Physics Education Laboratory
Lecture 10
Investigative Science Learning Environment

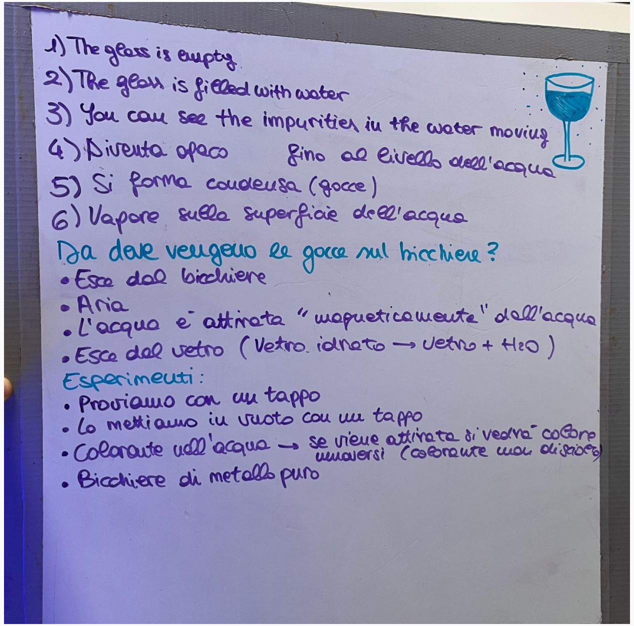
Francesco Longo - 30/10/23

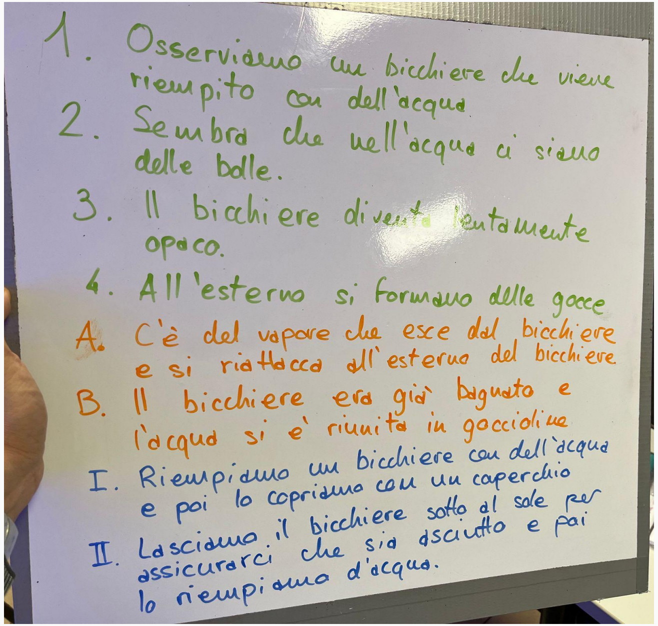
Investigative Science Learning Environment

(ISLE approach)

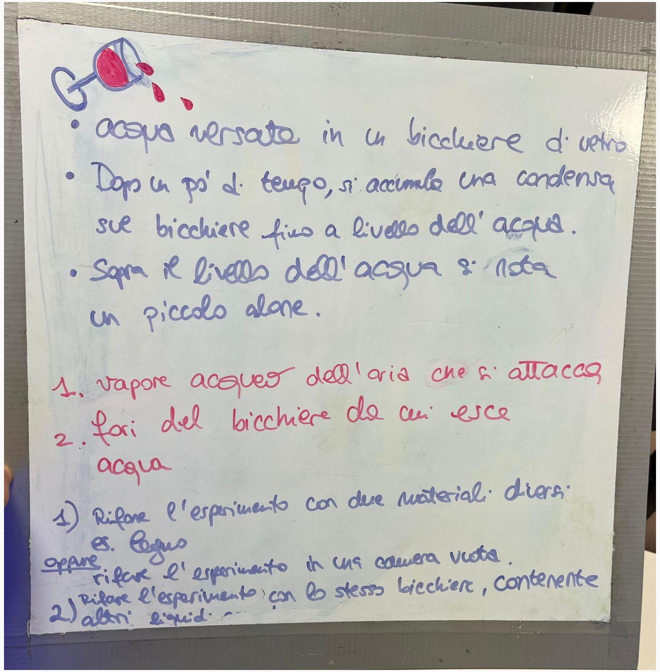
OBSERVATIONAL EXPERIMENT

ISLE - Laboratory





ISLE - Laboratory



As teachers, how do we create an environment in which students can discover and learn physics for themselves - to own it, so to speak?

ISLE approach involves students' development of their own ideas by

- Observing phenomena and looking for patterns,
- Developing explanations for these patterns,
- Using these explanations to make predictions about the outcomes of testing experiments,
- Deciding if the outcomes of the testing experiments are consistent with the predictions,
- Revising the explanations if necessary,
- Encouraging students to represent physical processes in multiple ways.

(Etkina et all, 2007-2010-2019)

The combination of these features is applied to every conceptual unit in the ISLE learning system, thus helping them develop productive representations for qualitative reasoning and for problem solving.

The ISLE Game

ISLE is a game that models the process by which physicists create their knowledge.

The key to what makes it non-threatening is that it is like a mystery investigation.

Students construct physics concepts and develop science process abilities emulating the processes that physicists use to construct knowledge.

The steps of the ISLE cycle proceed as follows:

1.Students come upon some interesting physical phenomenon that needs explaining.

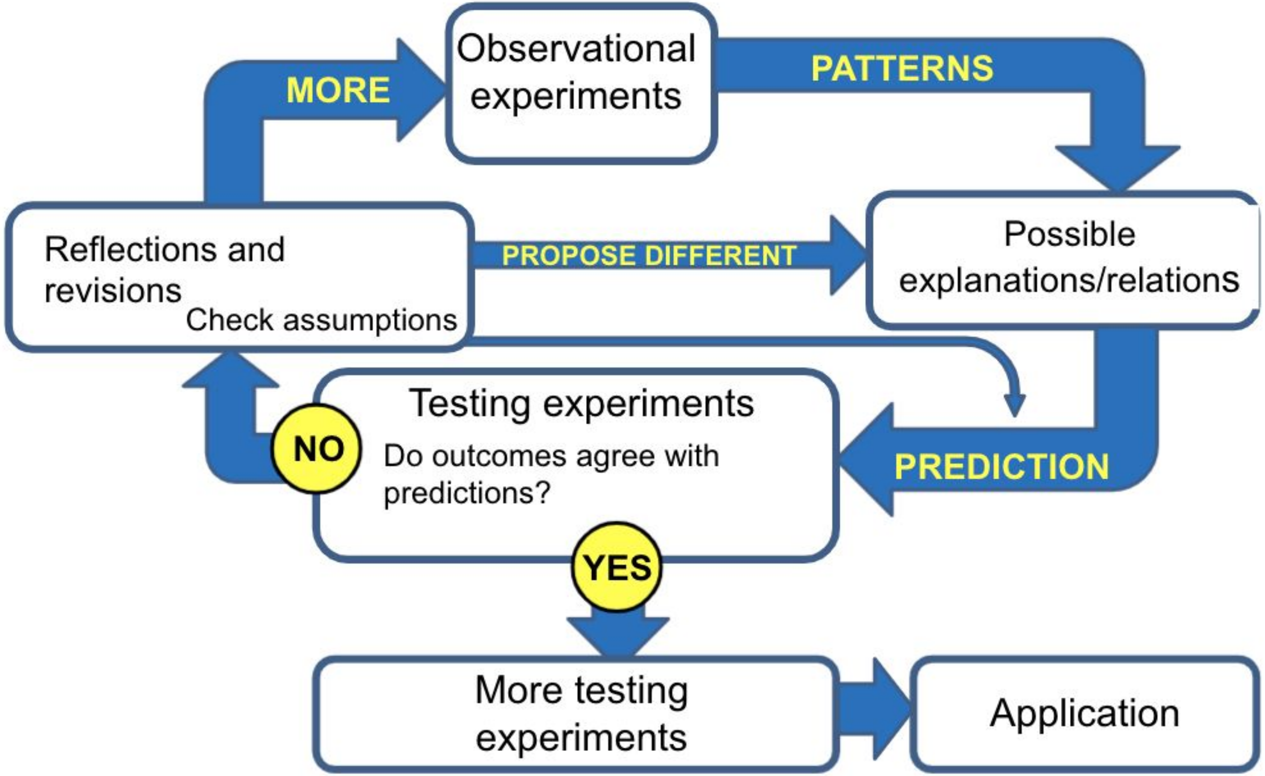
2. Students gather data about the phenomenon, identify interesting patterns and come up with multiple mechanistic explanations for why the phenomenon is happening.
We say “come up with any crazy idea that could explain this” because we DO NOT want students to feel deeply emotionally attached to their ideas.

3. They then test their explanations by conducting one or more testing experiments.

The primary goal is to eliminate explanations rather than “prove” them.
This is key to the non-threatening nature of the process. In ISLE, “predicting” means saying what would be the outcome of the testing experiment if a particular hypothesis were true. Ideas that are not eliminated are kept and re-tested with further experimentation.
Finally students apply the ideas they have established to solve real-world problems.

The cycle repeats twice, first qualitatively, then quantitatively.

Investigative Science Learning Environment - ISLE cycle



Etkina, 2015

Observational experiments: energy conversions - part 1

Goals: Explain a series of experiments using the knowledge of energy
Equipment: none

1. Watch the video [https://youtu.be/u3Y4npFvlO4] Answer the following questions:
   A. Construct a microscopic explanation for how the hot gas pushes out the stopper. Remember what you learned about molecules of gas, their motion, and the pressure that they exert.
   B. Choose the gas inside the test tube, the stopper, and Earth (not the flame) as the system, and use the concepts of work and energy to explain the experiment. If you need a new physical quantity or quantities for your explanation, define them qualitatively.
   C. Draw an energy bar chart to explain the experiment using this new physical quantity. The system is the gas and the cork. The initial state is before we started warming up the gas and the final state is when the cork is flying out.

Observational experiment - part 2

2. Watch the video of a cup of cold water in an aluminum container being placed in a container with warm water
https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-phys-egv2e-alg-15-2-2

The video is taken with a thermal camera and allows you to see the change of temperature of the water.

A. Describe what you observe (choose the initial state to be when the cup is outside the container and the final state when cup is inside and the temperature reaches some intermediate value).
B. Consider the water in the cup as the system and explain this observed process using your knowledge of molecules and their motion. Then use the generalized work–energy principle to explain what happened to the cold water. If you cannot explain this process with this principle, try to modify the principle (for example, introduce a new physical quantity) to account for your observations.
C. Repeat part b., only this time consider the water in the container as the system.
D. Use your knowledge of molecules and their motion to explain the reasoning behind when two liquids of different temperatures mix together, the mixture will eventually reach some intermediate temperature (called the equilibrium temperature).

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.

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.

Investigative Science Learning Cycle!

Etkina and Van Heuvelen (2001; 2007)