The ISLE approach: Essential elements that cannot be omitted

Eugenia Etkina and Gorazd Planinsic

Before we go into th elements, let's immerse ourselves into the ISLE approach to remind everyone of some important features

Question: How do sound canceling headphones work?

OALG 11.6.1 Observe and explain

a. Go to [https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-phys-egv2e-alg-11-6-1]. Observe and describe what happens. What do you see when two pulses coming from opposite directions meet?

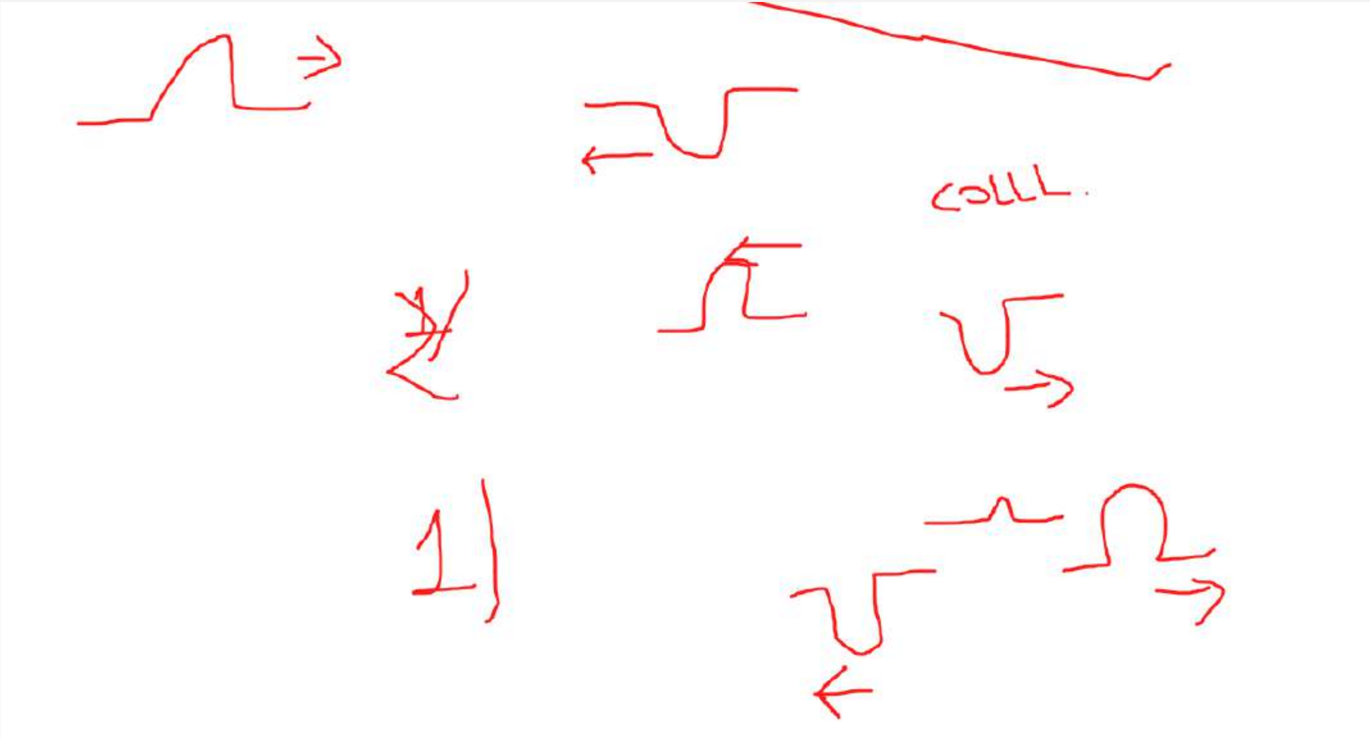
b. Brainstorm one or two ideas to explain what is happening when the two pulses meet each other.

c. If you come up with two competing ideas as to what happened, brainstorm ways in which you could conduct a testing experiment to decide which of these two ideas is correct.

Team 1 EE: Anything else that you see?

a) We see two wave pulses meeting in the middle of a Slinky (™). When they meet in the middle they combine (get bigger).
b) Either (I) the pulses pass through each other or (II) they reflect off each other.
c) Have the two waves have opposite orientations (one up and one down) so we can tell which pulse is which after they meet. We could give the two pulses different amplitudes as well.
    i) If idea I is correct, the pulse with the upward orientation will end up on the opposite side of the slinky from where it started.
    ii) If idea II is correct, the pulse with the upward orientation will end up back where it started.

Team 2



Team 3

OALG 11.6.1 Observe and explain

a. Go to [https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-phys-egv2e-alg-11-6-1]. Observe and describe what happens. What do you see when two pulses coming from opposite directions meet?

The pulses get bigger when they meet at the middle of the slinky.

b. Brainstorm one or two ideas to explain what is happening when the two pulses meet each other.

Idea 1:The two pulses bounce off each other, or they pass through each other.

c. If you come up with two competing ideas as to what happened, brainstorm ways in which you could conduct a testing experiment to decide which of these two ideas is correct.

Team 4

a. Go to [https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-phys-egv2e-alg-11-6-1]. Observe and describe what happens. What do you see when two pulses coming from opposite directions meet? **When the two pulses meet in the center, it appears that they combine to form one larger wave. Then, the two separate pulses reappear after meeting in the center and move towards the end of the slinky. Not sure if they bounce off each other or continue moving in the same direction.**

b. Brainstorm one or two ideas to explain what is happening when the two pulses meet each other.

Hypothesis 1 - Two waves “bounce” off each other.
Hypothesis 2 - Two waves travel “through” each other

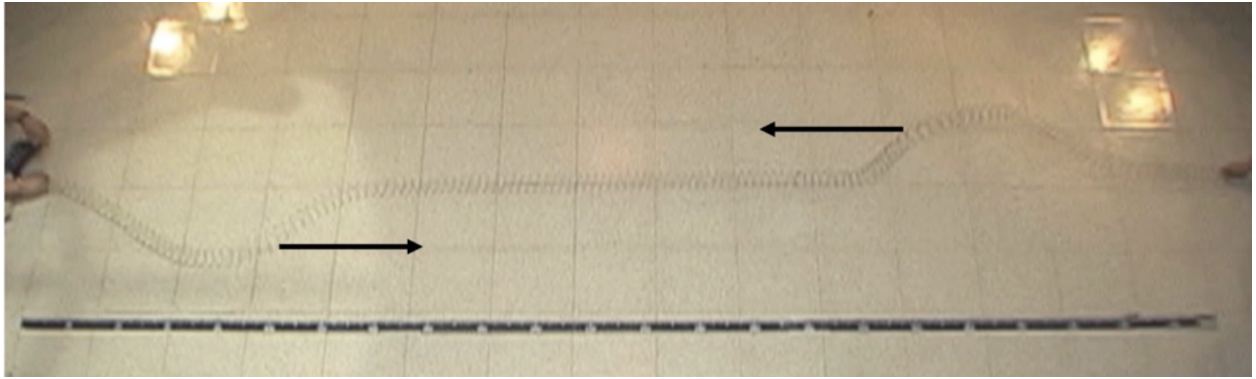
c. If you come up with two competing ideas as to what happened, brainstorm ways in which you could conduct a testing experiment to decide which of these two ideas is correct.

Send pulses in different directions is one way to test. If Hyp 1 is true, waves will be reflected back along original side. If Hypo 2 is true, waves will add to zero at center and continue along same side.

OALG 11.6.2 Test your ideas

Before you watch the video, answer the following questions:

In this video, two oppositely oriented pulses approach each other from opposite directions as shown in the snapshot below:



a. Use each explanation you developed in Activity 11.6.1 part **b.** to make a prediction about what the Slinky will look like just *after* the two pulses meet. (One prediction based on each explanation.) Sketch them on the whiteboard and paste them into the slide for your team.

Team 1

Team 2

Team 3

Team 4

b. Now that you have sketched out your predictions, watch the following video [ALG 11.6.2] to see which explanation best predicts the behavior in this video. (Which prediction was consistent with the actual outcome of this experiment?)

c. How can it be that two pulses arrive to the same place at the same time and the spring appears to be flat? Where did the energy of the system go in the instant when the spring is flat?

d. Watch the following video at [https://youtu.be/XUPHgm9dLIE]. Is the outcome consistent with the explanation you chose in part **b**?

How might everything that we did help us explain how noise canceling headphones work?

Team 1

Team 2

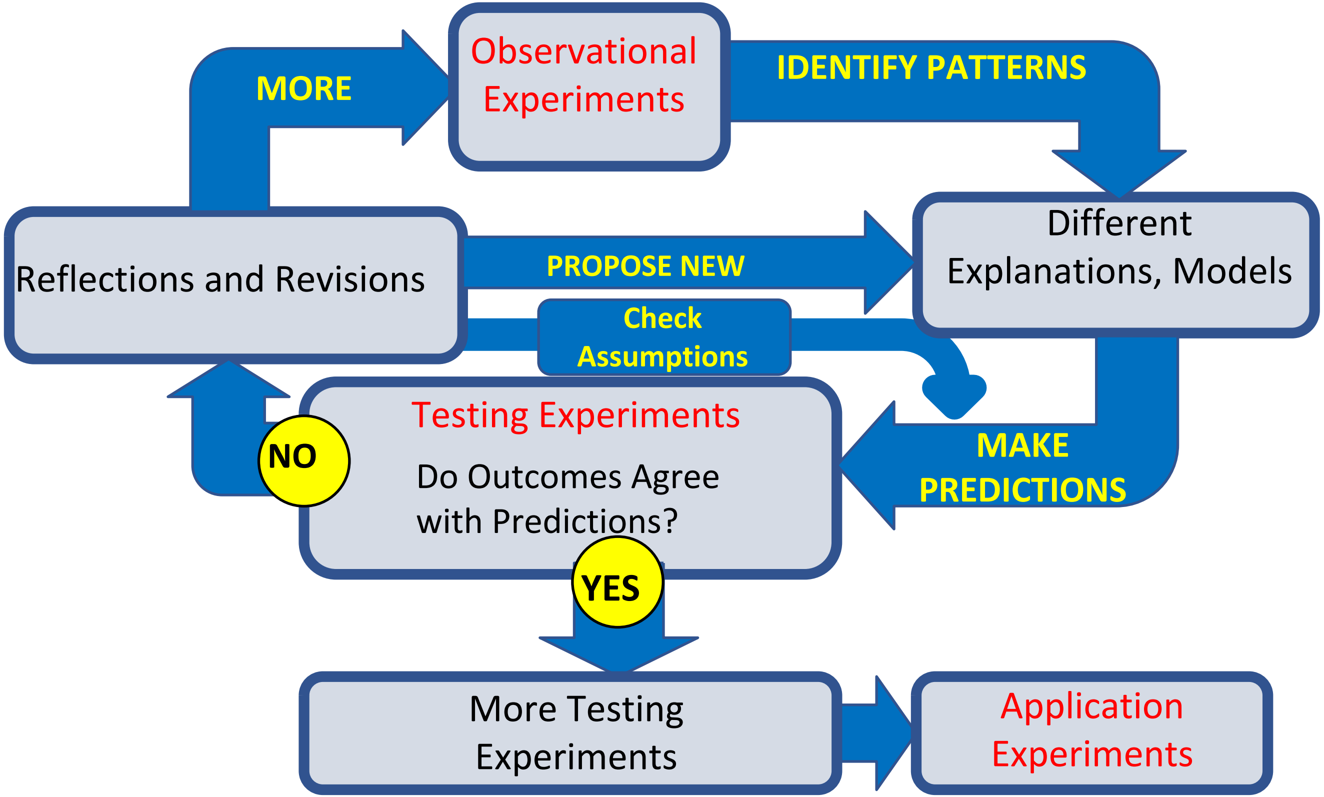
Team 3

Team 4

Let's brainstorm which elements of the process that we went through distinguish the ISLE approach from all other approaches to teaching physics.

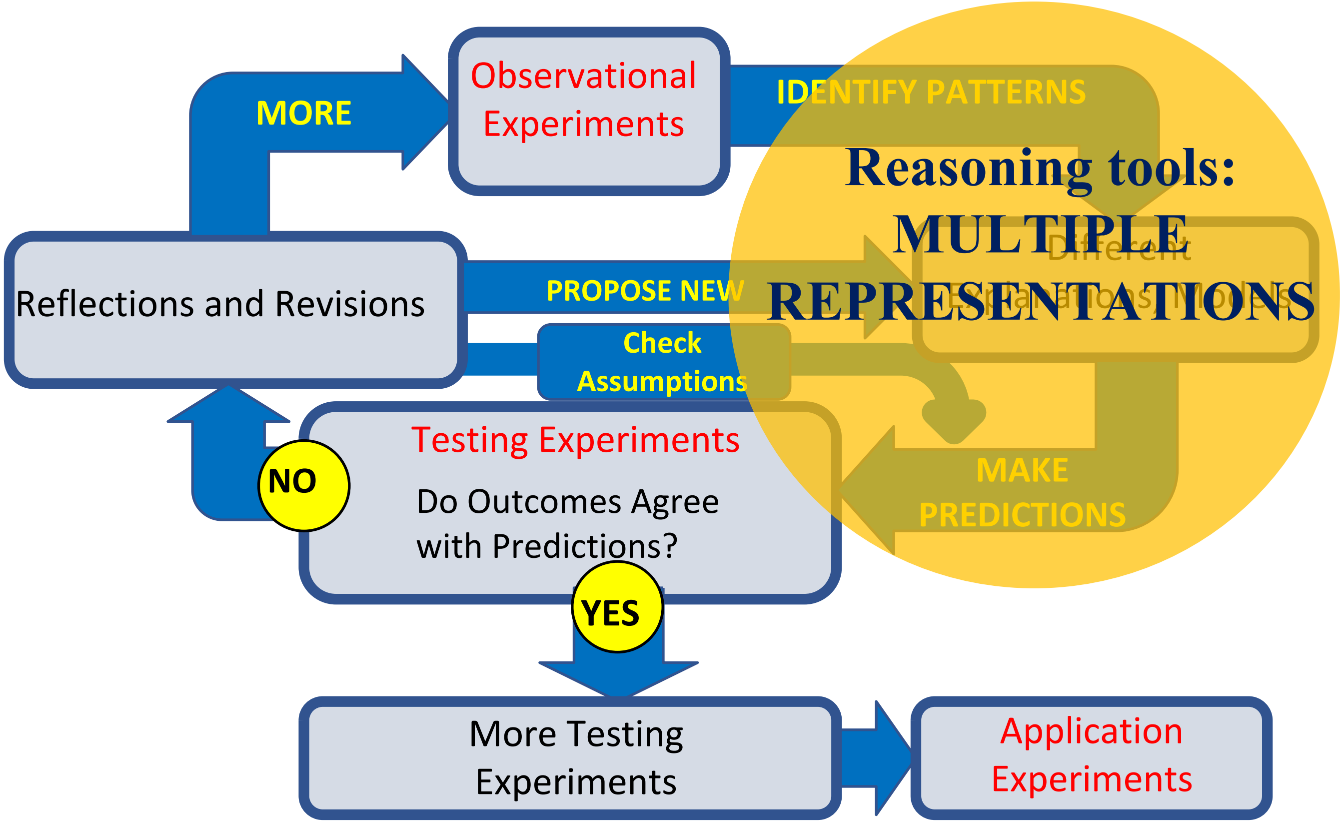
- Observe first, jargon later
- Modeling how physics is actually done
- Design their own experiments and actually perform them (instead of teacher choosing her own experiments)
- Every idea is true for the time being
- Making predictions based on (students' own!) hypotheses.
- Knowledge doesn't come from authority
- Students control the direction of the lesson
- Rejecting ideas is valued as an important part of the investigative process.
- Coming up with wild ideas (encouraged not suppressed)
- Designing testing experiments

Investigative Science Learning Environment (ISLE) process



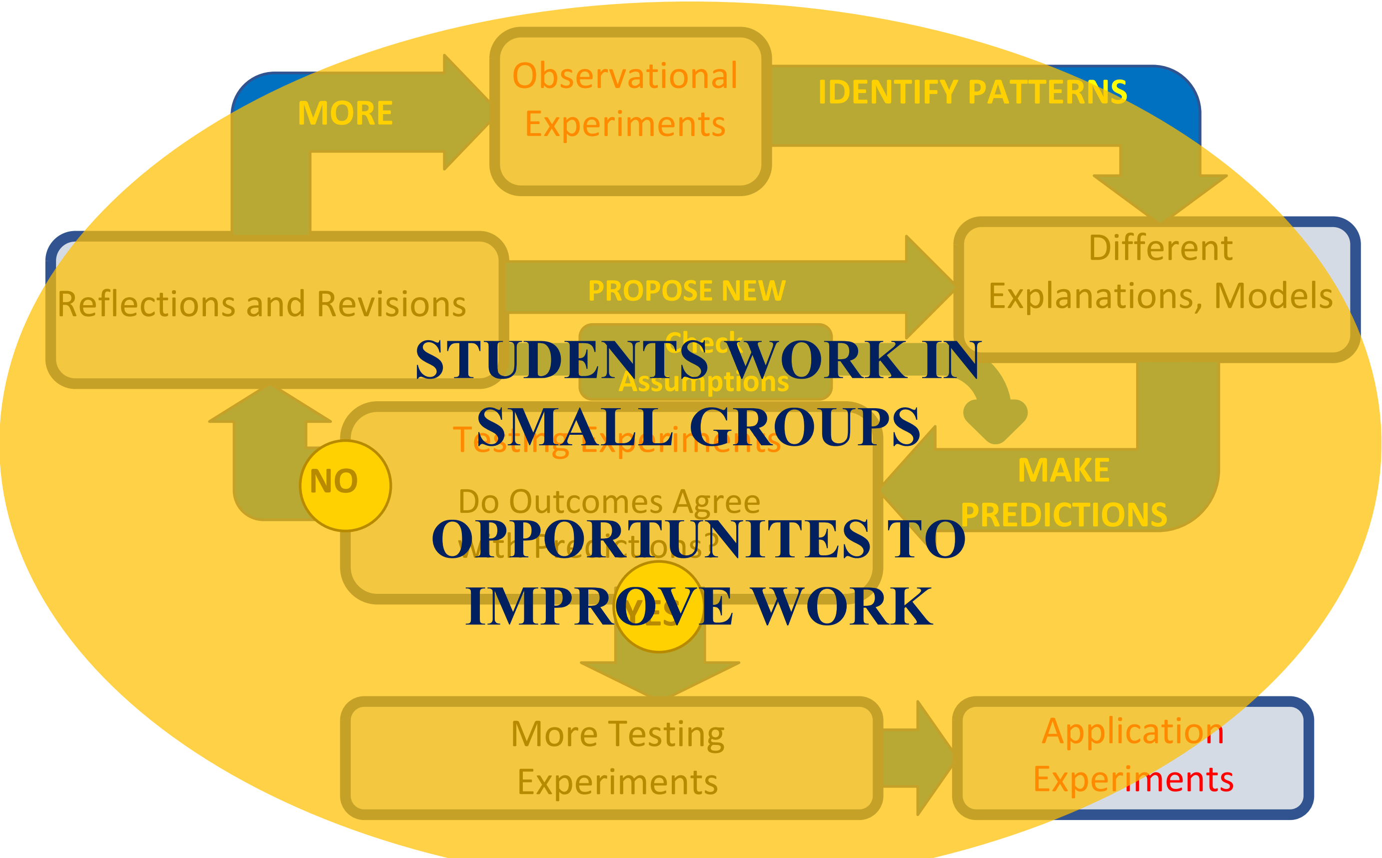
Etkina and Van Heuvelen, 2001, 2007; Etkina, 2015

The Investigative Science Learning Environment (ISLE) approach



Etkina and Van Heuvelen, 2001, 2007; Etkina, 2015

The Investigative Science Learning Environment (ISLE) approach



Etkina and Van Heuvelen, 2001, 2007; Etkina, 2015

Let's break essential elements into three categories

Logical progression of student work when constructing a concept

Classroom set-up, student discourse, expectations of behavior of both students and teachers

Physics content ideas

Logical progression of student work when constructing a concept

1. Create the “need to know” before the unit starts and return to it at the end.
2. Three roles of experiments - no demos or labs
3. Clear distinction between a hypothesis (model, explanation) and a prediction.
4. No predictions before observational experiments.
5. No “wrong” predictions - a mismatch is a win! A wrong prediction is the prediction that is not based on the hypothesis/model
6. Experiment is the ultimate judge
7. Qualitative cycle before quantitative
8. Using graphical representations to bridge phenomena and math
9. Constructing the idea/model/relation first, name second
10. No reading textbook before “getting dirty” with the phenomenon. Reading the book AFTER the cycle in class.

Classroom set-up, student discourse, expectations of behavior of both students and teachers

1. High expectations with lots of immediate feedback.
2. Students work in groups and record their work on small whiteboards or parts of the big board (having them write on the board is essential) and then present their work to the rest of the class (this varies a lot, let's talk about it). After that - teacher's "time for telling".
3. There are no misconceptions, there are testable ideas.
4. They can fix their work any time looking at other groups work
5. No fancy language at the beginning of the exploration, only use the terms if everyone agrees on their meaning.
6. Scientific abilities rubrics for self-assessment
7. Opportunity to improve work without punishment (homework, quizzes, lab reports and sometimes exams)

Physics content ideas

1. Representations other than algebra/calc
2. Systems approach
3. Force notation
4. Force language (and language in general)
5. Energy approach
6. Assumptions and their role
7. Evaluation strategies
8. New types of problems.
9. Weakest link for uncertainties

Still feels like a lot…. What are the things that you absolutely cannot omit?

1. Experience with the phenomenon and opportunity to think about it before learning the “right answer”. Innovation-efficiency corridor.
2. No predictions before observational experiments. Three types of experiments.
3. Students work in groups first. All ideas are welcome as long as they are experimentally testable.
4. Multiple representations as reasoning tools.
5. Opportunities to improve work (or some part of it) with no punishment.

Still a lot… Can we cut some more?

If a student can tell you how they know what they know (and it is not what they read in the book or heard from you) and why they believe in it citing experimental evidence and coherence with other knowledge and they are not looking for the right answer but for ways to figure it out themselves (even if it takes multiple trials), you are on the path to ISLE implementation.