, Standards Based Education*

Pre-assess Before or As Part of Student Engagement

Of most importance in the engagement activity, beyond the administration of pre-assessments, is that teachers have class discussion centered on students' responses. It is not enough to provide students with the correct science. Teachers must provide students with chances to explain their thoughts, whether they are scientifically correct or incorrect. Learners use their current schema as a filter, bridge, and base for learning new knowledge.

> Because learning involves transfer from previous experiences, one's existing knowledge can also make it difficult to learn new information.
>
> *How People Learn: Brain, Mind, Experience, and School; John D. Bransford, Ann L. Brown, and Rodney R. Cocking; Committee on Developments in the Science of Learning, Commission on Behavioral and Social Sciences and Education, National Research Council, 1999*

Let us shift our focus to an example of how to use the research literature, information on the Instructional Management System (IMS), and released Ohio assessment items to develop and analyze a pre-assessment.

Individual questions can give you specific information limited to the content covered in the question, *not* the entire scope of the benchmark or standard.

For this example, we will focus on Ohio's Physical Sciences Benchmark D:

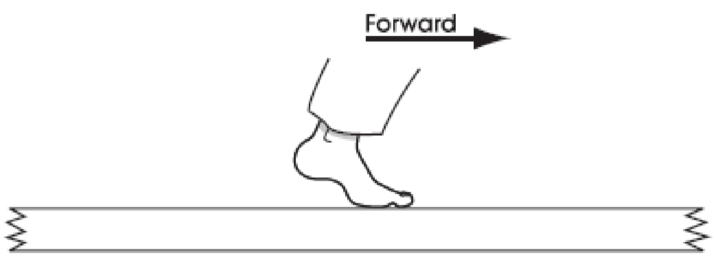
> *Explain the movement of objects by applying Newton's three laws of motion.*

This benchmark focuses on motion and associated forces as described by Newton's laws of motion. Students learn that motion is relative to a frame of reference (there is no motionless point from which to judge all motion), and they learn the principle of action versus reaction. Students learn that when an object has no net force acting on it, it will either be at rest or stay in motion at a constant speed in a straight line. They also learn that when an object is accelerating, it means there is net force acting on the object and that net force is equivalent to the mass of the object multiplied by its acceleration. Additionally, students learn that when a force acts on an object, the object exerts an equal force that acts in the opposite direction of the original force (rotational forces are excluded at this level). Finally, students learn that frictional force always acts to oppose motion (Ohio Science Matrix).

As a starting point, search the IMS for multiple-choice questions that are aligned to the benchmark.

The spring 2007–2008 Ohio Graduation Tests contained a physical sciences item that focused on the correct directions of the force of the foot on the sidewalk and force of the sidewalk on the foot. This item can be used to begin to pre-assess students' preconceptions of Newton's three laws.

Use the picture to answer question 7.



7. Which statement accurately describes the interaction between the foot and sidewalk as a person moves forward along the sidewalk in the direction of the arrow?

   A. The foot pushes forward on the sidewalk; the sidewalk does not push forward on the foot.

   B. The foot pushes forward on the sidewalk; the sidewalk pushes forward on the foot.

   C. The foot pushes backward on the sidewalk; the sidewalk pushes forward on the foot.

   D. The foot pushes backward on the sidewalk; the sidewalk pushes backward on the foot.

If, for example, the majority of your students selected option A, or the class's answers seemed randomized (equal selection across the four choices), you should further probe to learn why students selected options A, B, or D. Conversations with students may lead to your hearing statements such as "I don't know," "I guessed," and "only the foot is exerting a force." These sorts of statements by students are what literature on misconceptions informs us to expect.

A limited explanation of the science for the item can be found on Ohio's IMS website. A partial example of the type of information found on the IMS is shown below:

This multiple-choice question asks students to identify the correct description of forces for the diagram shown. Students need to analyze the diagram to determine the correct directions of the force of the foot on the sidewalk and force of the sidewalk on the foot. The direction of motion of the person is forward, so the foot is pushing backward on the sidewalk and the sidewalk is pushing forward on the foot (applying an equal and opposite force).

Answer choice C is the correct answer. Answer choice A is incorrect because the foot pushes backward, not forward on the sidewalk and the sidewalk does push forward on the foot. Answer choice B is incorrect because the foot pushes backward on the sidewalk, not forward. Answer choice D is incorrect because the sidewalk pushes forward on the foot, not backward.

In answer choices B and D, the forces are in the same direction, which is not correct. When a person is walking on the sidewalk, the foot pushes on the sidewalk, propelling the person forward and the sidewalk, due to Newton's third law of motion, pushes back on the foot with an equal and opposite force (Ohio Department of Education).

Background Information on the Misconceptions on Newton's Three Laws

Additionally:

A vast literature on science "misconceptions" argues that erroneous beliefs about the physical world are held by many, ranging from preschoolers to adults. And many of these beliefs are highly resistant to change by instruction (Chi, 2005). Much of that literature, especially in the area of mechanics, has focused on high school and college students (e.g., Brown and Clement, 1987; Carmazza, McCloskey, and Green, 1981; Minstrell, 1983, 1988; Clement, 1982). This literature makes clear, however, that the elegant theoretical construction of Newtonian mechanics (including its three primary laws of motion) is by no means obvious even to high school or college students who have had courses in introductory mechanics.

- Student misconceptions are sometimes revealed in tasks in which they are to predict the trajectories of objects or evaluate whether an observed trajectory is possible or impossible, but even more often when they are asked to identify and explain the forces acting on an object in a given situation. . . .

Although even young children, like adults, have an explicit concept of force that they use to explain what happens in different physical situations, the meaning of force is an intuitive one, very different from the mathematicized notion embodied in Newtonian mechanics. They tend to thinks of forces as active pushes or pulls that are needed to explain an object's motion, rather than coming in interactive action-reaction pairs that are needed to explain not an object's motion but its change in motion (acceleration). Thus, they see forces in situations in which a physicist has no need to postulate a force . . . , and they fail to see forces that are essential to Newtonian analysis (e.g., many of the action-reaction pairs that are so central to a Newtonian analysis, such as the forces exerted by a table on a book when it is resting on the table).

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At the end of this article is another OGT question that can be used to check students' understanding of Physical Sciences Benchmark D. The IMS page is included in its entirety to provide a complete example of how the information will appear on the website.

Summary—Ways to Use OGT Released Test Materials

Even though Ohio's assessments can provide some information that may be useful to inform curriculum development, this should not be the only resource used. Other forms of assessments (projects, performance-based assessments, laboratories, homework, in-class quizzes, interviews, portfolios) can give more detailed information and should be used in conjunction with released test materials.

There are several strategies teachers can incorporate to use assessment data to inform curriculum:

- Use reports to examine student responses to all options of a multiple-choice question.
- Use the IMS to learn about science behind incorrect foils in multiple-choice questions.
- Use research literature on student misconceptions/preconceptions to help identify what misconceptions students have.
- Use other formative assessments (NSTA probes) to learn more about student misconceptions.

Ohio Graduation Test for Science – March 2006
Annotated Item 44

Standard and Benchmark Assessed:

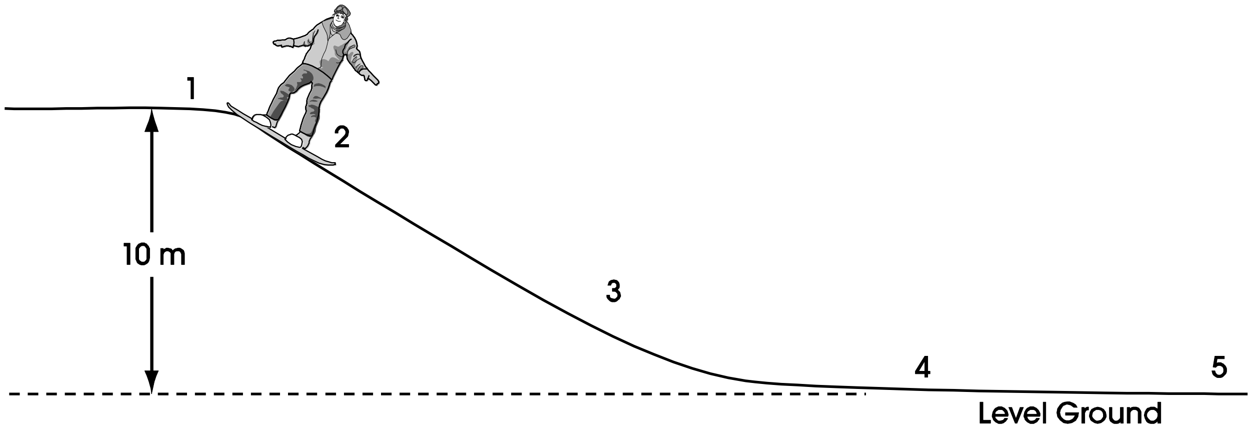
- Standard: Physical Sciences
- Benchmark: D. Explain the movement of objects by applying Newton's three laws of motion.

Multiple Choice Question:

Use the information and illustration to answer question 43 and 44.

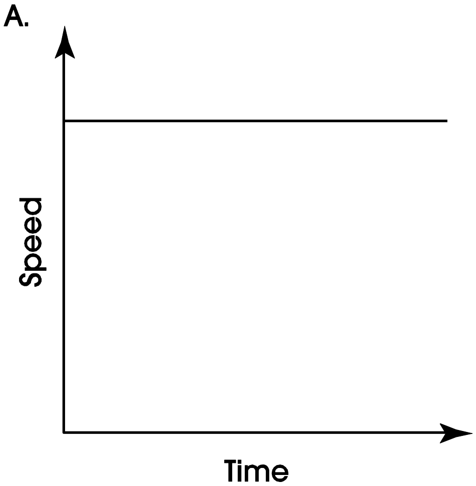
Snowboarding Science

A snowboarder begins his run from rest (point 1) on top of a hill. He moves straight down the slope until he reaches the bottom of the hill (point 4) and the ground levels off. The snowboarder continues to move horizontally across the level ground and eventually comes to a stop (point 5).

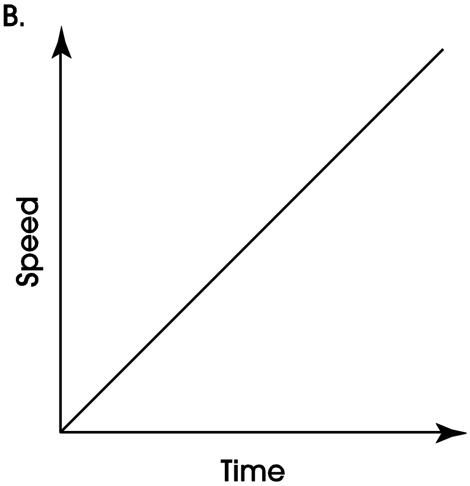


Which graph best represents the speed of the snowboarder as he moves from point 2 to point 3?

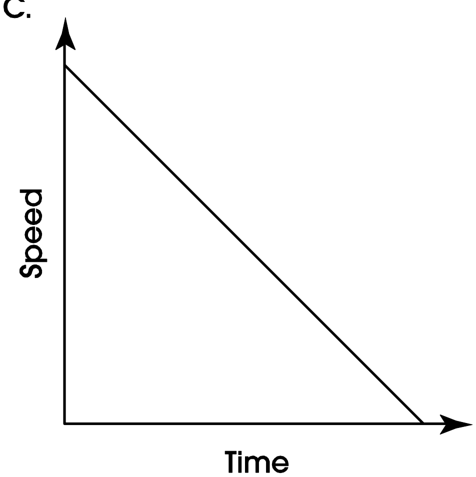
A.



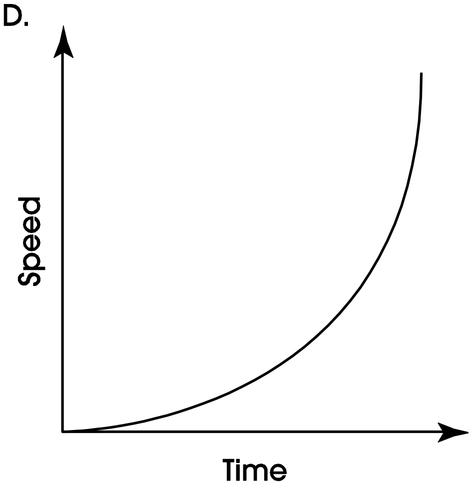
B.



C.



D.



Commentary:

This multiple-choice question asks students to select the graph which best represents the speed of the snowboarder as he moves down the slope between two identified points. From points 2 to 3 on the slope, students must correctly observe that the hill has a constant steepness, assume that the hill is completely snow covered, and infer that the distance is relatively short. Students must infer that combined frictional forces on the snowboarder produce a relatively small, constant force on the snowboarder up the hill compared to the large, constant effect of gravitational force on the snowboarder down the slope. Based on this analysis and an understanding of Newton's Second Law ($F_{net} = ma$), students must conclude that the unbalanced (net) force causes the snowboarder to accelerate down the slope in the same direction as the unbalanced force while he moves from point 2 to point 3.

Answer choice B is correct because this is the speed vs. time graph which correctly shows best how the speed of the snowboarder would change in the time it takes for him to move from point 2 to point 3, showing speed increasing by equal amounts in equal time intervals.

Answer choice A is incorrect because it shows a constant (unchanging) speed for all time intervals. This is the speed vs. time graph for motion with no acceleration. Answer choice C is incorrect because the speed vs. time graph shows speed decreasing by equal amounts in equal time intervals.
Answer choice D is incorrect because the speed vs. time graph does not show speed increasing by equal amounts, but rather by unequal amounts, in equal time intervals.

The question is classified as Communicating Understanding / Analyzing Scientific Information because the task requires students to analyze information provided in a snowboarding scenario, make valid inferences and select the graph which best shows the change in the snowboarder's speed during the prescribed time period to demonstrate understanding of the underlying law and concepts.

Performance Data:

- The percent of public school students selecting answer choice B for question 44 on the March 2006 Ohio Graduation Tests was 45 percent.

Keywords:

- acceleration, net force, Newton's Second Law of Motion