The ISLE approach: Essential elements that cannot be omitted

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Question: How do sound canceling headphones work?

OALG 11.6.1 Observe and explain

a. Go to [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

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 2

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 two pulses appear to meet in the middle and double in size. Afterwards, the two individual pulses reappear.

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

We're not sure yet if those two pulses bounce off each other or if they continue moving in the same direction as before. We think the two pulses could be adding together when they meet in the middle.

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.

We can send two pulses of different sizes towards each other.

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?

1. We see that the pulses meet and combine in the middle and then continue on to the other side.
2. We see that the pulses meet and combine in the middle and then bounce back.

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

The pulses have bounced off each other or passed 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

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?

Become one, height of pulse increases, add together

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

Going through each other or reflect off 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.

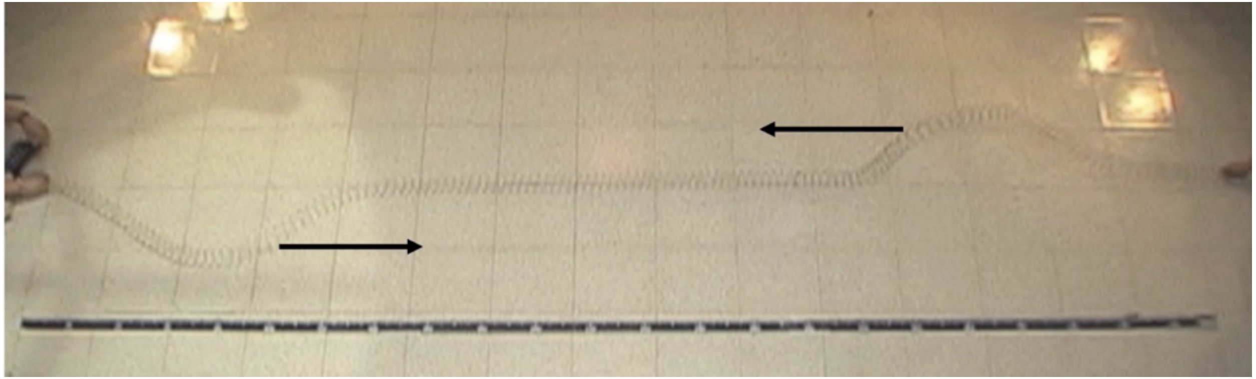
Exaggerate the different pulse sizes (height, width, up/down direction) to see if they reflect or go through. EE: What does it mean to do a testing experiment?

Choose an idea to test, make a prediction based on the idea, do experiment, see if outcome matches prediction. The outcomes predicted from the two ideas should be different.

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 [Investigating unequal pulses]. 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.

“Need to know” (headphones)

Testing hypothesis for making predictions. All explanations are accepted, then they have to been tested

No wrong explanations at first . Students build their own ideas and feel the need to explore

Accept an explanation/idea as true and that come up with experiment to test it.

There is no prediction for the observational experiment.

Observational experiment: Start with an observation (the spring), not explaining anything yet

Students must design an experiment to test competing explanations for the observation

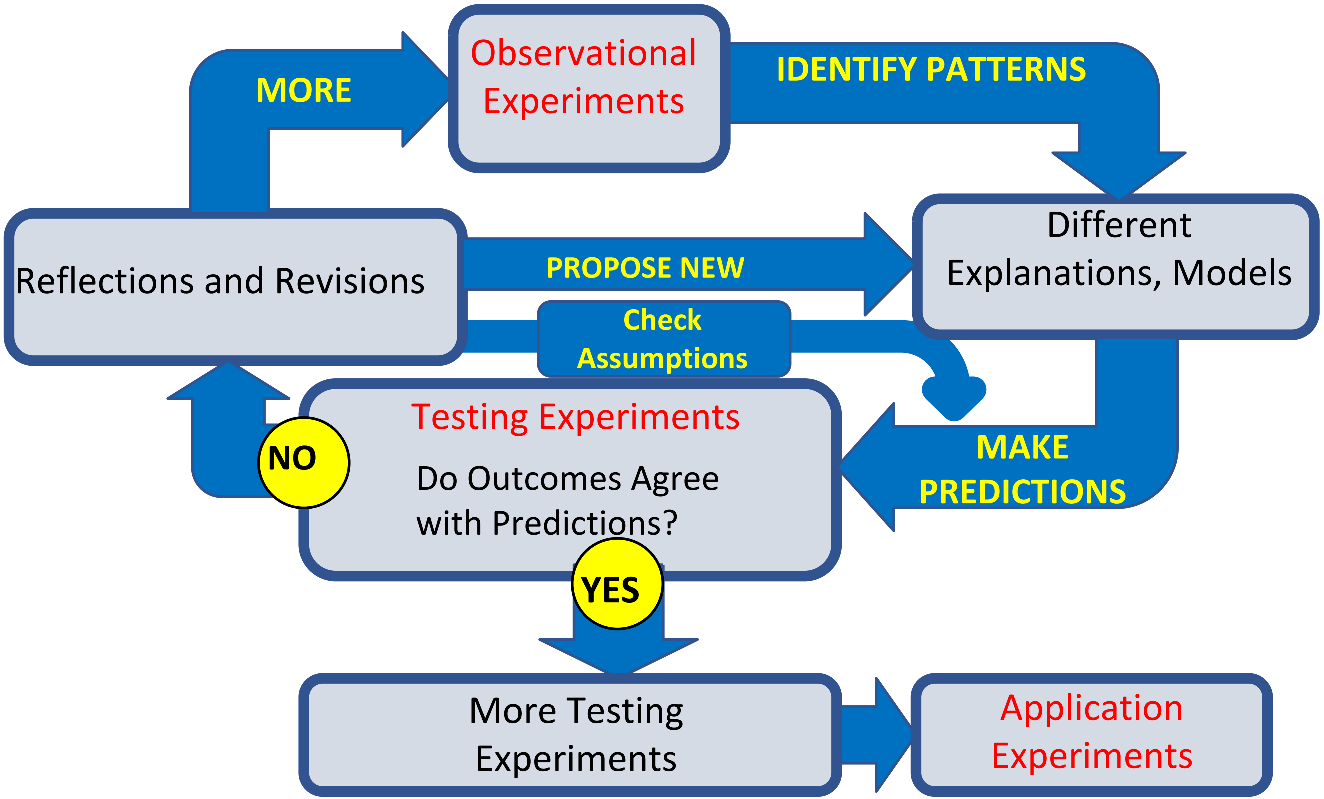
Predictions. “What will happen if they bounce?” “What will happen if they go through?”

The role of the experiment (testing experiment vs. observational one): in other teachings normally we collect data

Save vocabulary for later, use simple words to describe first

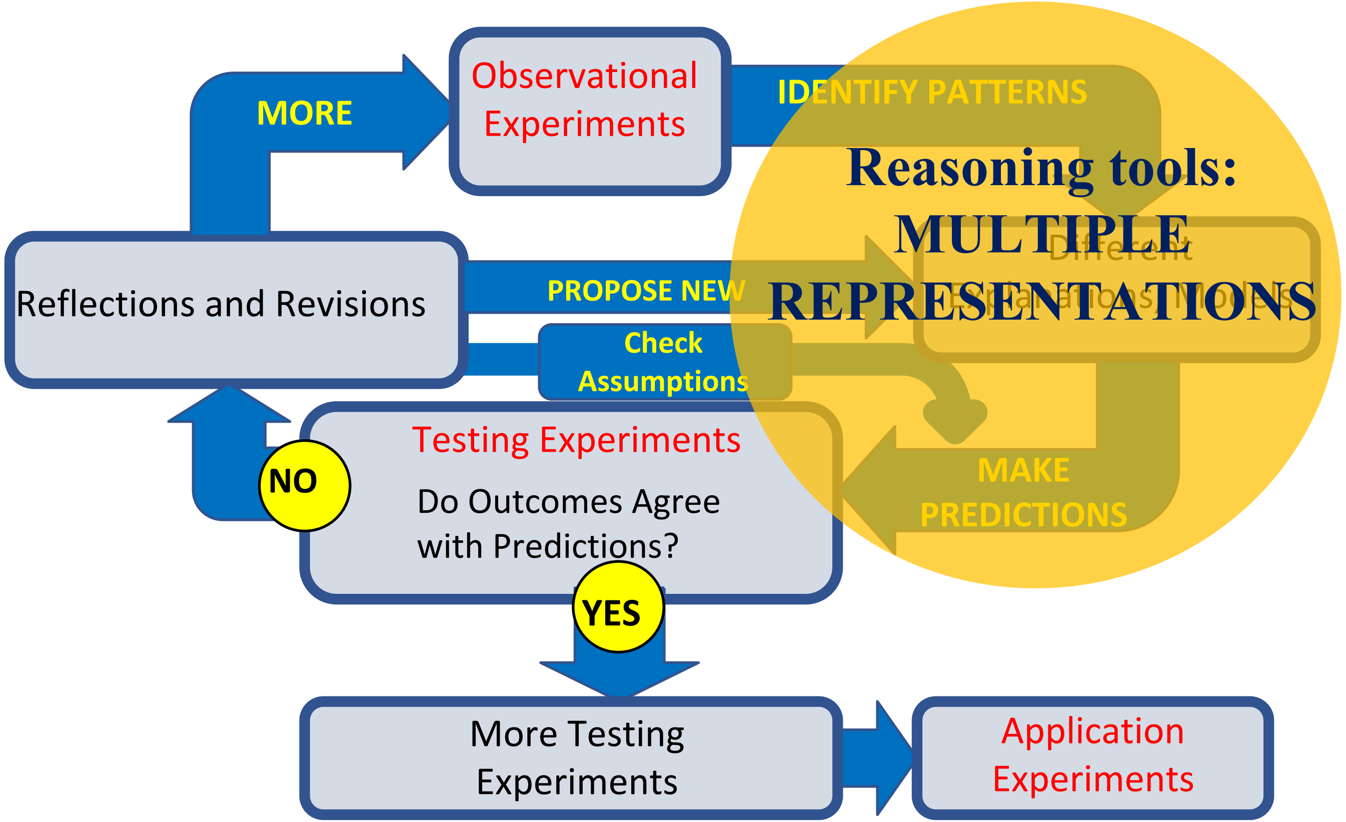
Observe a phenomenon, create multiple explanations for the phenomenon. Record observations first, the create explanations.

Investigative Science Learning Environment (ISLE) process



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

The Investigative Science Learning Environment (ISLE) approach



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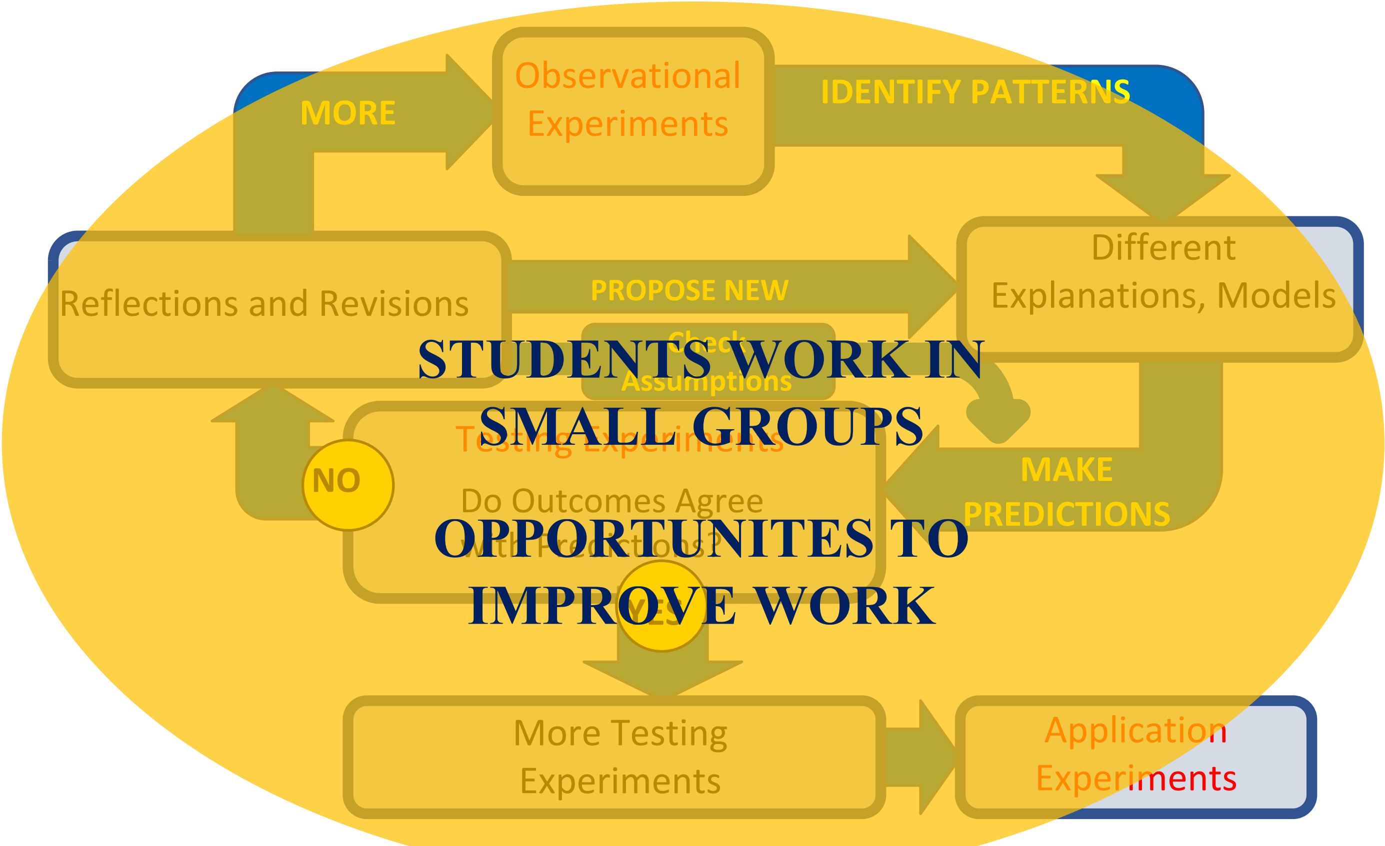

Etkina and Van Heuvelen, 2001, 2007; Etkina, 2015

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 knowledge for teaching (CKT)

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 knowledge for teaching (CKT)

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 and then share to build a community. 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 your students 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 a path to ISLE implementation.