Physics Education Laboratory
Lecture 12
Content Knowledge for Thermodynamics

Francesco Longo - 16/11/21

Observational experiment - part 3

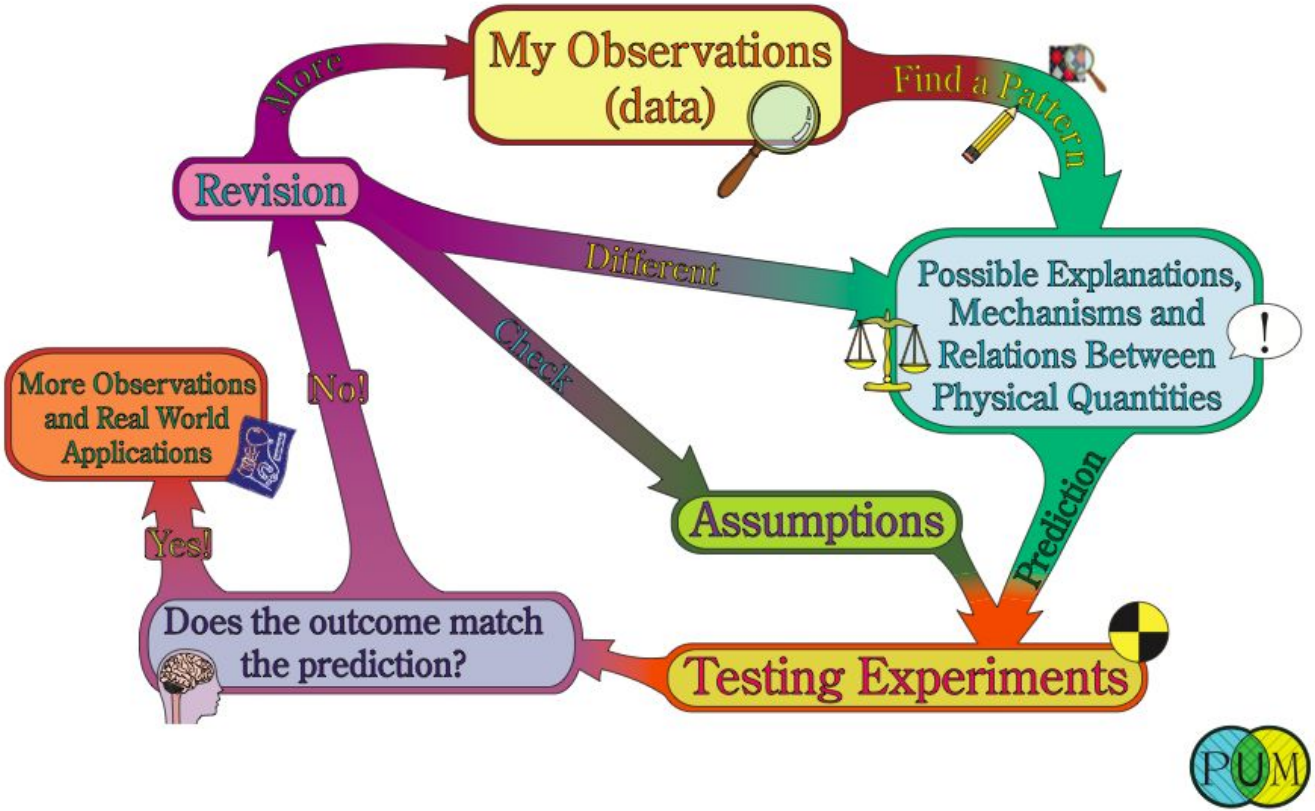
3. Watch the video of a cup of glycerin being stirred by a mixer used to whip cream [https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-phys-egv2e-alg-15-3-1]. The video is taken with a thermal camera and allows you to follow the temperature of the glycerin at the spot marked by cross hairs.

a. Describe what you observe.

b. Draw a bar chart to represent the process. Indicate any assumptions that you made.

Investigative Science Learning Cycle!

Etkina and Van Heuvelen (2001; 2007)



https://docs.google.com/document/d/1F7XA_jZz8bIhB4RxS6cWgDJn4DbUQknO/edit

Demonstrative experiment

A demonstrative experiment is an experiment that students watch when they are involved in the study of a phenomenon already explained. Thus, they do not make any measurements, nor they do not make predictions, nor make comparative analysis between measurements and prediction. Students do no construct by their own any qualitative or quantitative relationship.

Observational experiment

An observational experiment is an experiment that students perform when they are investigating a new phenomenon. Thus, they do not make predictions or have expectations about its outcome. Students need to collect data, analyze them and find a pattern in the data. They then need to explain the reasons for the pattern (if applicable), and/or construct a qualitative or quantitative relationship.

Testing experiment

In a testing experiment, students use an explanation or relationship to make a prediction of the outcome of the experiment. They also decide what additional assumptions they are making. Then they perform the experiment, and record the outcome. Based on the (dis)agreement of the prediction and the experimental outcome, and taking into account theoretical assumptions and experimental uncertainties, students have to make a judgment about the explanation or relationship that they are testing.

Students learn that when their prediction agrees with the experimental outcome, it only means that the explanation/relationship cannot be rejected. On the other hand, if their prediction does not agree with the experimental outcome, they have to either reject the explanation/relationship they tested, or reconsider the additional assumptions they made. Thus, the emphasis is on trying to disprove an idea

Application experiment

An application experiment typically involves solving a practical problem or determining an unknown quantity by performing experiments. Students need to solve these experimental problems using at least two different methods and then compare the results. Often they need to perform additional experiments or make informed estimates to determine some physical quantities.

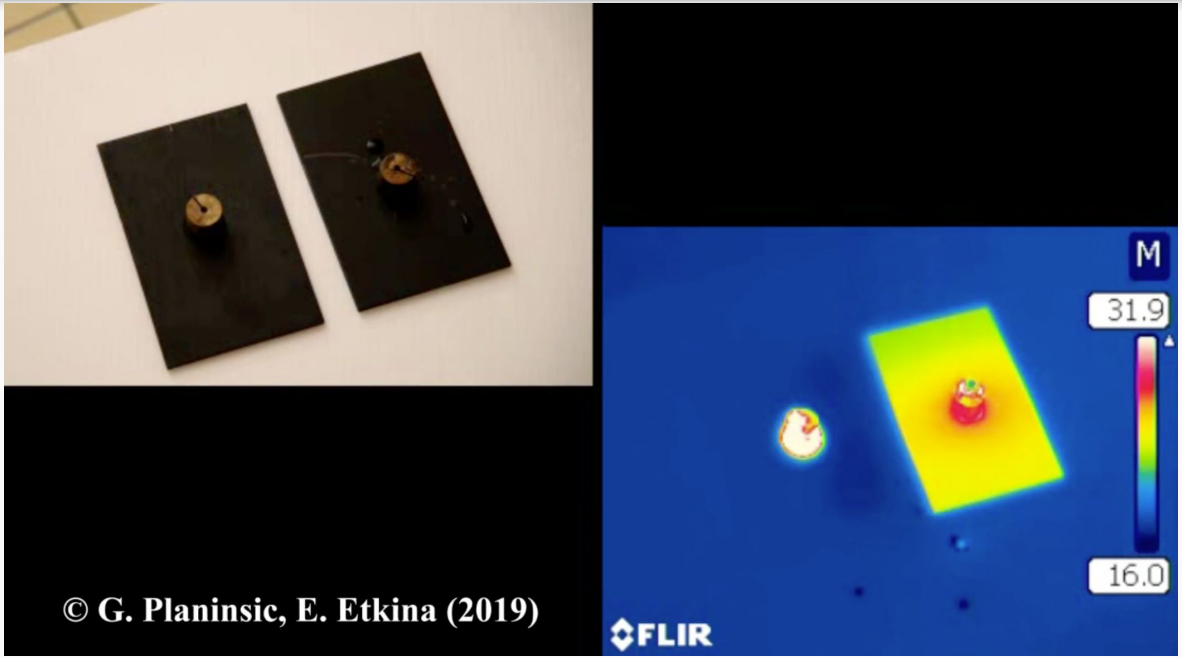
Video problems as Application experiment

A video problem is a subset of the category “application experiment”. From each video one can determine a physical quantity such as the coefficient of friction between two surfaces, the height of a table, etc. . . by two independent methods. The results determined from each method should agree with each other.

https://drive.google.com/file/d/1YOWDDJujMnD_BY5gw60eDNtxqjeiPXjN/view?usp=sharing

Example 1:
First law of thermodynamics

Example of Observation Experiment



In the experiment, two identical metal objects (made of brass) are taken from the same hot water bath and placed on two identically-shaped (same height, length, and width) plates. The plates are made of wood and aluminum (colored with the same black paint to reduce the reflective properties of aluminum) and have been sitting on the table for a long time.

a. Describe what you observe.

b. Devise one or more explanations for your observation.

https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-phys-egv2e-alg-15-7-2

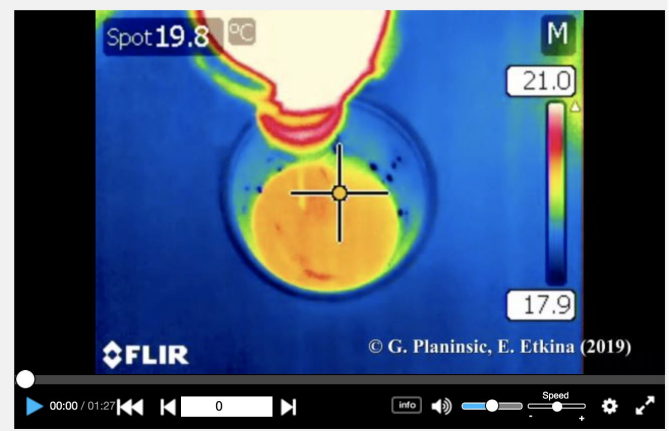
Example of Testing Experiment

a. Use the explanations you made in Observational Experiment to predict what you will observe.

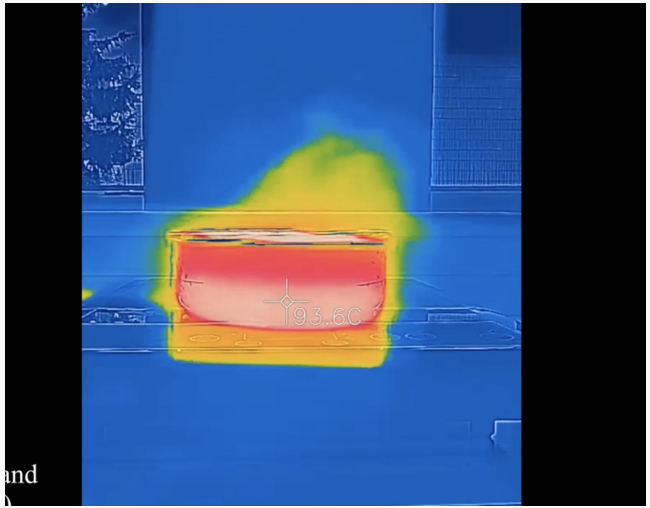
b. View the video [https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-phys-egv2e-alg-15-7-3] and compare the outcome to your predictions. Do you need to revise your explanation?

Example of Application Experiment

https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-phys-egv2e-alg-15-5-7



https://youtu.be/hLcYCzMgSzc



Example of Video- Application Experiment

[https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-phys-egv2e-alg-15-5-7].

The video is taken with a thermal camera and allows you to follow the temperature of the glycerin at the location of the cross hairs.

a. Use the data provided in the video to estimate how much energy provided by the mixer went into warming up the glycerin.

b. Could this experiment be used to test the equivalence of work and heating as a means for energy transfer? Justify your answer.

Lesson 1: Particles of Matter

1.1 Observe and Explain

Dip a piece of paper in rubbing alcohol (or rub the paper with alcohol) and place it on a table.

a) Observe what happens and describe it in your own words.

b) What do you need to **assume** about the makeup of alcohol to explain the *gradual* disappearance of alcohol from the paper?

1.2 Hypothesize

Think of possible **explanations** for the alcohol's *disappearance*. Suggest at least three different mechanisms. Fill in the table that follows.

Here's An Idea!

Coming up with explanations for this can be difficult but don't be afraid to use your imagination. There are no wrong ideas, only testable or non-testable ones!

For Example: *The alcohol is still there but we just can't see it (Testable Idea)*

Leprechauns came by, collected the alcohol, and left (Non-Testable Idea)

1.3 Test Your Idea

a) Think of an experiment you can perform to rule out each explanation.

b) Write a **prediction** for each testing experiment based on the corresponding explanation.

c) Perform the experiments. Some possible testing experiments can be found at: http://paer.rutgers.edu/pt3/experimentindex.php?topicid=7&cycleid=13

1.4 Explain

Based on the outcomes of the testing experiments what judgment can you make about each explanation? Revise your hypothesis for the disappearance of the alcohol.

1.5 Test Your Idea

You and your lab partners have a glass of pure alcohol, a container with colored alcohol, and a dropper. One of your lab partners says,

"*I think that the alcohol is made up of little tiny parts that are constantly in motion.*"

Your other partner disagrees. She says,

"No, I agree that the alcohol is made up of little tiny parts but they are definitely not moving!"

a) Based on your experience from the previous activities, which explanation do you agree with? Why?

b) How can you use the materials listed above to test these ideas?

c) Write your prediction for each of your partners' mechanisms.

d) Perform the experiments and record the outcomes.

e) What judgment can you make about each explanation?

Did You Know?

Scientists call these little parts that make up objects **particles**. Although we cannot see the particles, we can discuss their properties. Understanding their properties will help us better understand the nature of the object as a whole.

Homework

1.6 Represent and Reason

a) Create a picture that represents what the particles are doing in the alcohol experiment.

b) How do you think solids, liquids, and gases look at a particle level?

https://drive.google.com/file/d/1foYc9_g9Rr27W4iXb5kjJUDp0j0oDJqm/view?usp=sharing

Example 2: Gas on line laboratory

The Three Components ISLE

The first component is a cycle of logical reasoning that repeats for every new topic that is learned. The reasoning logic is a marriage of inductive and hypothetico-deductive reasoning:

Inductive: Observational experiments provide students with interesting data (and patterns) that need to be explained. Students generate multiple explanations based on prior knowledge and analogical reasoning.

Hypothetico-deductive: If this explanation is correct, and I do such and such (perform a testing experiment), then so and so should happen (prediction based on explanation). But it did not happen, therefore my idea is not correct (judgment). Or and it did happen therefore my idea has not been disproved yet (judgment).

The Three Components ISLE

The second component of ISLE is an array of representational tools that students learn to use to travel around the ISLE cycle and solve real-world problems (applications).

pictures

motion diagrams

graphs

force diagrams

impulse-momentum bar charts

electric circuit diagrams

work-energy bar charts

ray diagrams

The Three Components ISLE

The third component of ISLE is the development of a set of scientific abilities or scientific habits of mind that allow students to travel around the ISLE cycle and solve real-world problems (applications) by thinking like a physicist.

Students are able to identify assumptions they are making and how those assumptions affect a result. Notice that this ability applies in multiple contexts. Assumptions are made in designing a testing experiment and may affect the outcome of that experiment or the conclusions that are drawn from that experiment.

Assumptions are made when applying physics knowledge to solve a real-world problem (e.g., figure out how far a projectile will travel). The assumptions made will affect the result of the calculation when compared with the actual outcome (i.e., firing the projectile and seeing how far it actually went). The full set of scientific abilities and the multiple contexts in which they occur are codified in the scientific abilities rubrics.