Physics and Everyday Thinking High School: Teacher Professional Development & College Prep

PhysTEC February 6, 2015

University of Colorado Boulder

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Physics and Everyday Thinking (PET)

- Inductive Reasoning
- Originally designed for undergraduate non-science majors and pre-service elementary teachers
- Research-based and research-tested
- Ongoing research-based revisions to make the curriculum accessible and appropriate for high school physics students

Goldberg, Robinson, & Otero, 2007

Supported by the U.S. National Science Foundation Grant 0096856
Learning Structure

- Initial Ideas
- Collecting & Interpreting Evidence
- Summarizing Questions
- Consensus Discussion

Scientific Principles
Results from PET in the High School

Average normalized gain: 0.62
University normalized gain: 0.4
Normalized gain for the other subgroups: 0.53

Belleau & Otero, 2013
Chapter 3 Activity 1

**Learning Objective:** Students will determine the relationship between mass, acceleration and gravitational force.

**Related Previous Experiences in the PET-HS Course:**
- Balanced and Unbalanced Forces and resultant motion (Net Force)
- Acceleration and Mass (Newton’s Second Law)
Chapter 3 Activity 1

**Left Side of the Folder**

**Instructions:** Work with group members to explore Chapter 3 Activity 1 and process some of the pedagogical moves made throughout the activity.

... Then we will share our ideas and look at examples student work and classroom interactions.
3.1 Initial Ideas

(1) Predict how high school students might answer the Initial Ideas questions.
Initial Ideas Question 2: Do you think the gravitational force is the same or different on a bowling ball and a soccer ball? Explain your thinking.

NO, because gravity is one force! No matter how heavy an object is, gravity will pull with the same amount of force.
3.1 Initial Ideas

Initial Ideas Question 3: If you were to drop a bowling ball and a soccer ball from the same height, which one do you think would **reach the floor first**? Explain your thinking.

The heavier the object the more force needed.
Bowling ball falls first.
(2) Step 1 and Step 2 of Experiment 1 have students compare the effort it takes to hold up a 100g mass and a 1000g mass. Why might this be a useful activity for students to do?

(3) Read through Experiment 2. In Step 3, what might be some reasons students were asked to compare carts to the dropping spheres?
(4) Predict what types of ideas you think high school students might have at the end of Experiment 2.

(5) Read through the Summarizing Questions. Discuss why it might be important to include these questions at this time.
Chapter 3 Activity 1

Right Side of the Folder

Instructions: Work with group members to explore the 3.1 Scientist Ideas Reading and Math and discuss how this curriculum may be useful for college prep and teacher prep.

... Then we will debrief.
(6) Read through the Scientist Ideas and notice how the language is a hybrid between standard textbooks and everyday language. Do you think this is a good idea? Why or why not?
(7) Evaluate some of the previous mathematical activities (2.1 and 2.2) and then evaluate the math activity for 3.1. What is similar and what is different from traditional physics activities?
(8) After exploring these activities from the PET-HS curriculum, what role do you think this curriculum could serve for college preparation?

(9) After exploring these activities from the PET-HS curriculum, what role do you think this curriculum could serve for teacher preparation and professional development?

Share Out
What do students think about the relationship between gravitational force and acceleration?

Methods:
- 3 multiple choice questions
  - General physics students at Longmont High School (N=45)
- Compared results to:
  - Scores when given before instruction at Univ. of Mass (n=527) calc- & algebra-based physics)¹
  - Results after instruction at Arizona State (N=33; algebra-based physics)²

²Meltzer, D
1. Two metal balls are the same size, but one weighs twice as much as the other. The balls are dropped from the top of a two-story building at the same instant of time. The time it takes for the balls to reach the ground will be:

   a. About half as long for the heavier ball
   b. About half as long for the lighter ball
   c. About the same for both balls
   d. Considerably less for the heavier ball, but not necessarily half as long
   e. Considerably less for the lighter ball, but not necessarily half as long

2. Two metal balls are the same size, but one weighs twice as much as the other. The balls are dropped from the top of a two-story building at the same instant of time. As the balls are falling, the force on the two balls is:
   a. About twice as large for the heavier ball
   b. About twice as large for the lighter ball
   c. About equal for both balls
   d. Considerably less for the heavier ball, but not necessarily half as large
   e. Considerably less for the lighter ball, but not necessarily half as large

3. Two equal sized objects, one weighing 2 lbs and the other weighing 4 lbs, are released from rest from the roof of a two-story building. Which of the following statements is true? About half as long for the heavier ball

a. The force on the 4-lb object is about twice as large as the force on the 2-lb object, therefore, the 4-lb object reaches the ground in about half the time.

b. The forces on the two objects are about equal, therefore, they both reach the ground at the same time.

c. The force on the 4-lb object is about twice as large as the force on the 2-lb object, but they both reach the ground at about the same time.

d. The forces on the two objects are about equal, but the 4-lb object reaches the ground in about half the time.

e. None of the above.

Gravitational Force and Acceleration:

Gravitational Force and Acceleration

Preliminary Results: Falling Objects Assessment

<table>
<thead>
<tr>
<th>Question</th>
<th>Longmont High School General Physics (Post Test) N=45</th>
<th>University of Massachusetts Calc and Algebra Based Physics (Pre Test) N=527</th>
<th>Arizona State Algebra Based Physics (Post Test) N=33</th>
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<tbody>
<tr>
<td>Question 1</td>
<td><img src="image1" alt="Bar Chart" /></td>
<td><img src="image2" alt="Bar Chart" /></td>
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<tr>
<td>Question 3</td>
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Gravitational Force and Acceleration

Preliminary Results: Falling Objects Assessment

- Longmont High School General Physics (Post Test) N=45
- University of Massachusetts Calc and Algebra Based Physics (Pre Test) N=527
- Arizona State Algebra Based Physics (Post Test) N=33
Preliminary Results: Falling Objects Assessment

- **Question 1**: Students with Correct Response
  - Longmont High School General Physics (Post Test), N=45
  - University of Massachusetts Calc and Algebra Based Physics (Pre Test), N=527
  - Arizona State Algebra Based Physics (Post Test), N=33

- **Question 2**

- **Question 3**
Initial Ideas

Learning Target: You will determine the relationship between mass, acceleration and gravitational force.

- Do you think the gravitational force is the same or different on a bowling ball and a soccer ball? Explain your thinking.

- If you were to drop a bowling ball and a soccer ball from the same height, which one do you think would reach the floor first? Explain your thinking.
Gravitational Force and Acceleration

Collecting and Interpreting Evidence:

Experiment 1:
How does strength of gravitational force compare for objects of different mass?

Application of student understanding of zero net force and acceleration.
Experiment 2:
How does the mass of a falling object affect its motion?
Gravitational Force and Acceleration

Summarizing Questions:

Use evidence:
What is the relationship between mass, gravitational force and gravitational acceleration?

Students discuss and formalize this relationship using their understanding of horizontal motion.