Energizing Physics: Formative Assessment Strategies

Stephen Scannell

Gresham High School, Gresham Oregon

sgscannell@gmail.com

Abstract

This poster presents several formative assessment strategies used during a 2-year NSF project that developed a formative evaluation system for Energizing Physics, an introductory high school physics course focused on the essential concepts related to energy. Formative evaluation activities enable teachers to monitor student progress and help more students succeed.

The Course

Energizing Physics is an algebra-based physics course that introduces the concept of energy early and then connects energy to other physics concepts, allowing for a year-long discussion on energy and society. Each chapter includes end-of chapter projects which provide for a real-world context for the course material. Formative assessment strategies are imbedded to assist both teacher and student in identifying student strengths and weaknesses.

Ch 1: Speed and Measurement
Ch 2: Energy
Ch 3: Work and Energy
Ch 4: Forces and Motion
Ch 5: Electricity
Ch 6: Waves
Ch 7: Thermal Energy
Ch 8 Multiple Objects/Multiple Dimension

Learning Targets

Learning targets provide explicit information about what students should know, be able to do, and understand

Each Chapter lists learning targets for each lesson, and further breaks down which learning targets will be formally assessed.

Example from Ch 2:

Energizing Physics Learning Targets
Chapter 2 Learning Targets (those in bold will be formally assessed in the curriculum)

2.1. (I can) Develop a specific, testable prediction (hypothesis).

2.2. (I can) Design and conduct a scientific experiment.
a. Design an experiment which yields data appropriate for a specific question or purpose.
b. Utilize x-y scatter plots to identify mathematical relationships between variables.

2.3. (I can) Critically review experimental methods and results.
a. Compare and contrast results from various research teams.
b. Match experimental results with the methods producing those results.

2.4. (I can) Interpret important information on data variation from a histogram.
a. Develop a histogram for a data set.
b. Develop conclusions using information gleaned from histograms.

2.5. (I can) Use energy conservation to determine mathematical relationships involving speed and height.

2.6. (I can) Quantify kinetic energy, gravitational potential energy, and total energy.

2.7. (I can) Use energy conservation and energy models to quantify variables in situations involving different types of energy.

2.8. (I can) Use energy conservation to quantify kinetic energy, gravitation potential energy, and elastic potential energy at various points in a bungee drop.

Formative Assessment Strategies

GUIDE: A Problem Solving Strategy

Figure 1: GUIDE Strategy

Physics Problem Solving with GUIDE	
Given	Assign variables to represent the given information. Sketch the situation.
Unknown	Assign a variable to the unknown information.
Identify Tools	What concepts/equations will you use to solve the problem?
Do Math	Apply the tools and solve the problem.
Evaluate	Review your work. Does your result make sense?

GUIDE Example with Speed

Makayla measured the ramp to be 15 arms long. She timed a ball rolling down the ramp to be 15 swings of a pendulum. What was the average speed of the ball?

G	U	I	D	E
$\Delta x = 45\ arms$ $\Delta t = 15\ swings$	V	$v = \frac{\Delta x}{\Delta t}$	$v = \frac{45\ arms}{15\ swings}$ $v = 3.0\ \frac{arms}{swing}$	Units came out with distance on the top and time on the bottom just like speed limits.

Benefits

•Provides for both qualitative and quantitative analysis of student thinking.

•Engages students into thinking deeply about the problem, including evaluating their work, not just leading them to a quantitative answer.

•Provides a common language for teachers and students in discussing problems and the problem solving process. Especially helpful with the student who says, "I don't get it".

•Proves for efficient assessment (see figure 2).

•Many students find it helpful, but with some criticism. Examples of student comments.

- *"I have to admit that GUIDE has grown on me. It helps the problem solver to organize all the given information into one area, and it reminds the problem solver of what equation to use to solve."*
- *"Showed me what part of the problem I didn't understand"*
- *"It provides a structured method in case I'm not sure how to begin solving a problem"*
- *"I like how it organizes my work which makes it easier for me to get the correct answer and easier to go back and analyze my work later for studying etc. I also like how it makes finding what the problem is asking for easier".*

- *"Sometimes it could get tedious, and I didn't understand what we were supposed to do for the E step".*
- *"Sometimes it may take up a lot of space on my paper"*
- *Spending too much time organizing the problem"*
- *"GUIDE took much longer than just solving the problem"*

Figure 2: Learning Target C2.9: (I can) Use energy conservation to quantify kinetic energy, gravitational potential energy, and elastic potential energy at various points in a bungee drop.

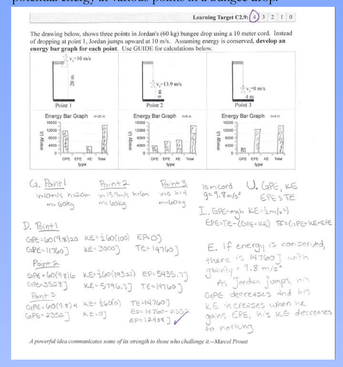
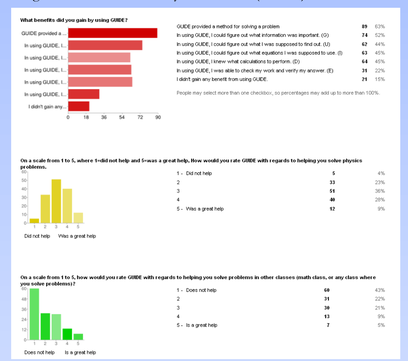


Figure 3: Results of survey on GUIDE (N=141)



DYGIT (Did you get it?) Questions.

After the conclusion of each introductory lesson, and prior to practice problems, each lesson has a DYGIT question(s) that allows the teacher and student to quickly and formatively assess the understanding of the key ideas. For example, for analyzing the motion of the bungee jumper using the example in figure 2:

1. Now let's consider what would happen to the bungee jumper after point 3. Which of the following choices correctly describes the motion of the dropper after point 3 if energy is conserved?
   i. The dropper springs upward halfway to the drop point and falls back downward
   ii. The dropper springs upward all the way to the drop point and then repeats the motion.
   iii. The dropper springs upward close to the drop point but not quite, then falls downward
   iv. The dropper springs upward past the drop point and then falls downward.
2. Is energy conserved in an actual bungee jump? Explain

4 point Scoring Guide

The 4 point scoring guide provides an efficient method of assessment, while also providing valuable information to the students- do they completely demonstrate their understanding, can they provide some relevant information? The scoring guide focuses not on having the correct "answer", but on demonstrating an understanding of the concepts. This provides "space" for students to correct mistakes, or complete the problem.

Figure 4: Energizing Physics Scoring Guide

Rating	Performance
4	Complete understanding *(Problem solved correctly with all aspects of GUIDE complete. Sig Figs and units are correct)**
3	Solid understanding *(Problem solved, but with minor omissions or errors)*
2	Some understanding but major gaps *(Problem not solved correctly, but demonstration of major concepts included)*
1	Limited understanding *(Some relevant information given.)*
0	No information *(No answer or not relevant)* information given.

Conclusions

These formative assessment strategies were an integrated part of the Energizing Physics pilot study. Although the effectiveness of the individual strategies was not tested as part of the project, both teachers and students described these strategies as being effective in assisting students with learning physics. Bedford, Freeman, & Worth Publishing are conducting a larger pilot study in the 2013-2014 school year.

Acknowledgements

Project Staff

Project Director, Cary Sneider, Portland State University
Energizing Physics Authors, Aaron Osowiecki and Jesse Southwick, Boston Latin School, Boston, MA
William Walker, Westview High School, Beaverton, OR
Jennifer Wells, Portland State University

Project Advisors

J. Myron Atkin, Emeritus Professor of Science Education, Stanford University
Marilyn Decker, Director of Science, Milton Public Schools, Milton MA
Karen Draney, Senior Education Researcher, UC Berkeley

20 Pilot Teachers 2008-2012

This poster was partially supported by a National Science Foundation grant to Portland State University (NSF grant # 1020385 Bridging the Gap Between High School and College Physics: An Exploratory Study). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the National Science Foundation.

References

Sneider, C., & Wojnowski, B. (Eds.) (2013). *Opening the door to physics through formative assessment* [monograph]. Portland, OR: Portland State University. Retrieved from National Science Education Leadership website: www.nsela.org/publications