



RUTGERS

Graduate School of Education

The Investigative Science Learning Environment  
approach (ISLE):  
When learning physics mirrors doing physics

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# Physics Education Research

## Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses

Richard R. Hake<sup>a)</sup>

*Department of Physics, Indiana University, Bloomington, Indiana 47405*

(Received 6 May 1996; accepted 4 May 1997)

**1998**

## Where's the evidence that active learning works?

**2006**

Joel Michael

*Department of Molecular Biophysics and Physiology, Rush Medical College, Chicago, Illinois*

## Active learning increases student performance in science, engineering, and mathematics

**2014**

Scott Freeman<sup>a,1</sup>, Sarah L. Eddy<sup>a</sup>, Miles McDonough<sup>a</sup>, Michelle K. Smith<sup>b</sup>, Nnadozie Okoroafor<sup>a</sup>, Hannah Jordt<sup>a</sup>, and Mary Pat Wenderoth<sup>a</sup>



## Secondary analysis of teaching methods in introductory physics: A 50 k-student study

**2016**

Joshua Von Korff<sup>a)</sup>

*Department of Physics and Astronomy, Georgia State University, Atlanta, Georgia 30303*

Benjamin Archibeque and K. Alison Gomez

We engage students in active learning.

But what should students learn?

# OECD: The future of education and skills

## *Education 2030 (2018)*

Organization for Economic Cooperation and Development

Position paper on what knowledge, skills, attitudes and values today's students will need to thrive and shape their world in future.



# OECD: The future of education and skills

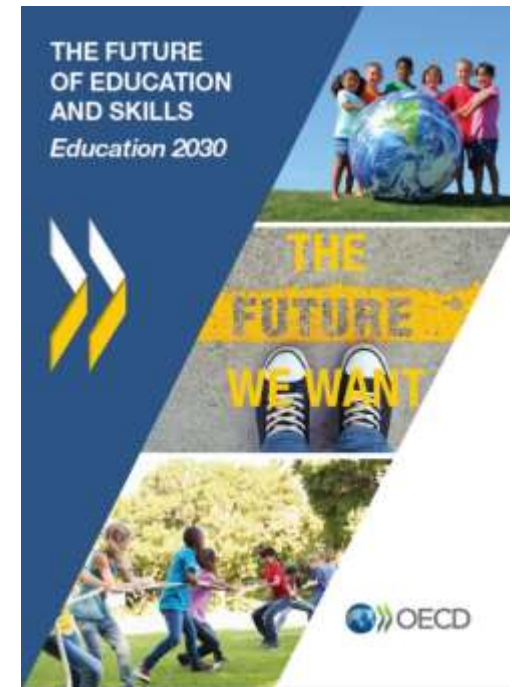
## *Education 2030 (2018)*

Position paper on what knowledge, skills, attitudes and values today's students will need to thrive and shape their world in future.

Disciplinary knowledge will continue to be important....

Epistemic knowledge, or knowledge about the disciplines, such as knowing how to think like a mathematician, historian or scientist, will also be significant, enabling students to extend their disciplinary knowledge.

Procedural knowledge is acquired by understanding how something is done or made .... It typically develops through practical problem-solving...



# Next Generation Science Standards (US, 2013)

“Any education that focuses predominantly on the detailed products of scientific labor—the facts of science—without developing an understanding of HOW those facts were established MISREPRESENTS science.”

# Three of the major challenges of today's physics education

1. How to achieve active engagement of students at all levels of teaching/learning process?
2. How to help students develop epistemic knowledge of the discipline (how to think like a physicist)?
3. How to ensure that all students feel welcome in a physics course, enjoy learning physics, and want to pursue STEM careers?

What is the ISLE approach?

The Investigative Science Learning Environment  
approach to learning and teaching physics





Rutgers  
University



Florida International  
University

# A simple example of the ISLE approach in action

OALG 1.1.2a

© G. Planinsic and E. Etkina (2020)

# What did you observe?

State in simple words that a 5 year-old can understand.

Glass got wet on the outside.

We can see water droplets on the outside.

Come up with a “wild idea” of where the water came from and to design an experiment to test their idea.

Wild idea: Water goes out from the top and settles on the outside.

Experiment: Take a glass filled with cold water and cover it.

Prediction based on the wild idea: It should not get wet.



# Where did the water come from?

~~Goes out from the top and settles on the outside~~

Sips through the glass.

Take an empty glass, put it into a cold place and then take out. It should not get wet.







# Where did the water come from?

~~Goes out from the top and settles on the outside~~

~~Sips through the glass~~

The material of the glass "sweats" and the water comes from the material of the glass.

Pour another cold liquid into the glass. There should still be water on the outside.



# Where did the water come from?

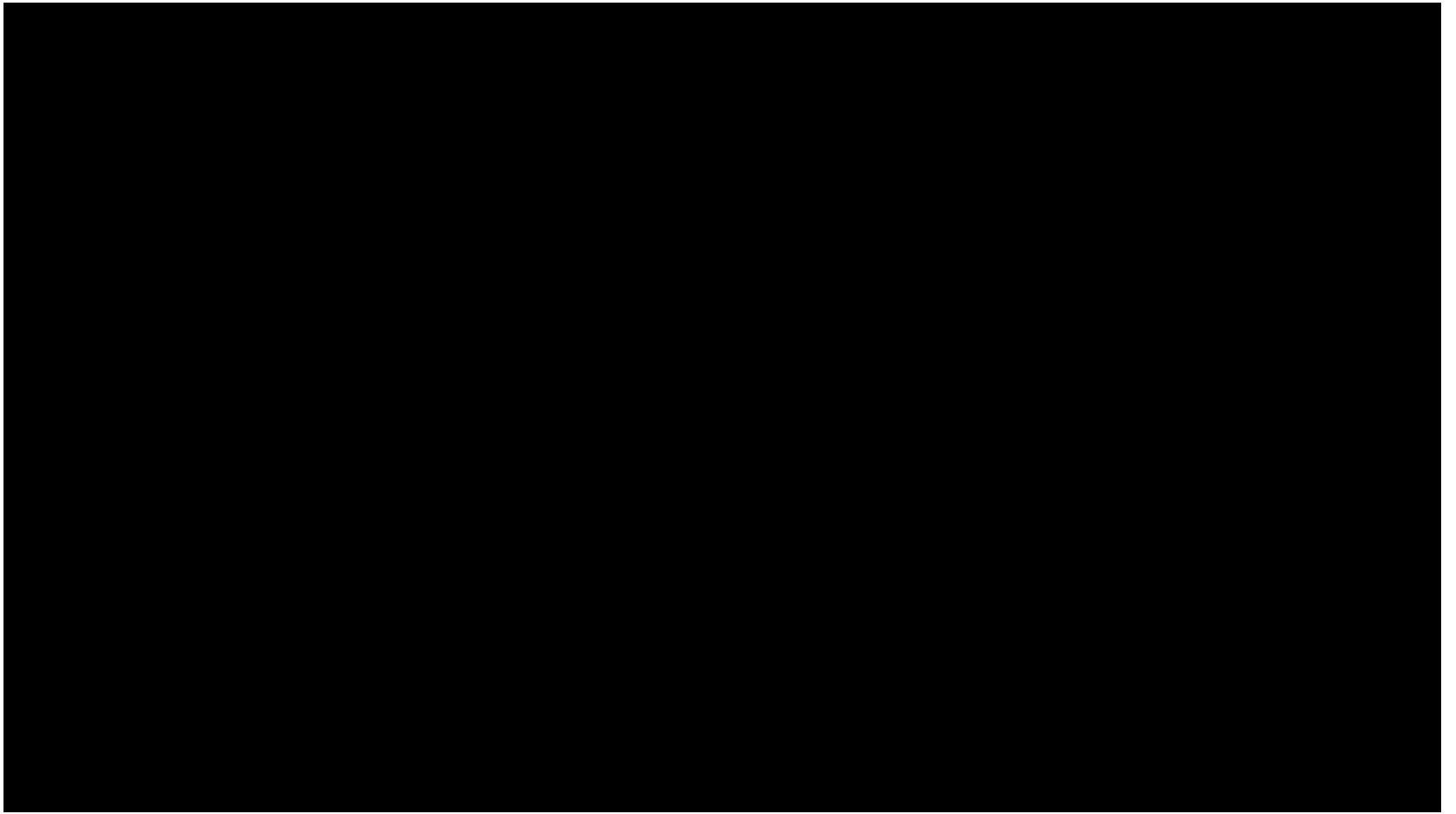
~~Goes out from the top and settles on the outside~~

~~Sips through the glass~~

The glass "sweats" **Failed to reject**

Water comes from the outside air.

Use a scale. If "glass sweats", the mass should stay the same or decrease. If the water comes from the outside air, the mass should increase.





WatAir Dew Harvesting System Provides Safe Drinking Water



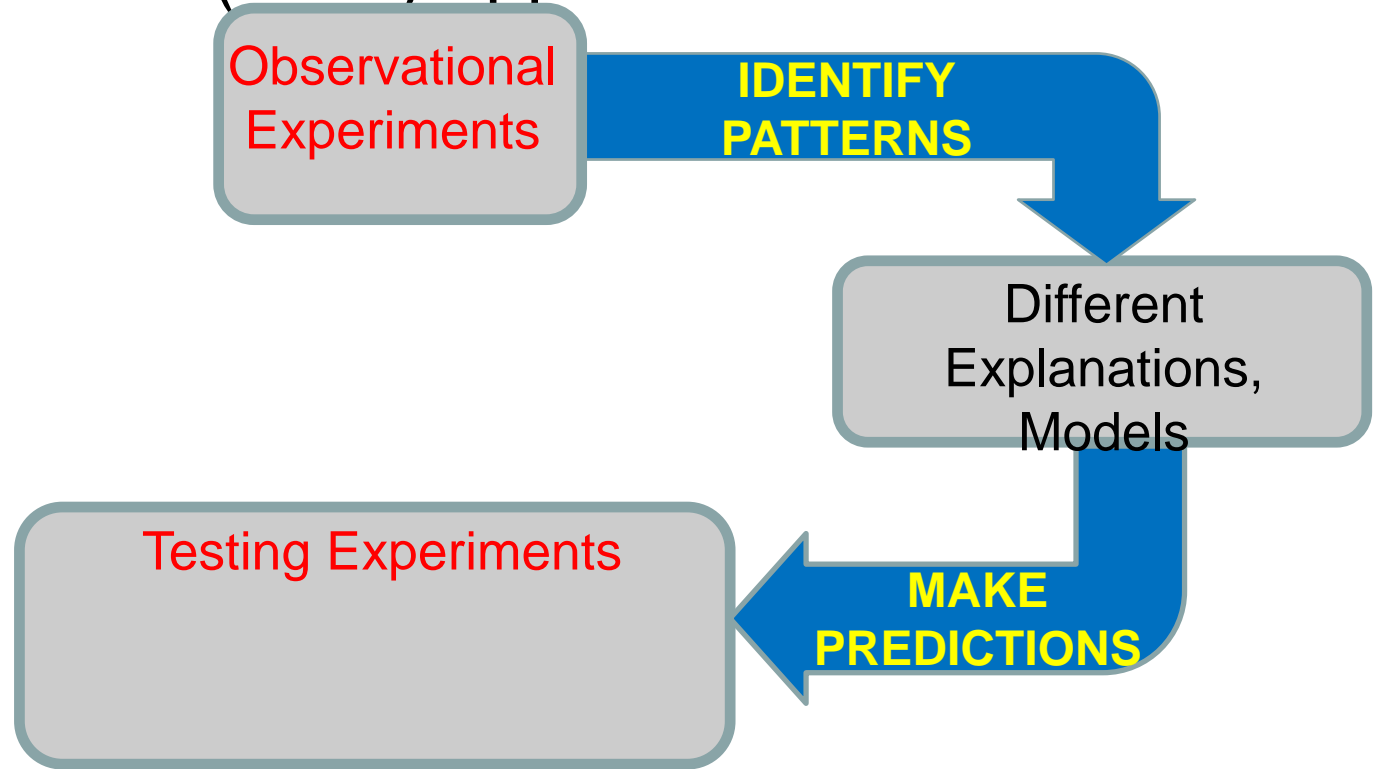
# The Investigative Science Learning Environment (ISLE) approach

Observational  
Experiments

IDENTIFY  
PATTERNS



# The Investigative Science Learning Environment (ISLE) approach



Water coming from the top, sipping through,  
coming from the material, coming from the outside.

# The Investigative Science Learning Environment (ISLE) approach

Observational Experiments

**IDENTIFY PATTERNS**

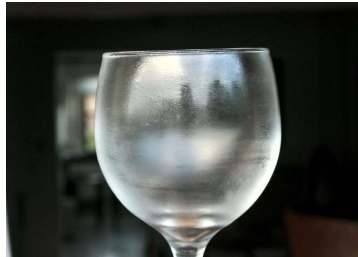
Different Explanations, Models

Testing Experiments

Do Outcomes Agree with Predictions?

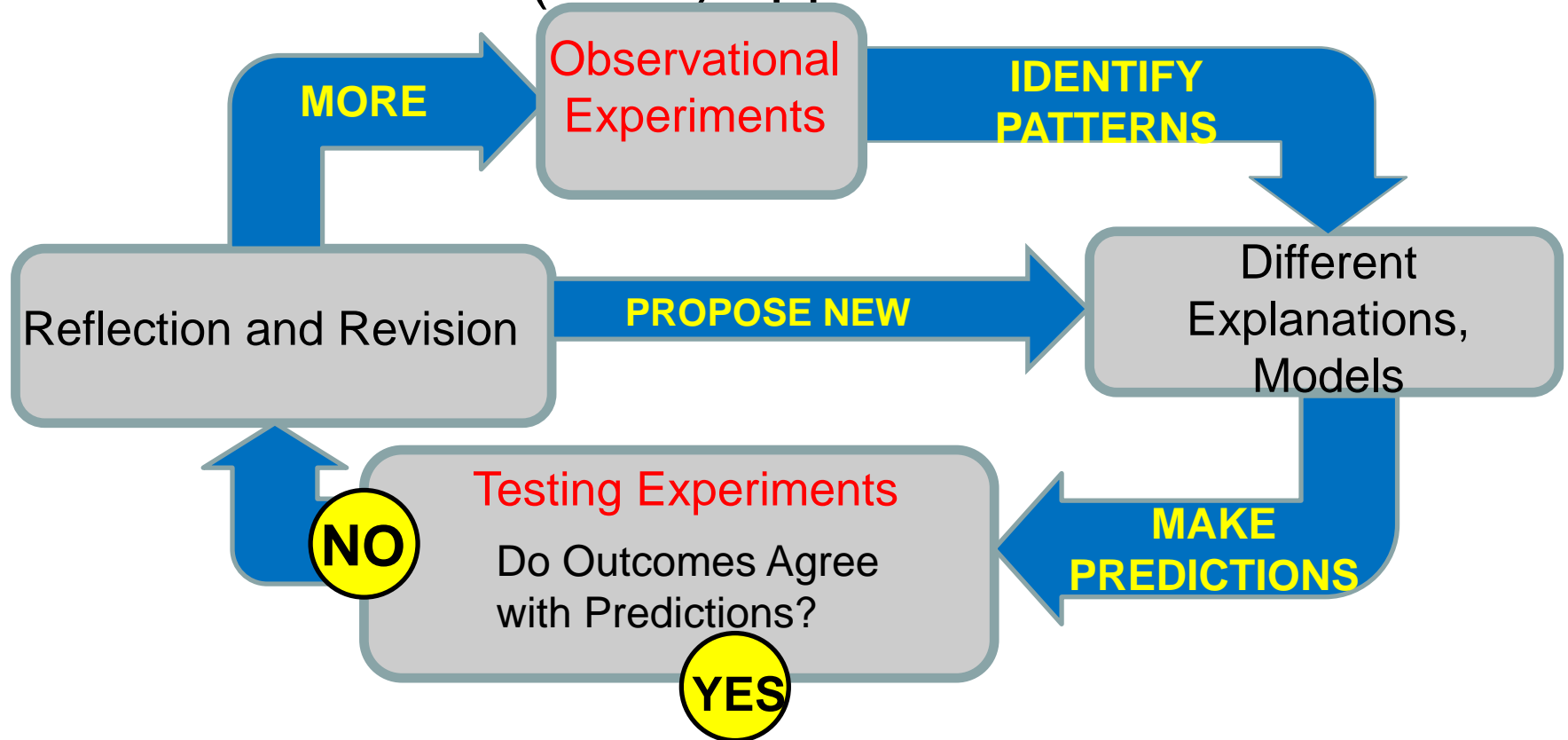
**MAKE PREDICTIONS**

**NO**

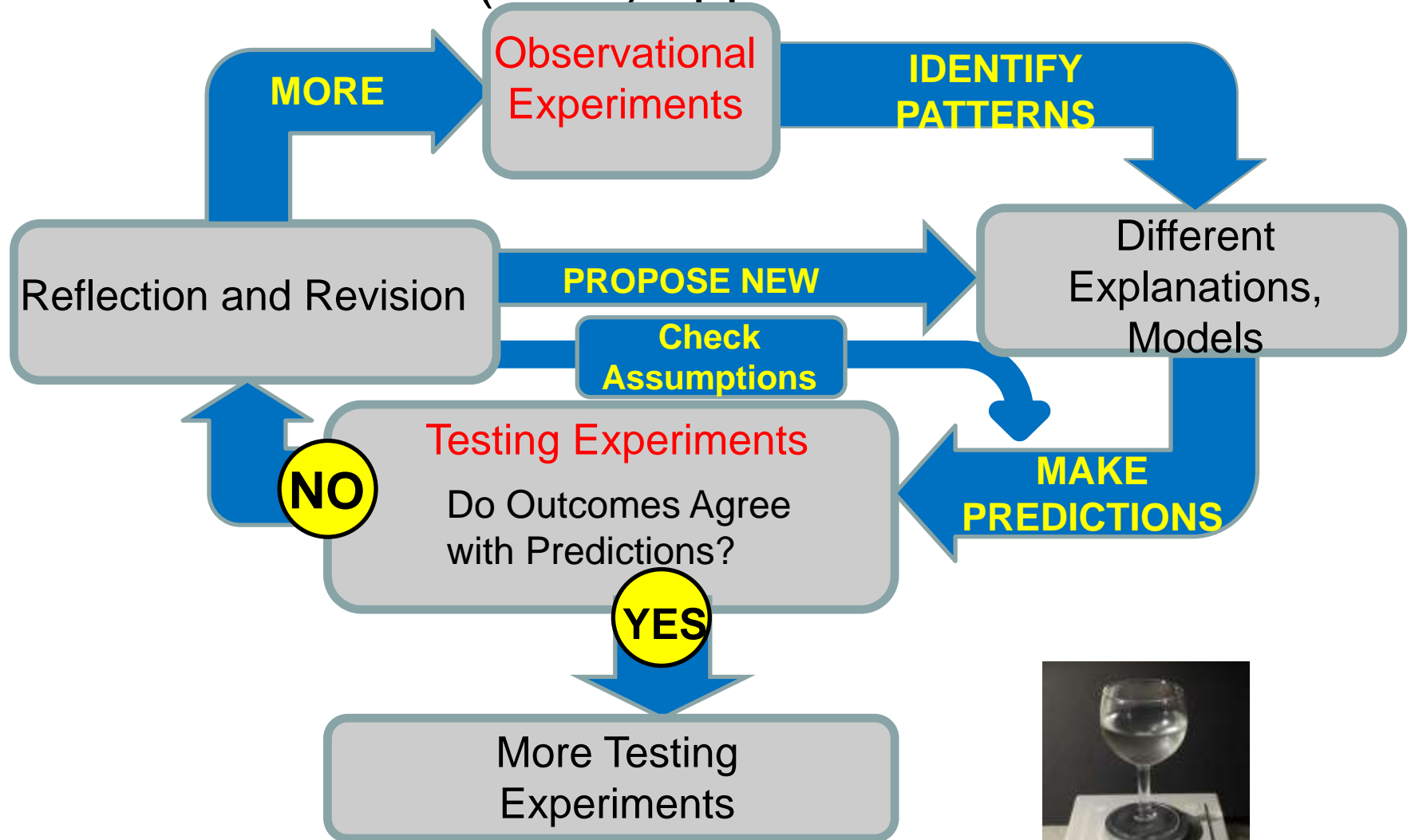




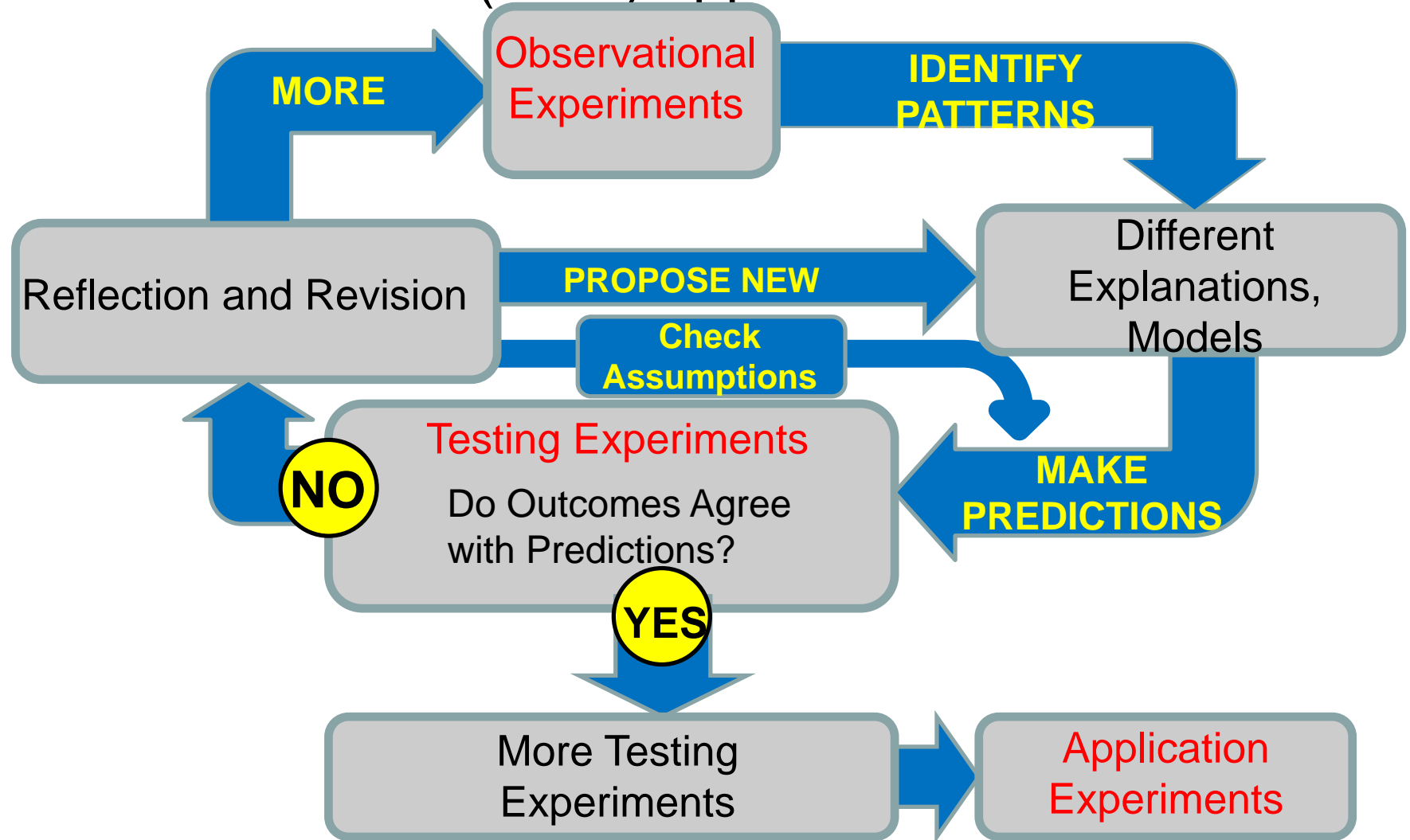
# The Investigative Science Learning Environment (ISLE) approach



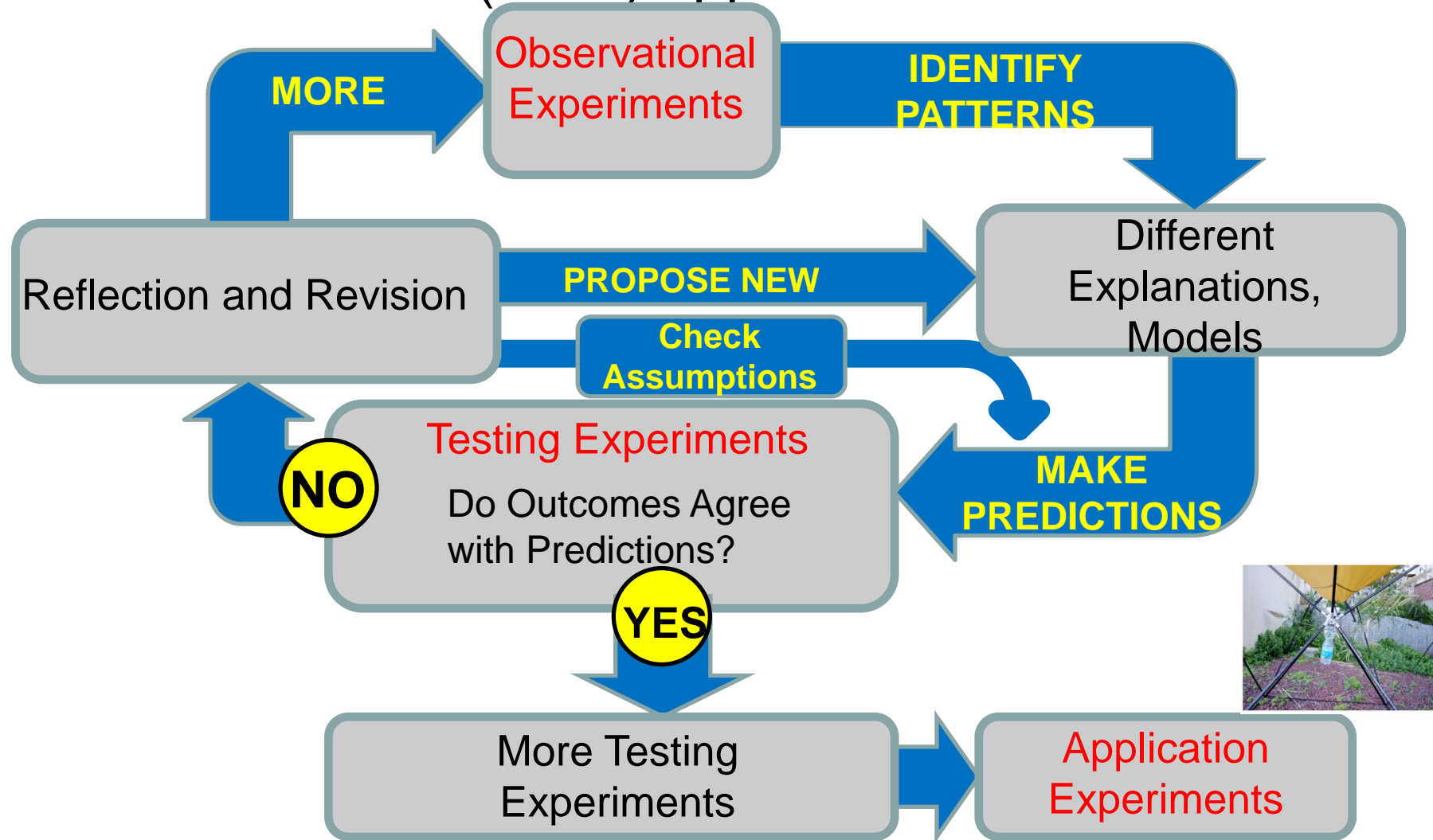
# The Investigative Science Learning Environment (ISLE) approach



# The Investigative Science Learning Environment (ISLE) approach



# The Investigative Science Learning Environment (ISLE) approach



That was easy, what about a more difficult idea?

- Imagine that your students learned KMT. They know that air consists of molecules.
- Imagine that your students learned electricity, magnetism, and electromagnetic induction. They know about conductors and dielectrics, they are familiar with ionization.
- Imagine that they learned wave optics and they know the electromagnetic wave model of light.
- For them at this point light behaves as a wave of alternating electric and magnetic fields.

Now they observe the following experiment:



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The first idea that the students usually propose is that UV light ionizes air and ionized air is a conductor. That is why the electroscope discharges.

If this is correct, then UV light should discharge positively charged electroscope as well.

It looks like it is not a good explanation. Maybe UV light kicks electrons out of the zinc plate?

If this is correct, then the neutral electroscope should become positively charged when UV light shines on it.

OALG 27.2.3a

© G. Planinsic and E. Etkina (2020)



Why didn't the electroscope get charged? Oh, we assumed that if the electrons get ejected, they leave the electroscope. Maybe the electroscope does get charged but the electrons come back to the positively charged electroscope... How can we test that?

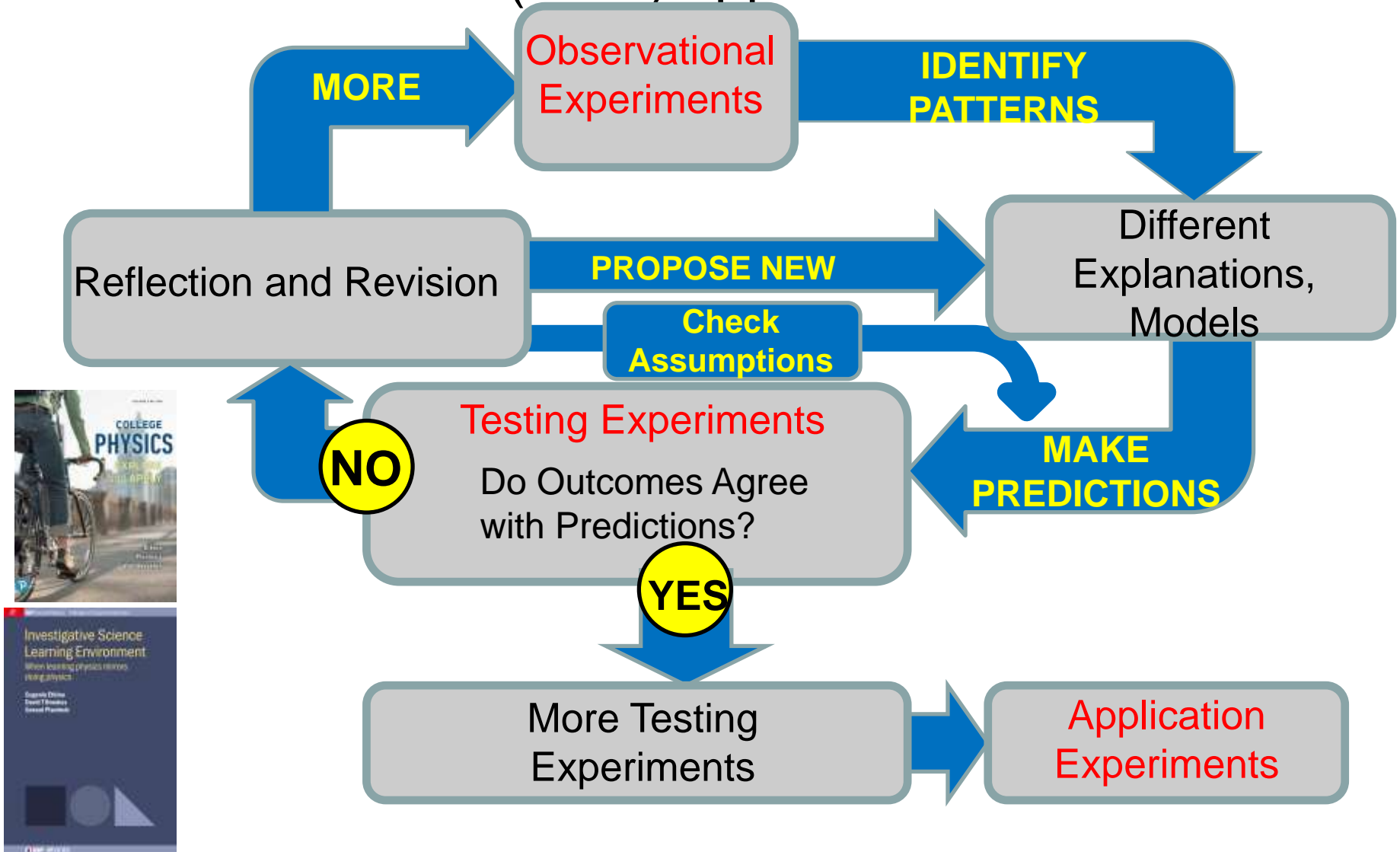
OALG 27.2.3b

If our reasoning is correct, then the electroscope on which we shone UV light should be charged positively.

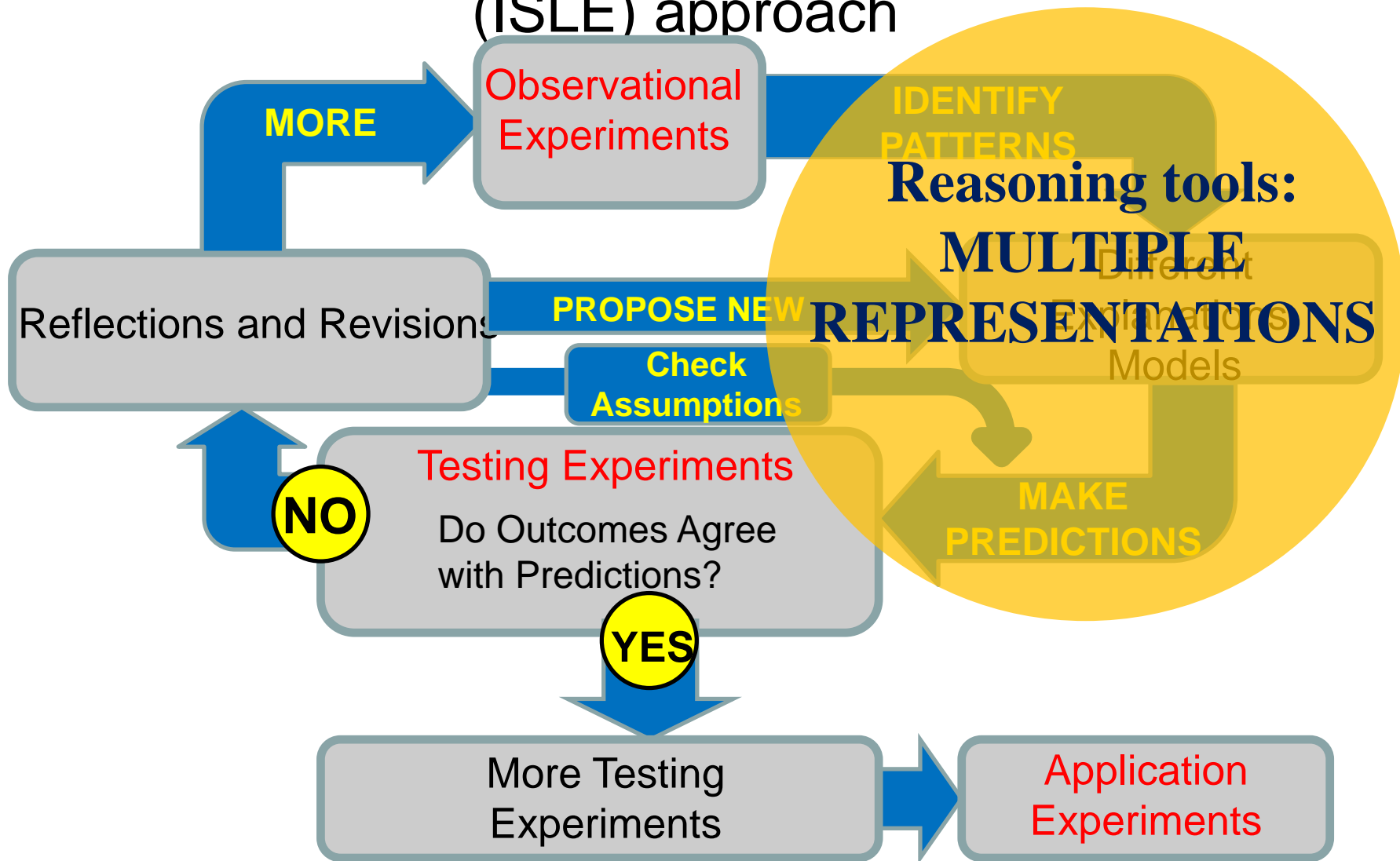
How can we check this?

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# The Investigative Science Learning Environment (ISLE) approach



# The Investigative Science Learning Environment (ISLE) approach



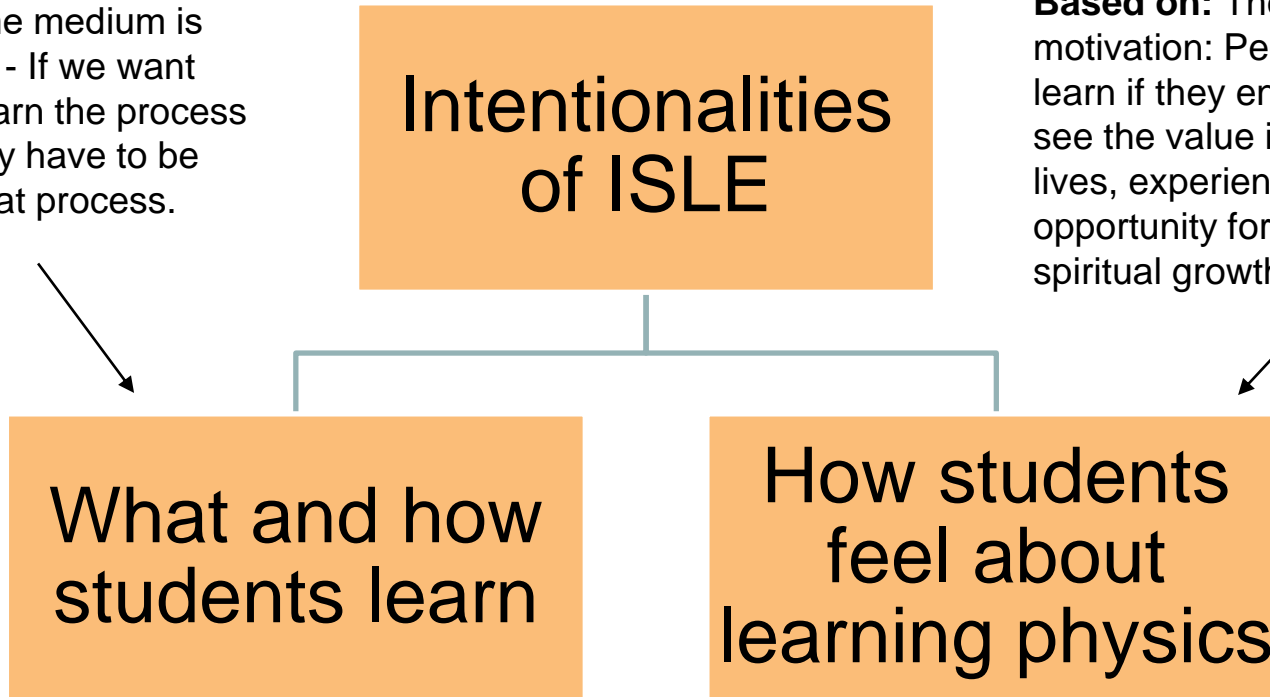
# The Investigative Science Learning Environment (ISLE) approach



# The ISLE approach– an intentional approach to curriculum design

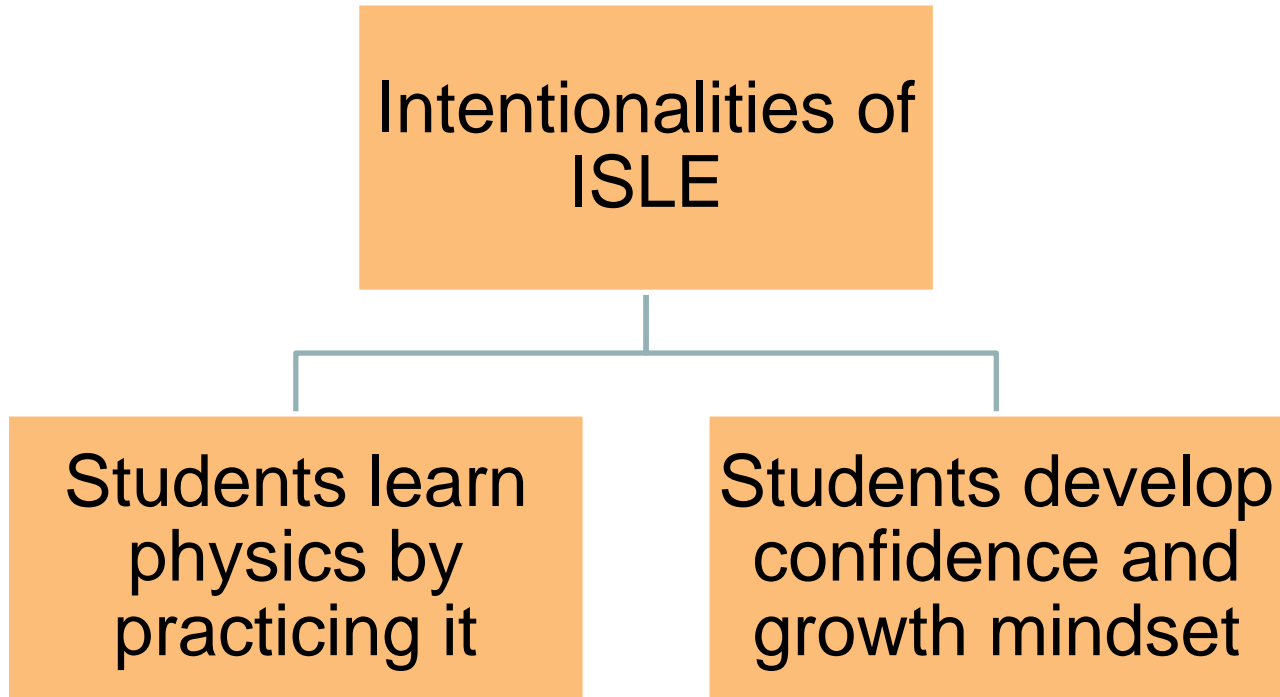
**Based on:** “the medium is the message” - If we want students to learn the process of physics they have to be engaged in that process.

**Based on:** Theories of human motivation: People will only learn if they enjoy it (c.f. Flow), see the value in their personal lives, experience learning as an opportunity for mental and spiritual growth.

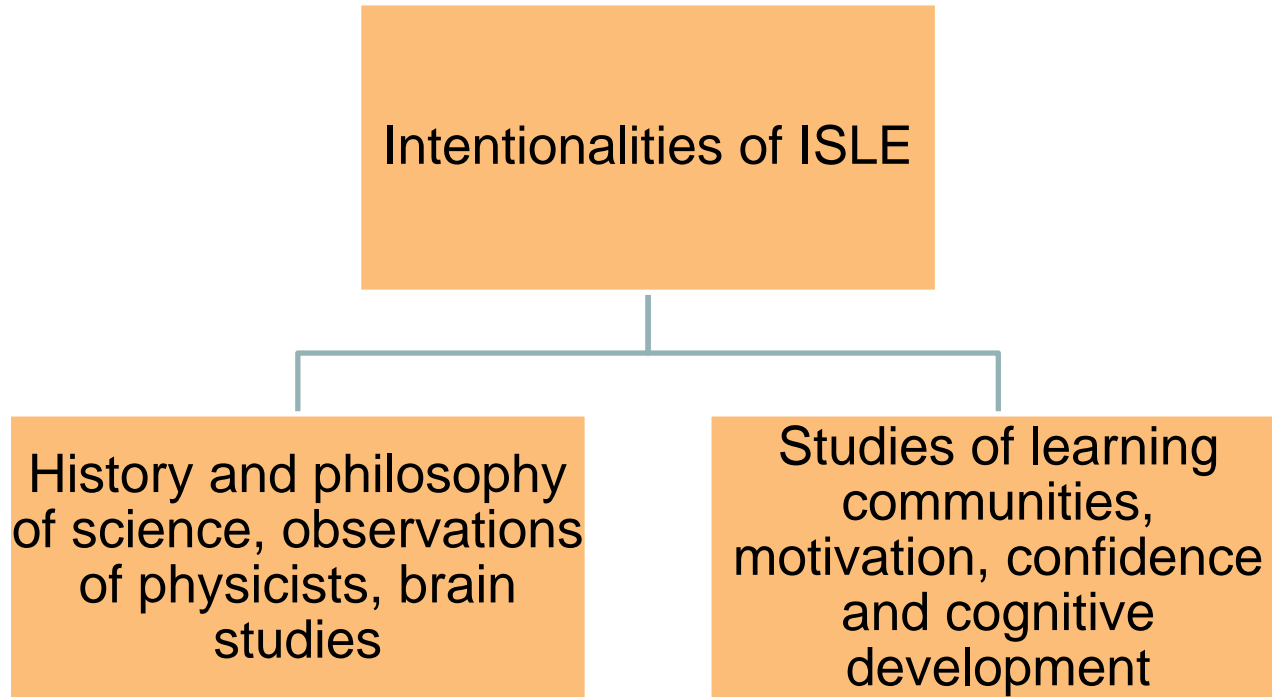


**Intentionality: the product of knowledge cannot and **should not be separated from the means by which it came to be known.****

# The ISLE approach– an intentional approach to curriculum design



# The ISLE approach– an intentional approach to curriculum design



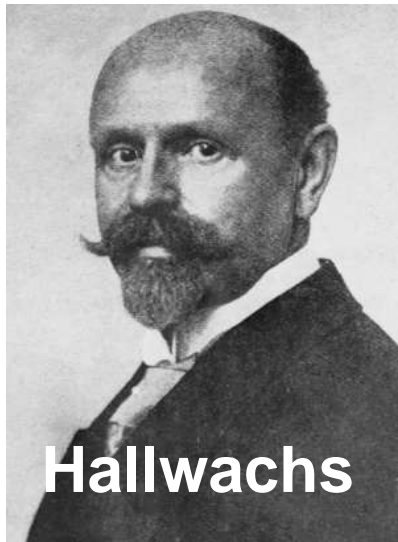


# History of science: Photoelectric effect



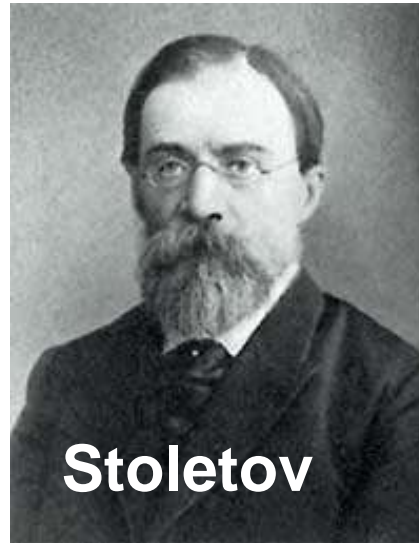
**Hertz**

**Accidental  
observation**



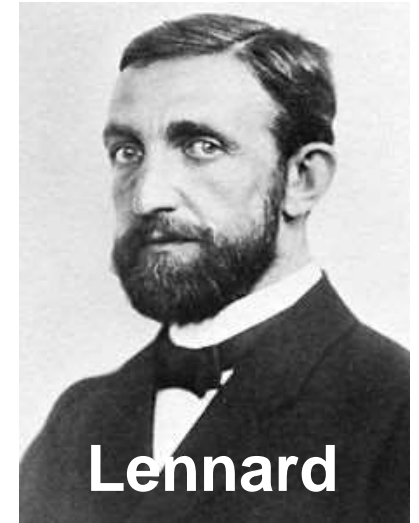
**Hallwachs**

**Qualitative observational  
experiments**



**Stoletov**

**Quantitative observational  
experiments and explanations**

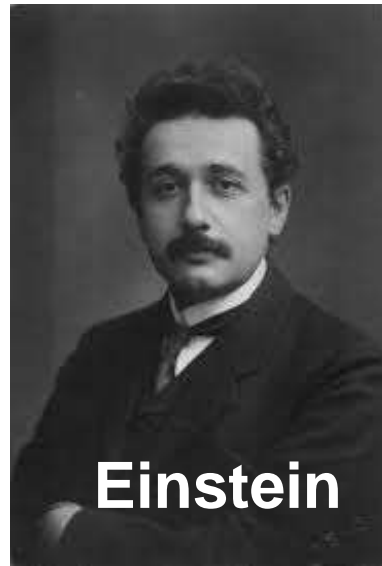


**Lenard**



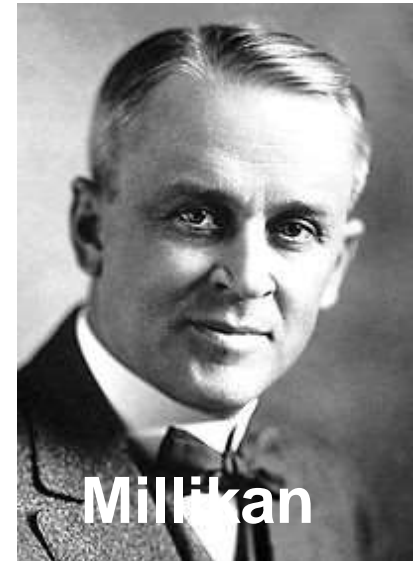
**Planck**

**Assumption**



**Einstein**

**Explanation**



**Millikan**

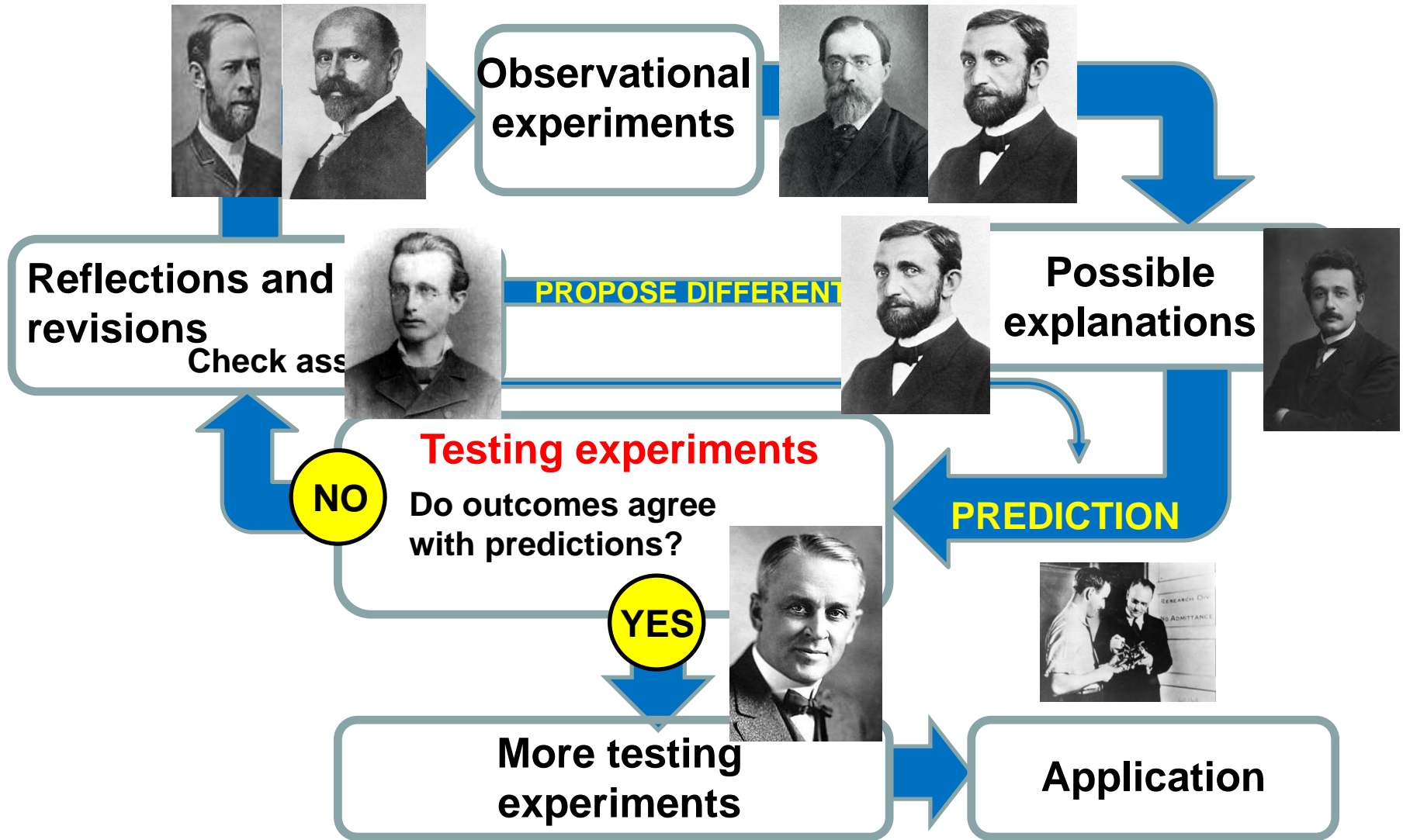
**Testing  
experiment,  
prediction,  
outcome**



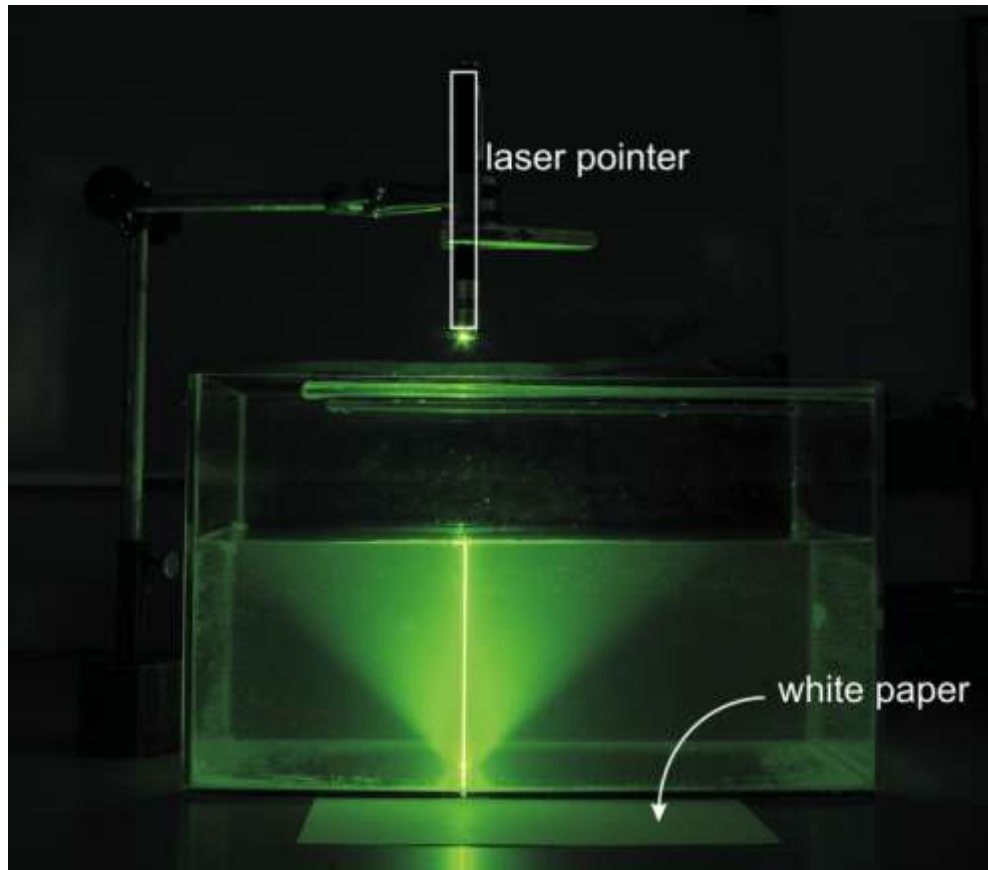
**Kubetsky, Iam  
Salzman**

**Application  
(photomultiplier tube)**

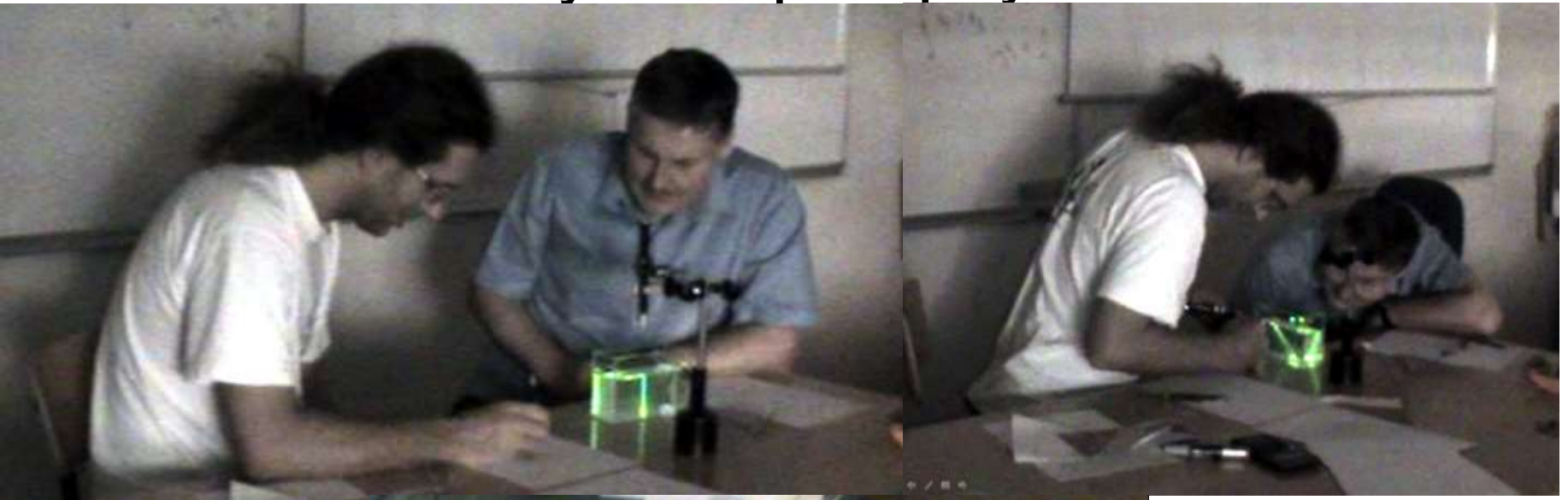
# Investigative Science Learning Environment - ISLE



How do we know that physicists actually work this way in real time?

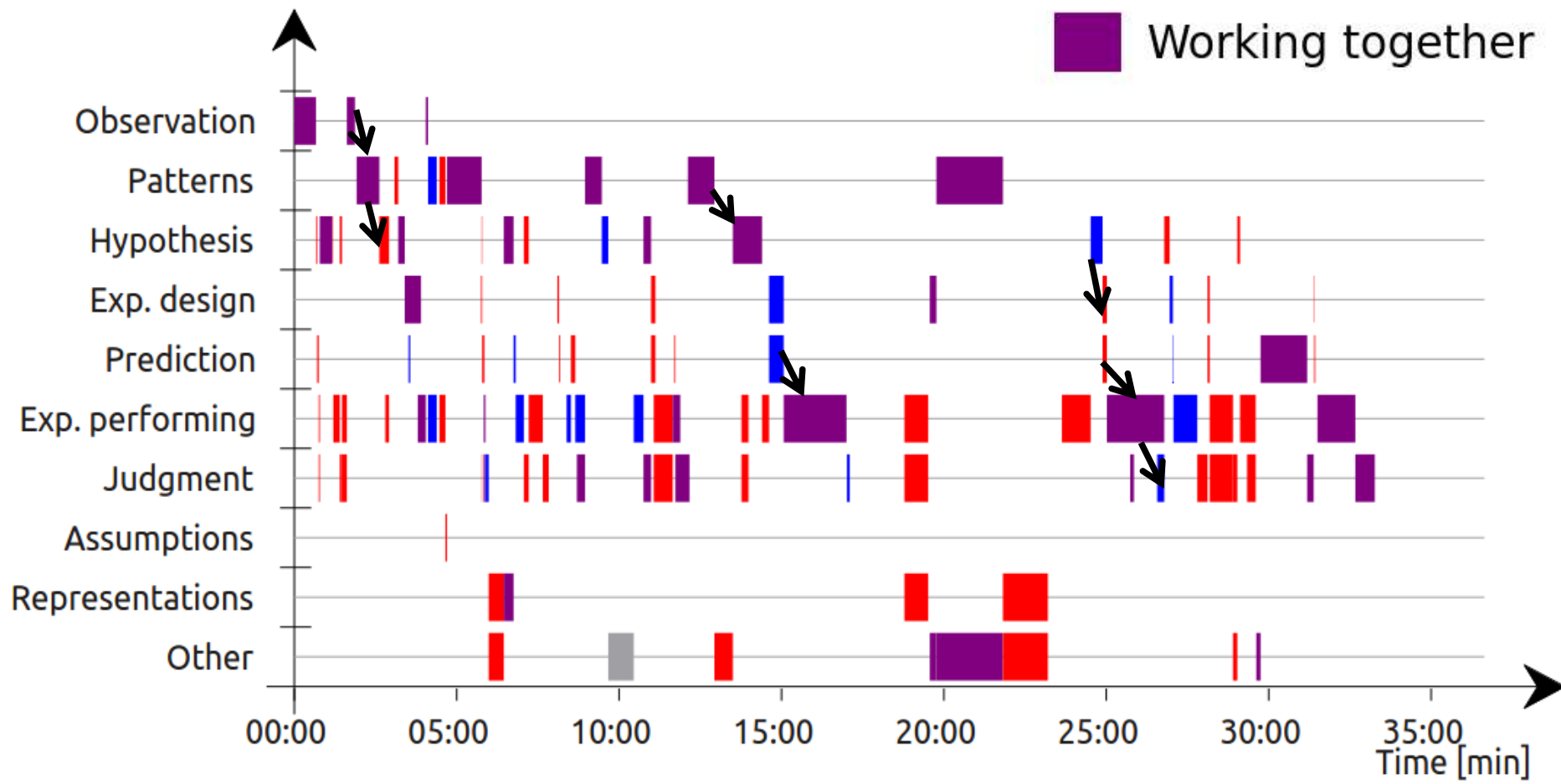
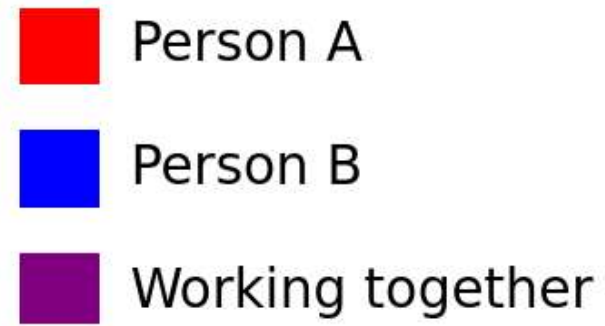


# Study of expert physicists

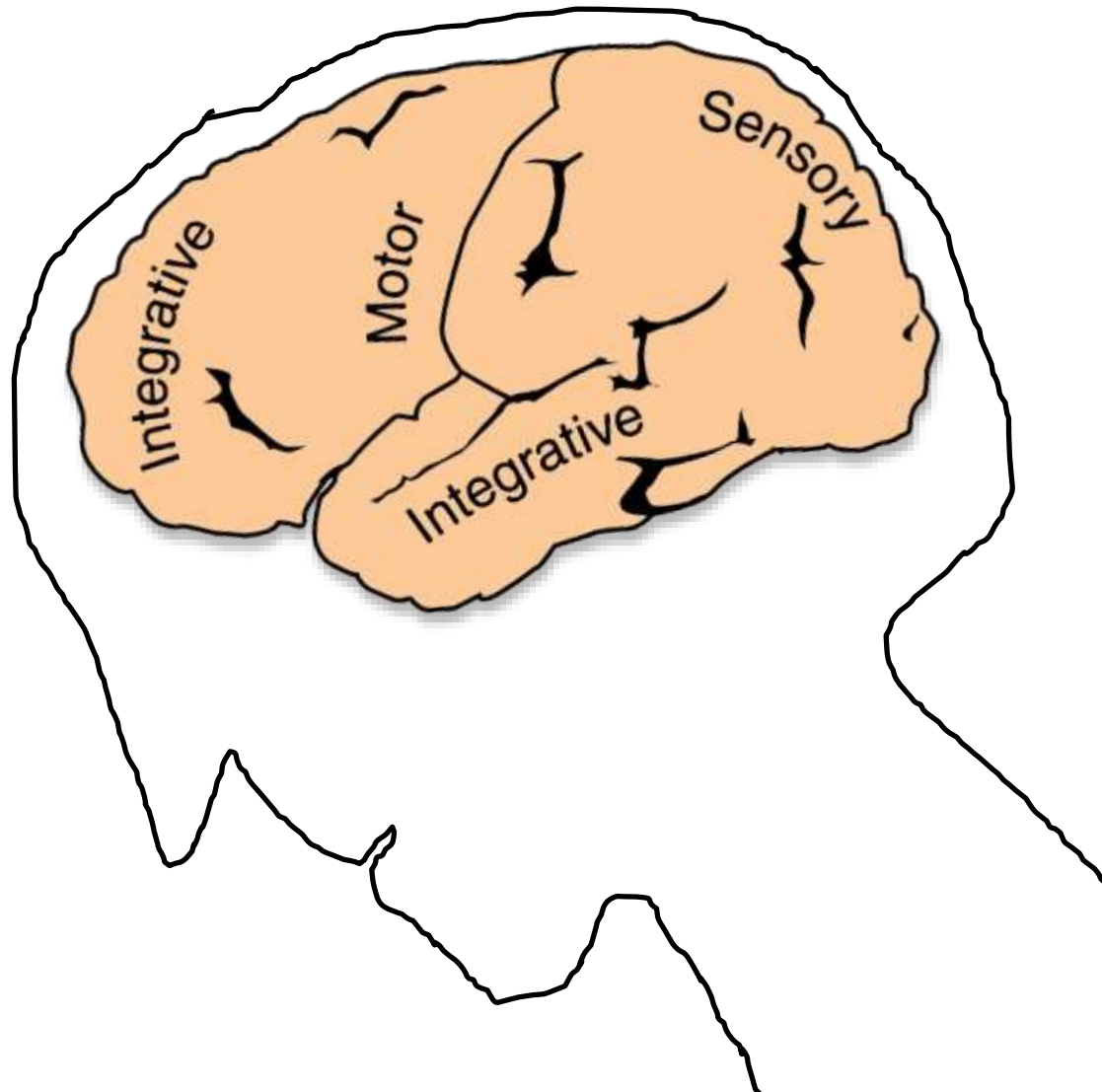


Poklinek, Planinsic  
and Etkina, AJP, 2015

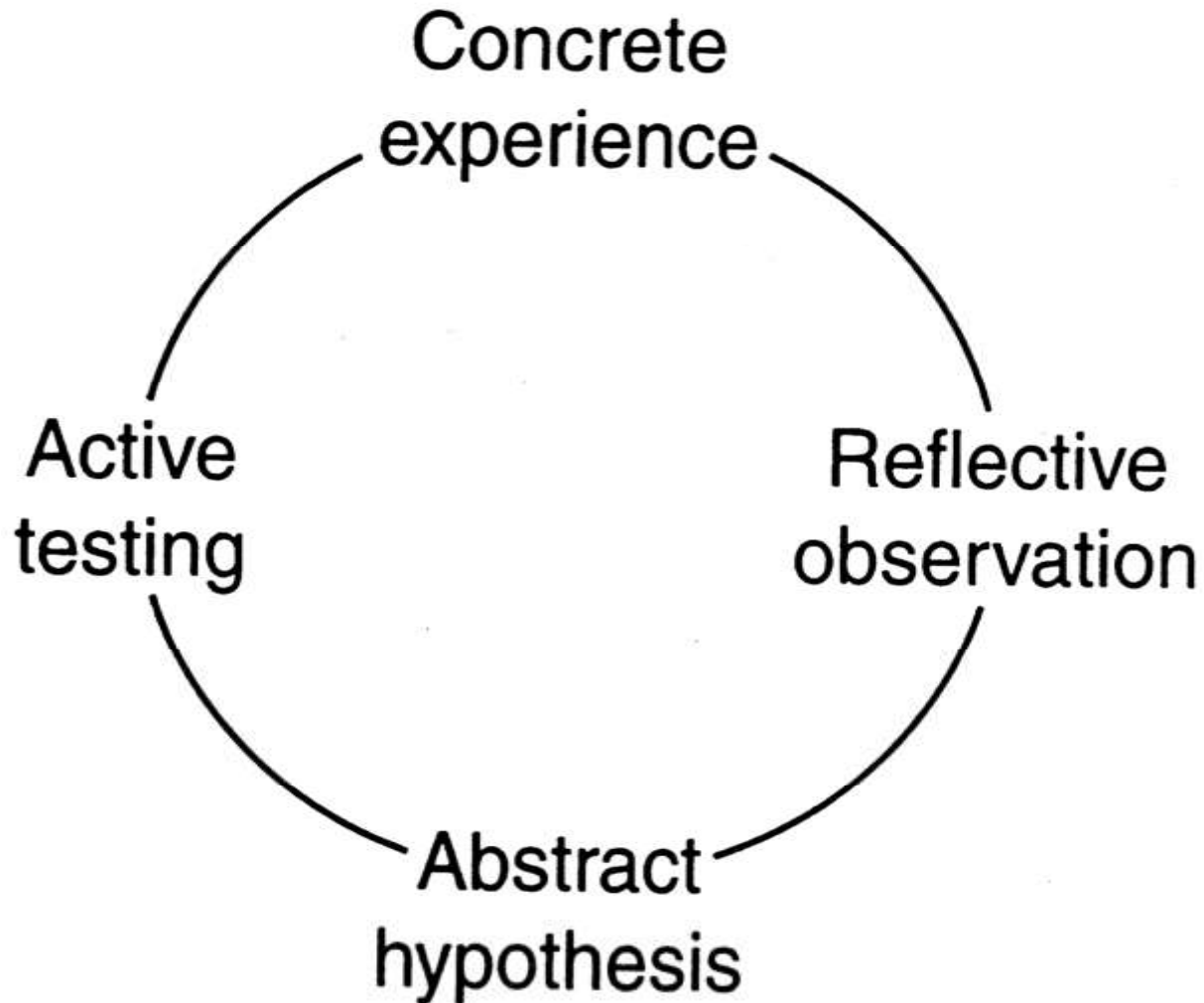
# Timeline of events



# Brain research



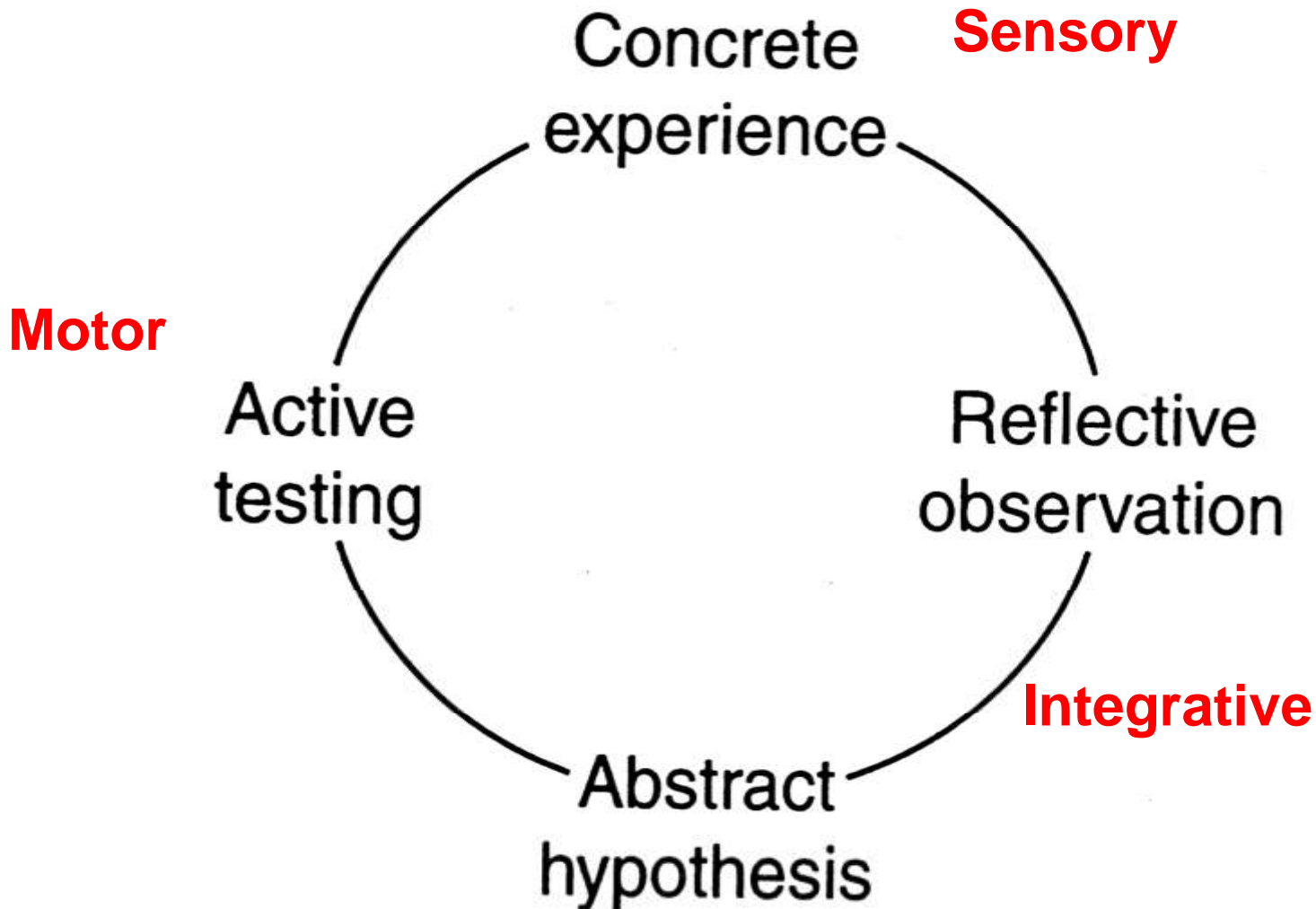
# Brain learning cycle



Kolb's brain learning cycle (Kolb, 1984)



# Brain learning cycle



# According to brain research

Learning is a **visible** physical change in the neuronal connections in the brain (and the whole body) of the learner.

# Cognitive science

**Learning is a social process** (Bielaczyc & Collins, Learning communities in classrooms: A reconceptualization of educational practice, 1999).

**Fixed or growth mindset determine how a person will learn and what choices they make in the process** (Yeager & Dweck, Mindsets That Promote Resilience: When Students Believe That Personal Characteristics Can Be Developed, 2012).

**Perseverance is one of the major predictors of success in life** (Hochanadel & Finamore, Fixed And Growth Mindset In Education And How Grit Helps Students Persist In The Face Of Adversity, 2015).

Do we need to teach these ideas to our students?





**Dirt**

**Observe**



**Looks like  
chocolate...**



**Observe**



**Hypothesize**



**When eat, will  
taste like  
chocolate**





**Observe**

**Hypothesize**



**Predict**



**Test**







They are all skilled in:  
Testing ideas experimentally  
Perseverance  
Working together

They are doing all this because they are motivated – they have the “Need to know”. And they are CREATIVE!

# Then, what is the problem?

The problem is that traditional (and even reformed) teaching goes against much of what we are good at, much of what we know helps people learn, and much of what is needed for success in 21<sup>st</sup> century:

The answers come before questions – no “need to know”

Ready knowledge is provided – no creativity

Grades without resubmission of work - no opportunity to try without being afraid to fail

Preset pace of the curriculum - punishment for learning at a pace different from expected

Grading on a curve - punishment for collaboration

Traditional problems on MC tests - punishment for needing reasoning tools other than mathematics

For women all these issues are exacerbated due to their tendency to blame themselves and often an “impostor syndrome” (which results in the absence of the learning community)

# Solution? Universal Design for education

The term "universal design" was coined by the architect Ronal Mace to describe the concept of **adapting the environment to be accessible** by everyone, regardless of their age, ability, or status in life.

What does it have to do with learning physics?

# Universal Design for physics education – make physics accessible to all students

Why is the ISLE approach an example of Universal Design for Education? (The argument was made in the book by Julie Maybee, professor of disability studies in her 2019 book “Making and Unmaking Disability”.)

Students learning physics through the ISLE approach:

1. Start on the same page – observe simple phenomena – **adaptation and confidence**
2. Do not use fancy language - **adaptation and confidence**
3. Use representations that help –**adaptation based on brain research**
4. Develop their own ideas creatively and test them right away  
CREATIVELY! – **adaptation and encouraged creativity**
5. Progress at their own pace – **adaptation and growth mindset**
6. Improve their work without punishment –**adaptation and growth mindset**
7. Are a part of a community with shared expertise – **confidence, avoiding impostor syndrome**
8. Develop productive habits – **set up for 21<sup>st</sup> century success**



# Student whiteboards

Worksheet: Degree of change

Question 2: 100% will be added

Question 3: 100% will not be added

**Table:**

Year	2000	2001	2002	2003	2004
1	1.00	1.00	1.00	1.00	1.00
2	1.00	1.00	1.00	1.00	1.00
3	1.00	1.00	1.00	1.00	1.00
4	1.00	1.00	1.00	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00

**all there:**

Use the degree of change to find the final value of the investment. Use the formula:  $FV = PV(1 + r)^n$

Example: The value of an investment of £1000 at 5% per year for 5 years is:  $1000(1.05)^5 = 1276.28$

Check the value of the investment at the end of 5 years. It is £1276.28. This is the same as the value of the investment at the end of 5 years.

Conclusion: Degree of change is the same as the value of the investment at the end of 5 years. This is the same as the value of the investment at the end of 5 years.

**Group 3**

**Q1:** We would plug the immersion heater to be able to heat to maximum heat. Then we will place a pot with water on top of the immersion heater and place the top of a digital thermometer in the water to measure the heat of the water. We will measure the volume of water that was heated and convert to joules.

$P = \frac{Q}{t} = mc\Delta T$

Time: 10s  
Initial: 20.0°C  
Final: 30.0°C  
t = 10s  
Q = 2000 J  
t = 10s  
P = 200 W

Close enough

**System: glass + air + balloon**

**initial** **final**

$W + Q = \Delta U_{int}$

**inflating:**

The diagram shows a vertical cylinder with a piston. A force  $F$  is applied downwards to the piston, pushing it up by a distance  $x$ . The work done on the gas is  $W$ . The gas expands, pushing back with a force  $F$ , doing work  $W$  on the surroundings. The change in internal energy is  $\Delta U_{int}$ .

**Question:** The power output of the immersion heater when it is used to heat water.

**Question:** The immersion heater power is when the thermometer is in the water.

**Question:** When the heater is used to heat water.

$P = Q = mc\Delta T \rightarrow P = (1.15 \times 10^3)(4180)(46.7 - 20.5) \frac{J}{s}$

$P = 1259.666 \text{ W}$

$P = 1256.9 \text{ J/s}$

**Conclusion:** 1500 J/s

**Conclusion:** 1500 J/s

**Conclusion:** 1500 J/s

**Group 3: 3 experiments**

**Experiment 1:** System: glass + air + balloon

**Experiment 2:** System: glass + air + balloon

**Experiment 3:** System: glass + air + balloon

**Conclusion:** The power output of the immersion heater is 1256.9 J/s.

ISLE process depicted on the diagram is a way of thinking about learning and teaching physics – we can apply it to any concept.

In the ISLE approach the lab is the place where students construct and test ideas and the “lecture” or whole class meeting time is dedicated to activities that **are based on what the students did in the lab.**

Therefore **all students do the same lab during the same week** and **it is closely coordinated** with everything else that they do this week.

# Lab: Students conduct a series of experiments

Scale 1

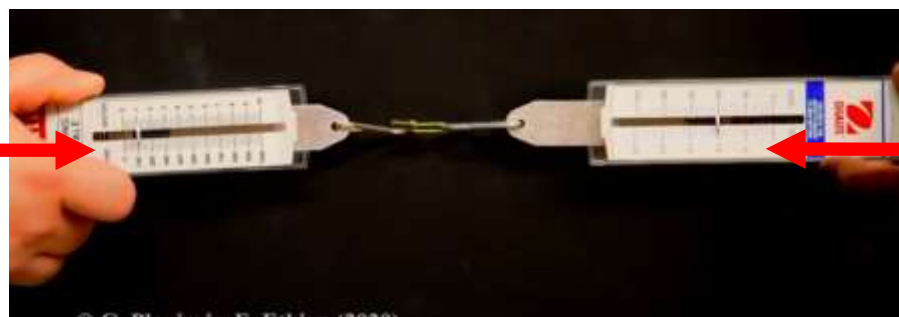
Scale 2

0.5 N



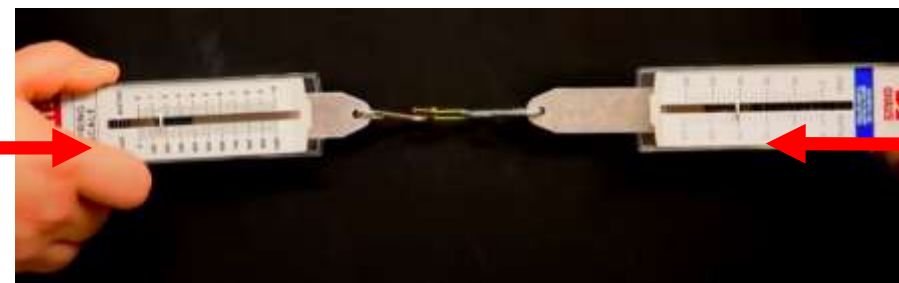
0.5 N

1.0 N



1.0 N

1.5 N



1.5 N



# They use tools to analyze patterns

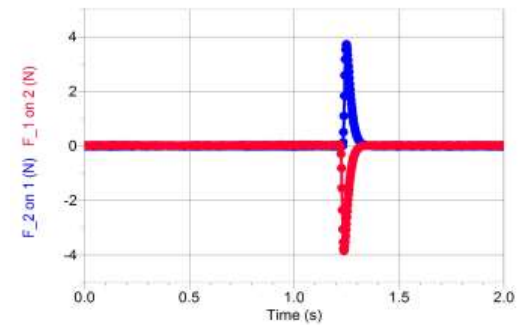


Explanation (hypothesis):

When ANY two objects interact with each other, they exert forces on each other that are the same in magnitude and opposite in direction.

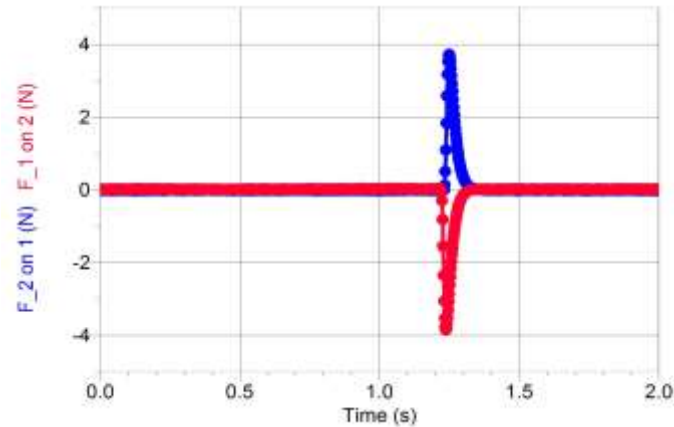
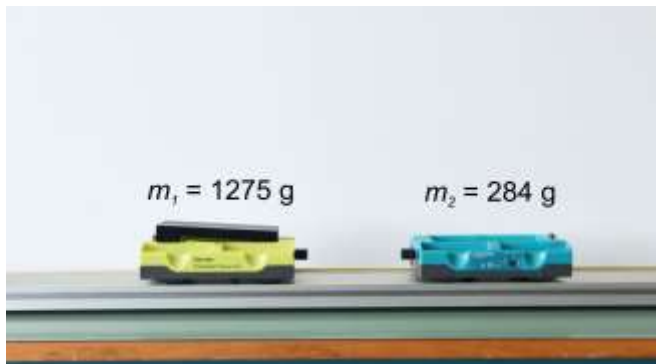
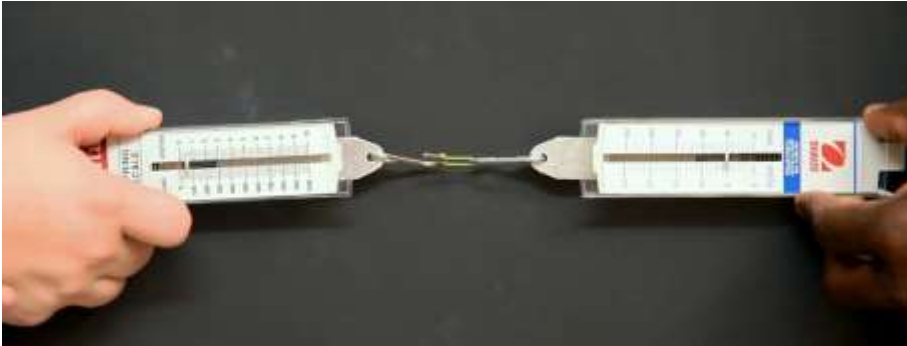
While it sounds rather wild, how can we test it?

# They design testing experiments



Etkina et al., 2019

# As a student you just invented Newton's third law



Etkina et al., 2019

# What happens in class after?

8. A book sits on a tabletop. What force is the Newton's third law pair to the force that Earth exerts on the book? Choose the correct answer with the best explanation.
- (a) The force that the table exerts on the book because it is equal and opposite in direction to the force that Earth exerts on the book
  - (b) The force that the table exerts on the book because the table and the book are touching each other
  - (c) The force that the table exerts on the book because it describes the same interaction
  - (d) The force that the book exerts on Earth because it describes the same interaction
  - (e) The force that the book exerts on Earth because it is equal and opposite in direction to the force that Earth exerts on the book

# What happens in class after?

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  - (c) The force that the table exerts on the book because it describes the same interaction
  - (d) The force that the book exerts on Earth because it describes the same interaction
  - (e) The force that the book exerts on Earth because it is equal and opposite in direction to the force that Earth exerts on the book

# What do students think? – Interviews of students of David Brookes

Did you take a physics class before? If yes, what was it like?

Why did you take this class?

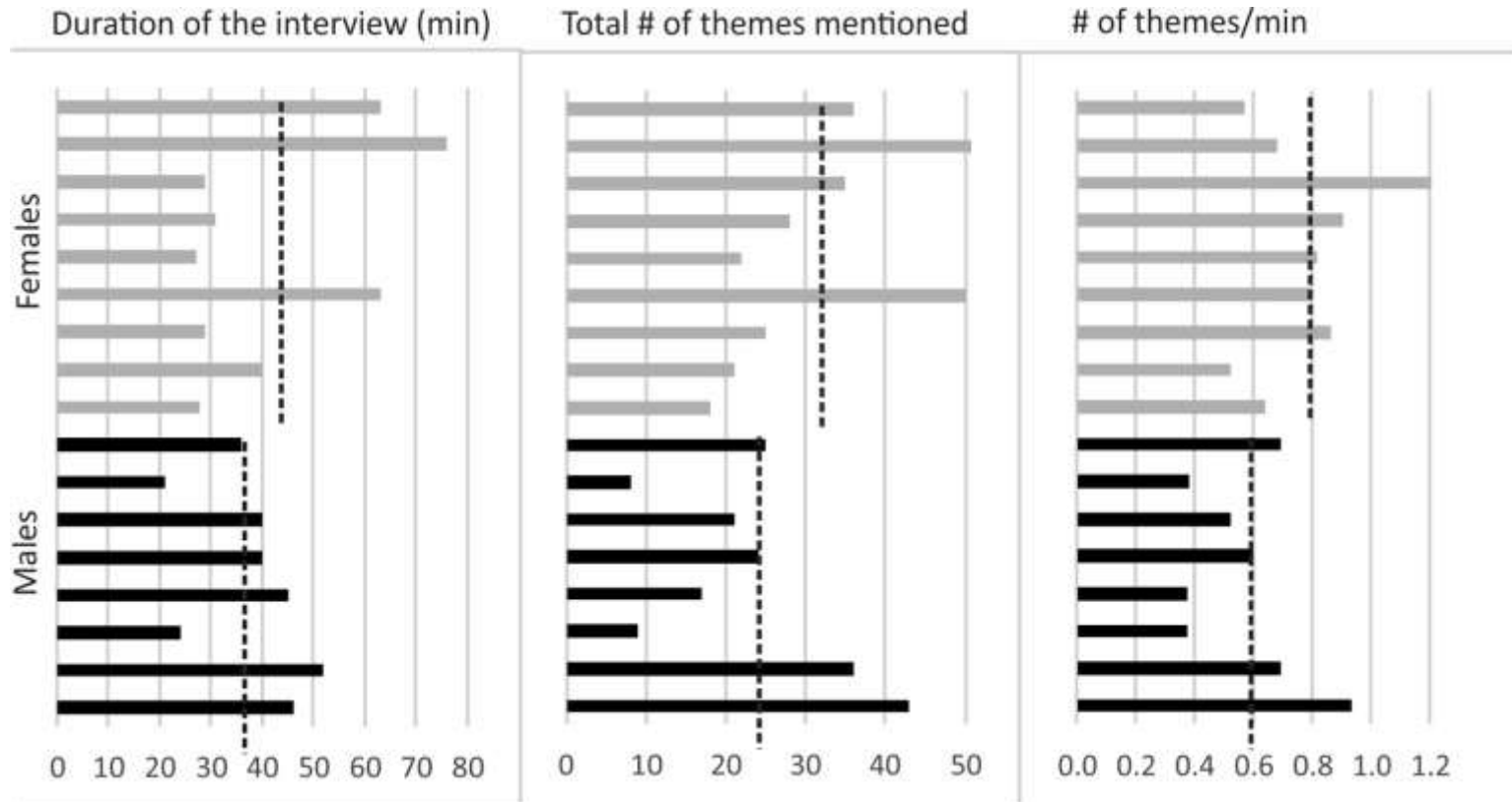
How does it compare to other science classes you are taking?

Would you like to change anything in how this class is taught?

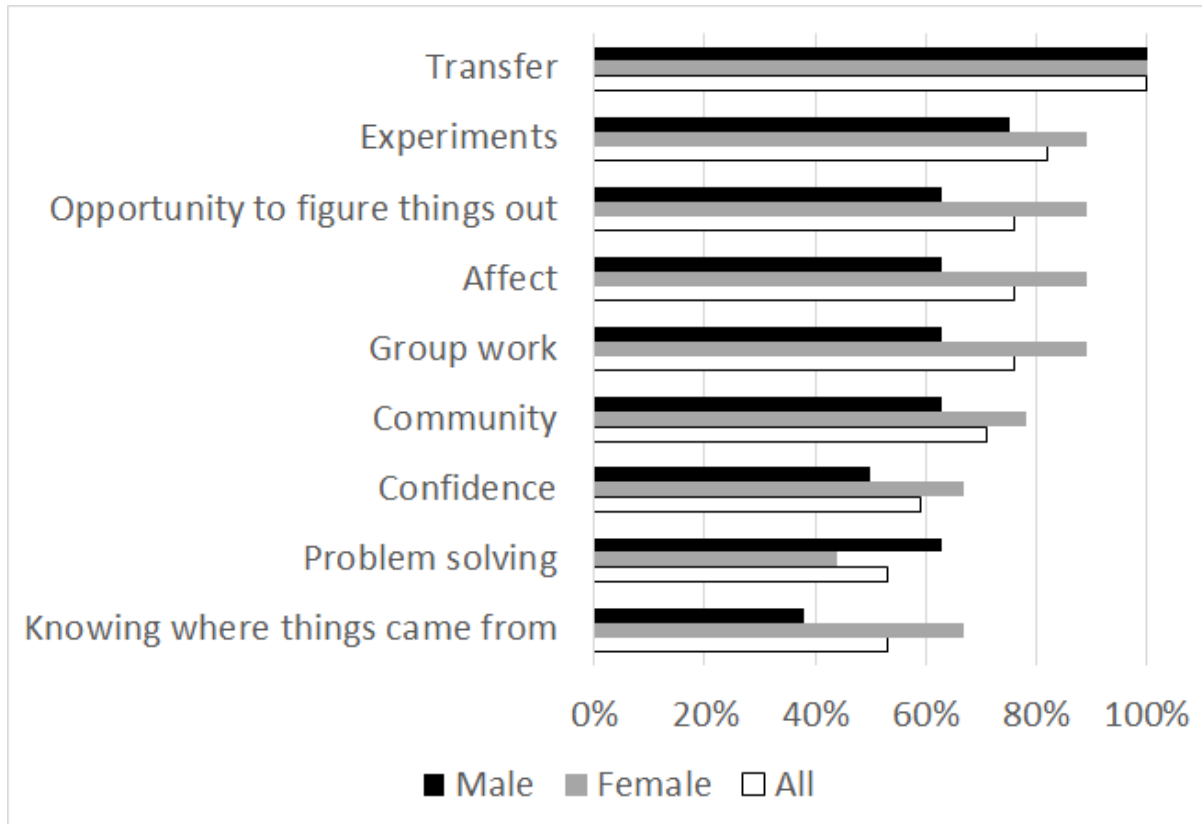
Examples of elaboration questions are: What do you mean? Can you be more specific? Can you give an example?

17 students (self-identified as 9 females and 8 males)

# Duration and themes N=17 (9 female and 8 male)

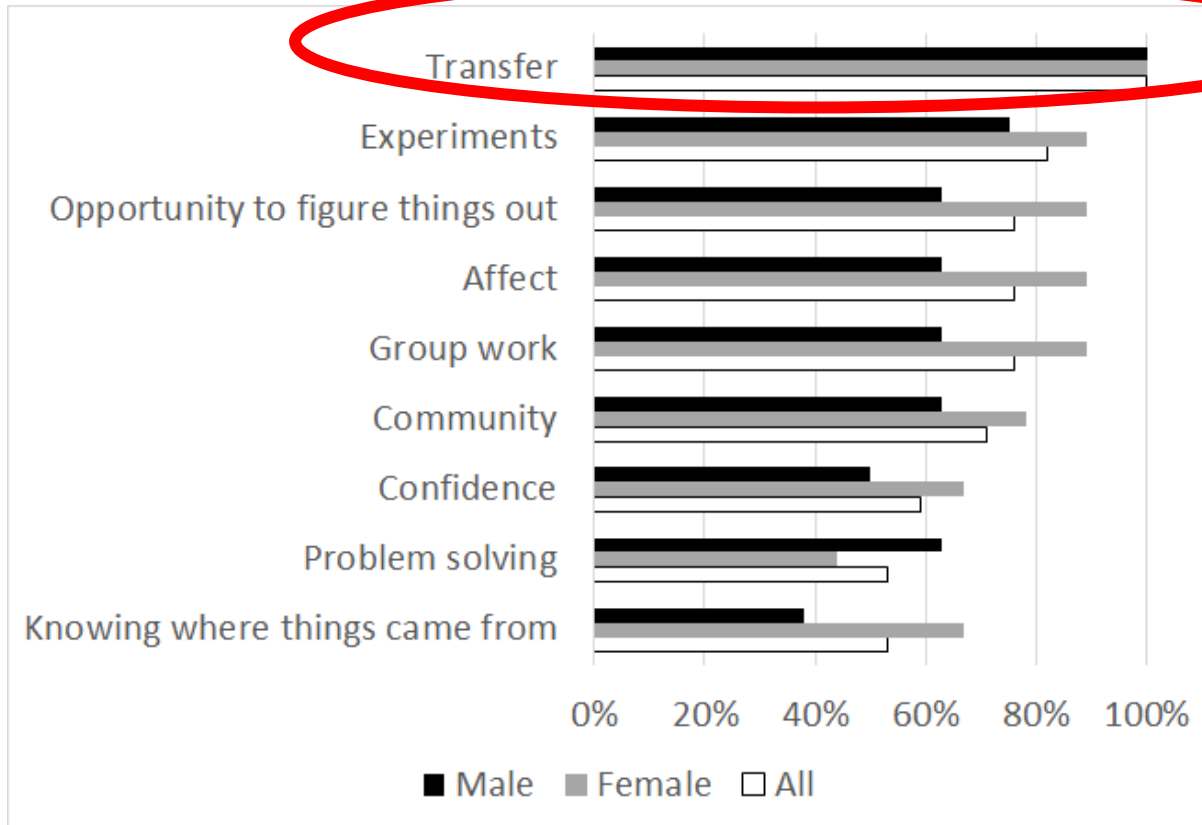


# Most common themes





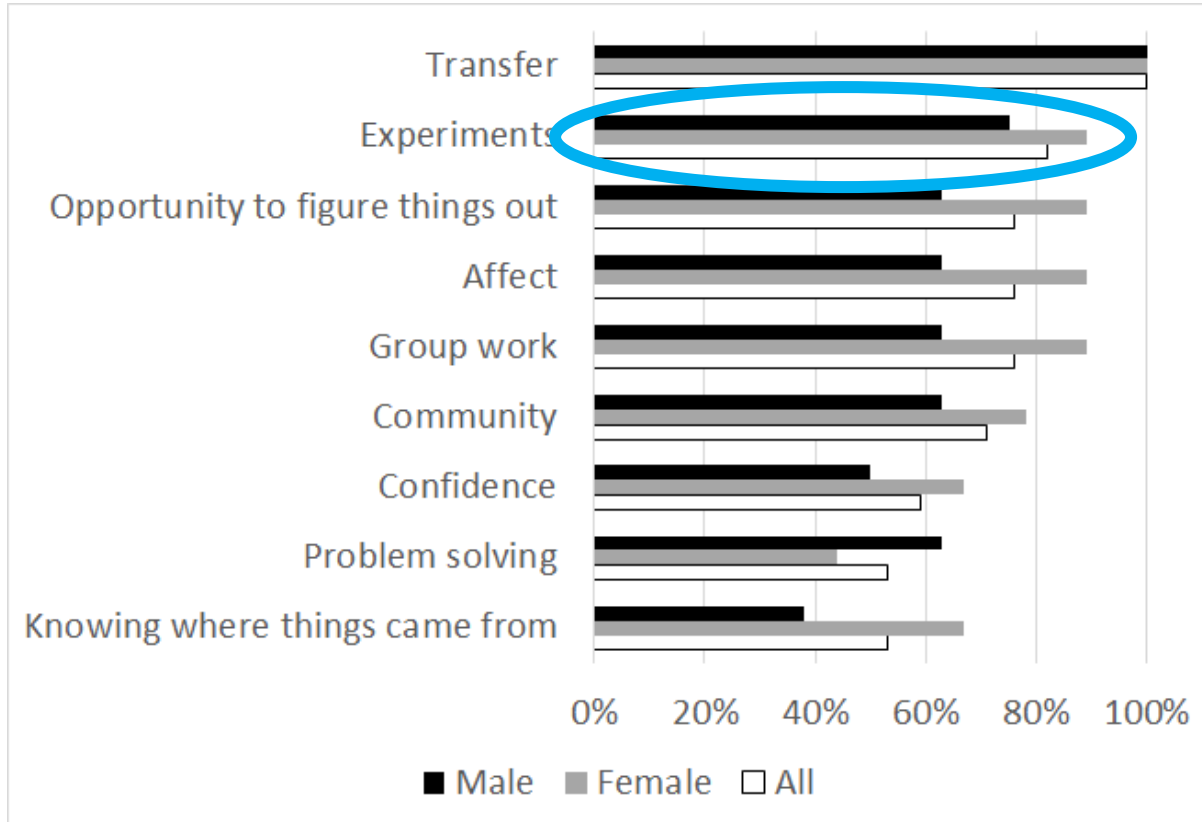
# Most common themes



Students talked about how they applied physics knowledge, physics representations, physics reasoning skills and learning strategies they developed in the course in other contexts such as outside world and other courses.

“So even if I’m in a class where the professors like a robot, just talking, reading, Power Points, I can go home and turn it into something that’s going to be interesting to me, because **you guys made us think about how we learned and what the best way to learn is.**”

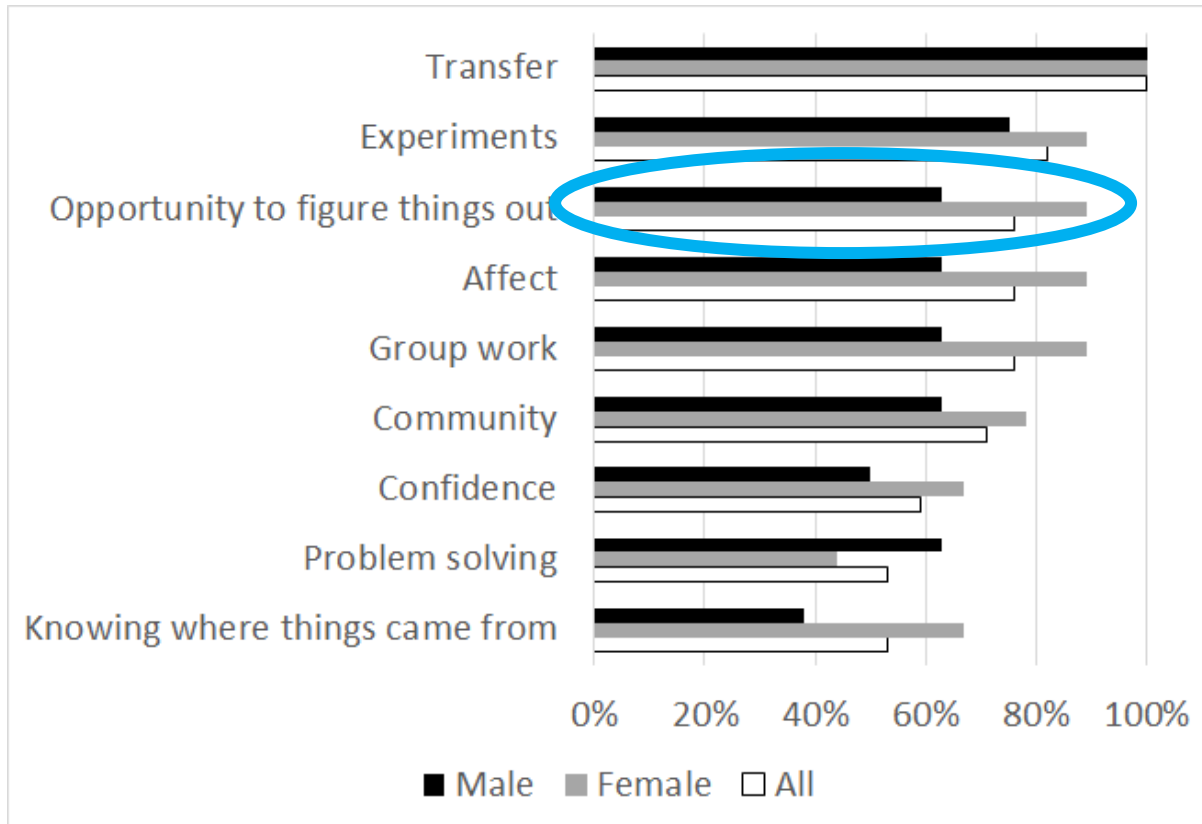
# Most common themes



“But the way that we learn these things, it’s not as hard as what the regular physics students. They’re like, oh, my God, this equation is so difficult to derive and this and that.

But our class, we’re like, well, it’s easy because if you grasp this and you think about the situation when you get this, and **it’s cool because we got to do all those experiments that we understand already how it works.**”

# Most common themes



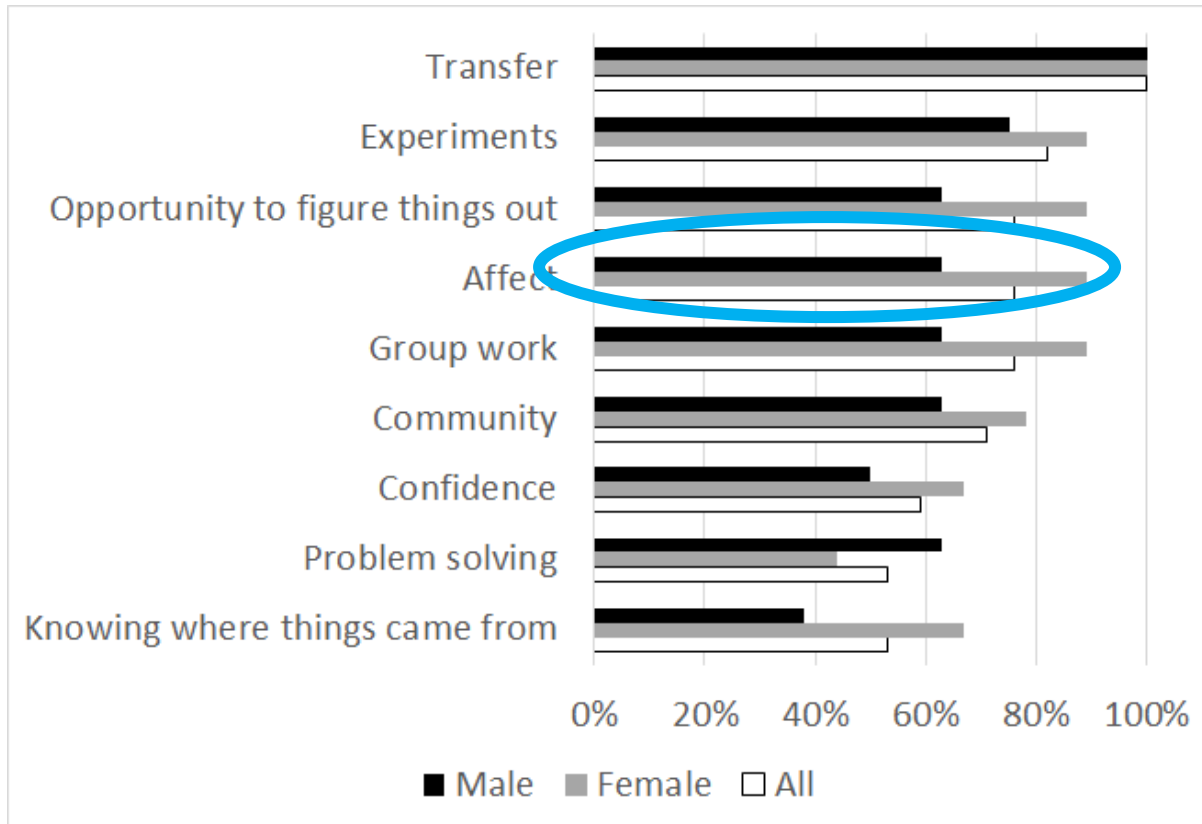
“It was a learning process because I was so used to be fed information and remembering it and repeating it that here at the beginning I didn’t like it because I was not shared information.

I said, what the heck is this, how am I supposed to learn anything, the professor didn’t tell me anything.

And I was so used—you’re so accustomed to being fed all this information and memorizing it that you have no idea what’s going on.

Here I have to figure out what was going on, and then a true understanding could arise.”

# Most common themes



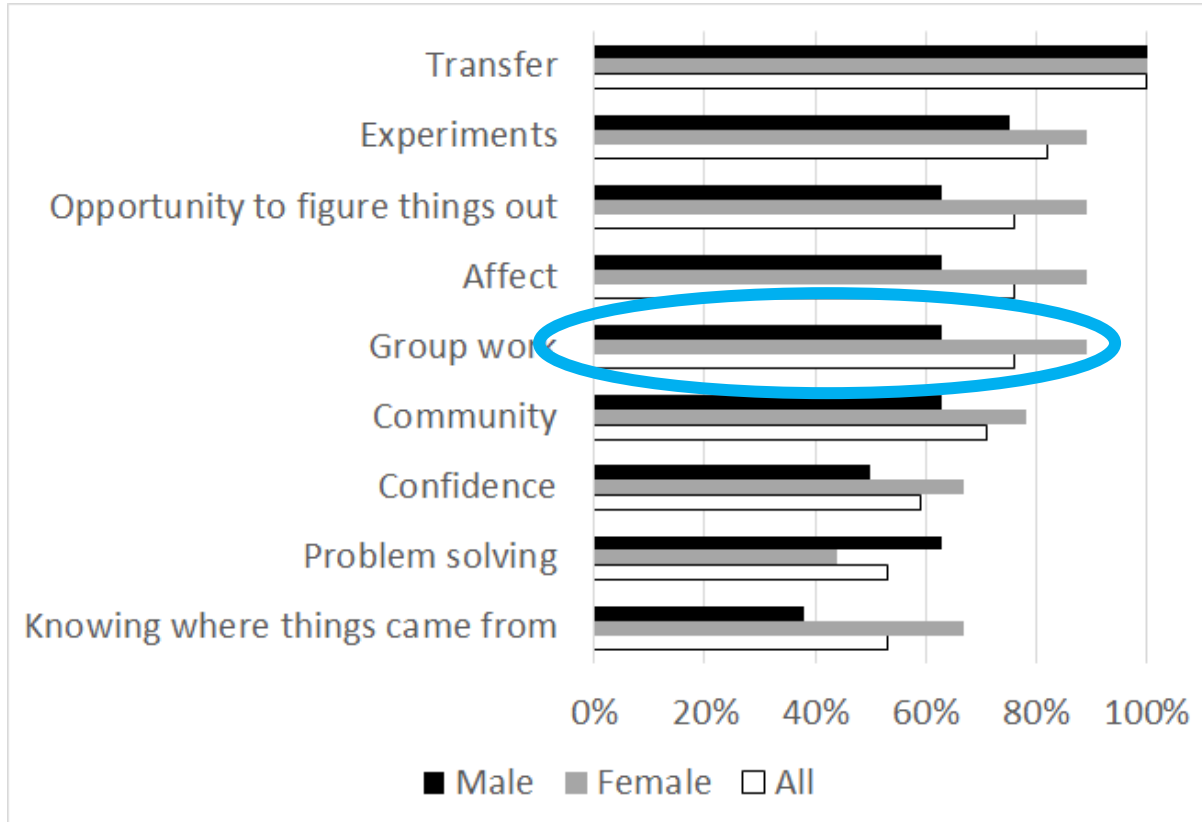
“I definitely do enjoy Physics. In terms of interaction and stuff like that, I like Physics a lot, a lot. At first I come to class and I’m like, “Oh what crazy thing are we gonna do today? Let’s see what happens.”

And then when we’re actually doing it I’m just so hyped and I’m so excited and magnets, you know I love magnets. My magnets, oh those are my babies, I love my magnets.

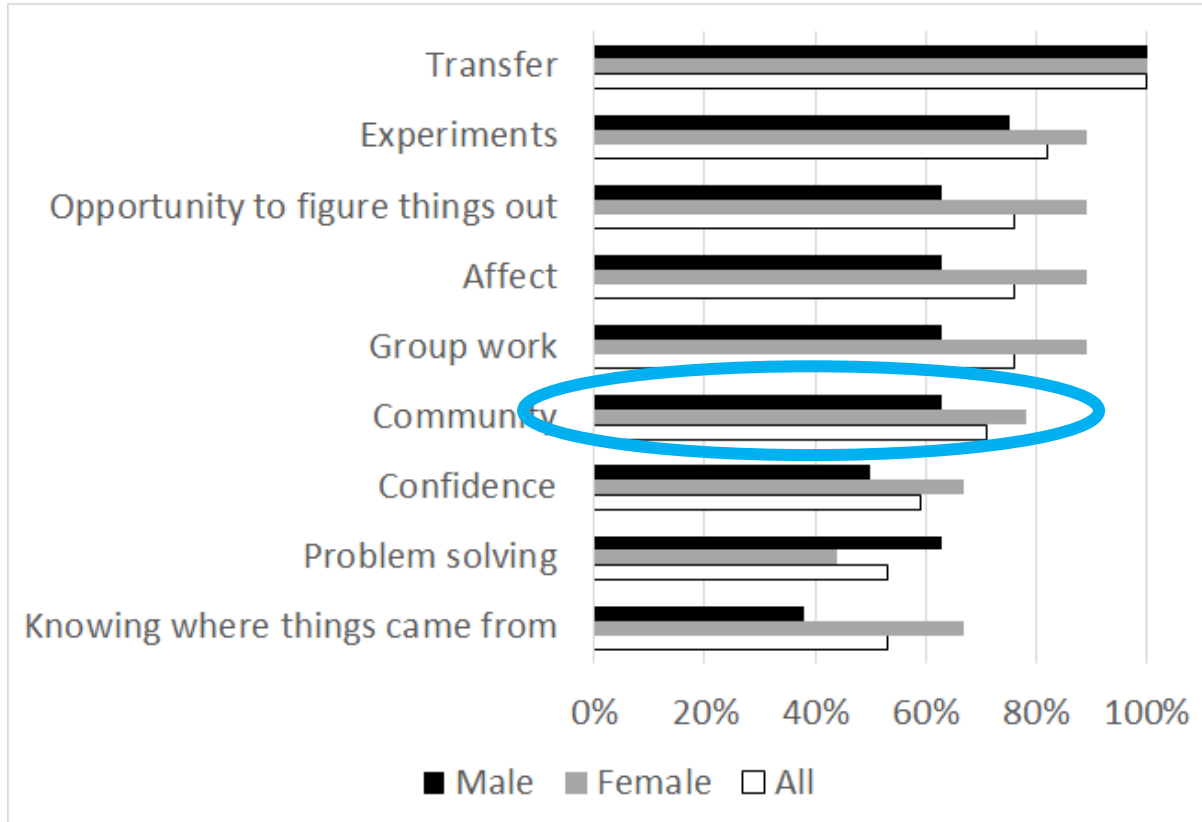
But with magnets and with mirrors and with lenses it was exciting, it was cool and it was like I knew I was gonna leave with something that was gonna blow my mind.”



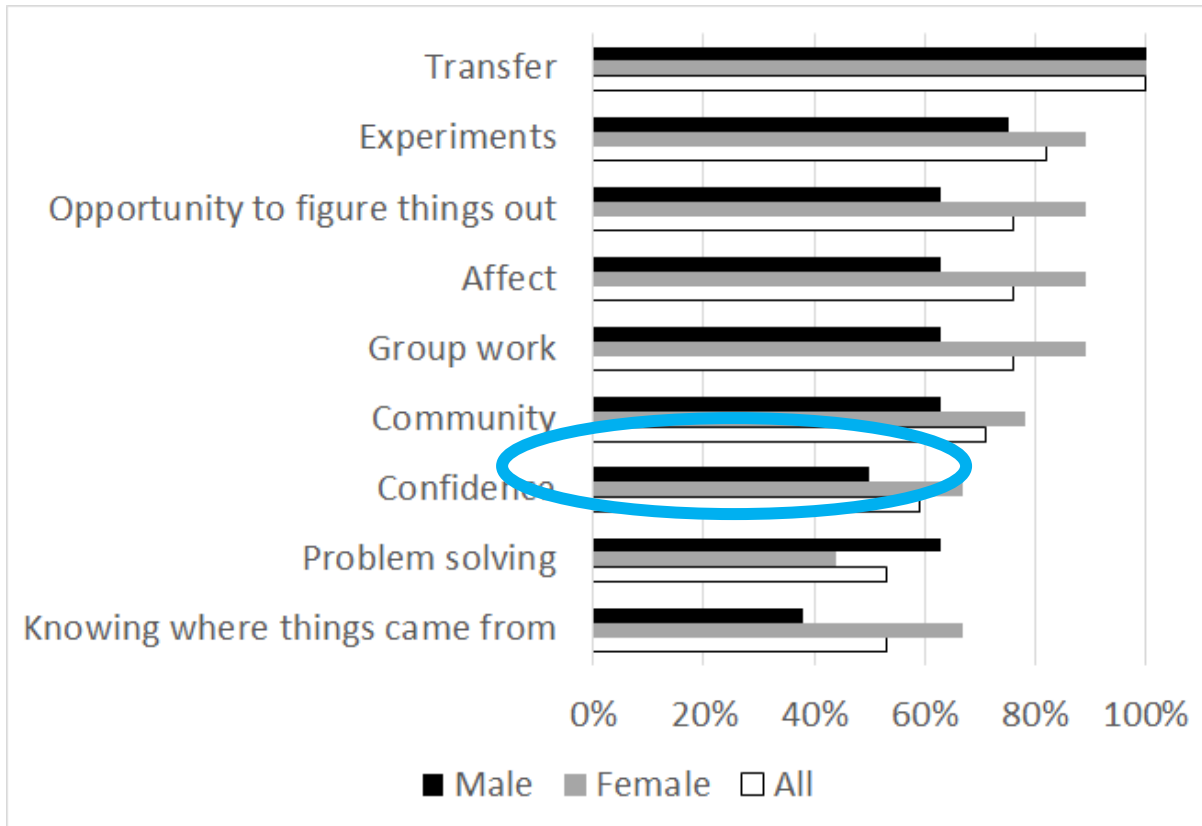
# Most common themes



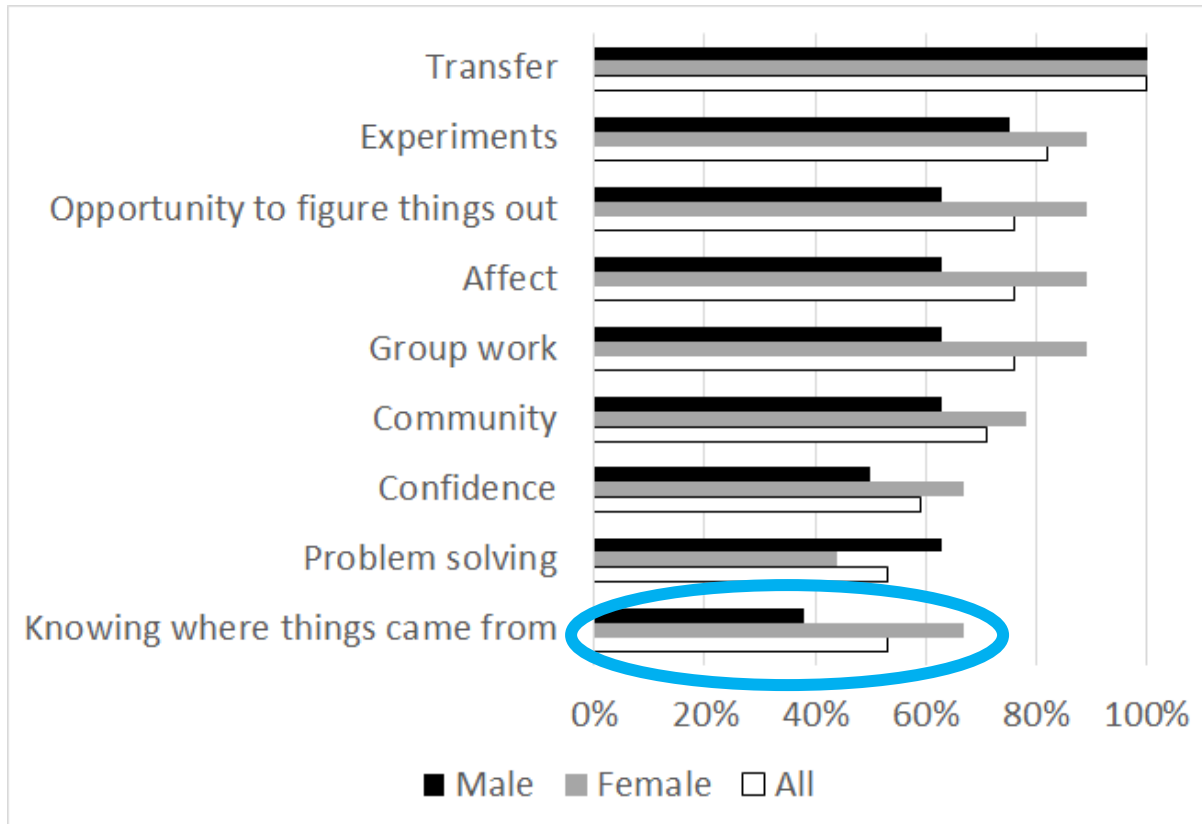
# Most common themes



# Most common themes



# Most common themes



# ISLE students reflecting on learning in pandemic times

- "I can say with no hesitation that this is the first and only class where I worked with a group successfully. In my previous experience, I have only been in situations where I be the one working and leading the group and trying to catch up with other groups in the class as other teammates do not contribute. So, I learned how to be part of a hard-working and a successful group this semester. **Another thing that I really enjoyed is boosting my self-confidence as I am used to be lectured and having a set of rules and formulas to follow in solving problems rather than going from the different problems in order to come up with a formula. So, teaching myself and teaching and being taught by other students helped me a lot rely more on myself.**"
- "**The biggest lesson I've learned from this class is how to be a better group-mate.** My group has been a great help this semester and they have been my rock when it comes to being caught up on physics. I'm going to make sure in the future to pass on the good vibes they've passed on to me."
- "**This class has first and foremost been a re-enforcer of the idea that is ok to make mistakes.** Growing up my school taught me to be fixed on the 'right' answer, rather than the process and means to the end. This class has helped me to slow down and not just gun for the right answer, but to puzzle and question the work that I have done up until point to see how far I can get, even if that is not entirely to the answer."

# Perseverance

Grit is one of the predictors of success.

We find that designing their own experiments develops perseverance while doing traditional labs does not.

On average the time spent by ISLE students **making sense of experiments** (designing, analyzing data, revising, etc.) is **4 - 5** times longer than for the students in traditional labs where they follow directions.

# What else do we know about ISLE students?

High gains on standardized tests (FCI, CSEM, MBT, etc.)  
(Etkina and Van Heuvelen, 2001; 2007, Etkina, 2015)

Spontaneous use of representations other than mathematics when solving problems  
(Rosengrant et al., 2009)

Ability to design experiments, collect and analyze data, evaluate assumptions and communicate findings  
(Etkina et al. 2006, 2008, 2010; Bugge and Etkina, 2016, Bugge 2020)

# Difficulties in implementing the ISLE approach to learning physics

Instructors need to learn to think about physics and student learning differently. They need to act differently in class.

Students need to learn to think about their learning and instructor's teaching differently. They need to act differently in class.

Lots of research shows that both are very difficult problems to solve and are subjects for another conversation...



# Resources to implement ISLE

# Big team!



# ISLE website - <https://www.islephysics.net/>



[ISLE Philosophy](#) [Why Do ISLE?](#) [ISLE Developers & Users](#) [Free ISLE Resources](#)

[Textbook Information](#) [Adopting the ISLE approach](#) [ISLE Blog](#) [ISLE References](#)

**E. Etkina, D.T.Brookes, G. Planinsic**

The Investigative Science Learning Environment (ISLE) approach is an intentional holistic learning environment which addresses two main goals: to help students learn physics by engaging them in the processes that mirror scientific practice and to improve their well-being while they are learning physics. Specifically, help them develop perseverance, growth mindset and physics identity. We believe that everyone can learn physics given tools, time, and support, therefore students learning physics through the ISLE approach are encouraged to improve their work without being punished for send or third attempt.



— SEARCH —

— RECENT POSTS —

<a href="#">Gases</a>	<a href="#">Useful link for those who are interested in the conversations related to learning through the ISLE approach</a>	<a href="#">Waves</a>
December 10, 2021 – 6PM	Vibrational Motion	

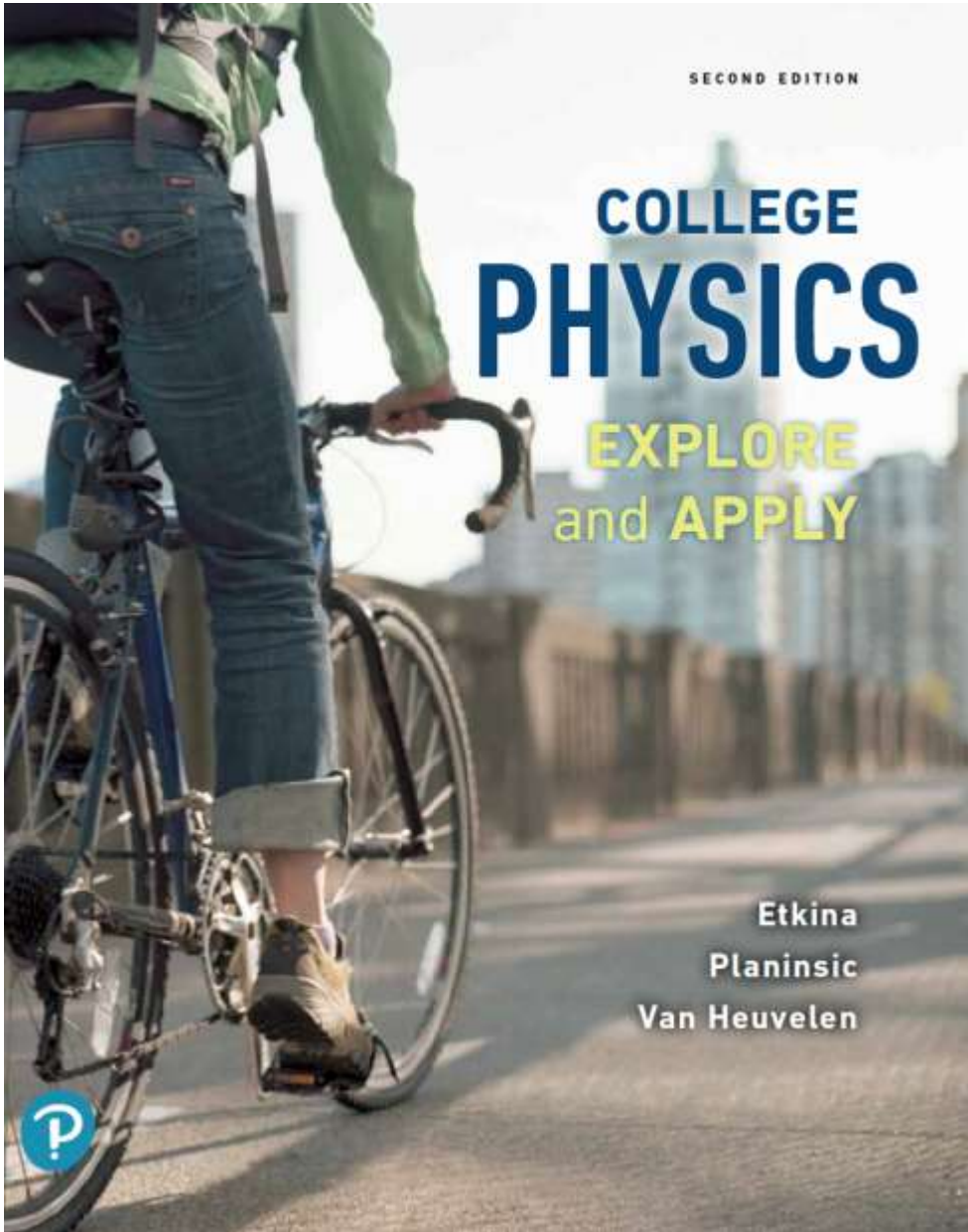


# Investigative Science Learning Environment

When learning physics mirrors  
doing physics

**Eugenia Etkina**  
**David T Brookes**  
**Gorazd Planinsic**





SECOND EDITION

# COLLEGE PHYSICS

EXPLORE  
and APPLY

Etkina  
Planinsic  
Van Heuvelen

## Active Learning Guide and On-line Active Learning Guide

### Instructor Guide

Over 300 videos  
freely available to  
use without  
adopting anything

# Exploring and Applying Physics Facebook group with over 1300 members from all over the world (including Sweden)

The image shows a screenshot of the Facebook group page for "Exploring and Applying Physics". The page layout includes a top navigation bar with the Facebook logo, a search bar, and navigation icons for home, video, group, and settings. The group name "Exploring and Applying Physics" is prominently displayed in a blue banner with the text "Switch communities PHYSICS EXPLORE and APPLY" and an "Edit" button. Below the banner, the group is identified as a "Private community" with "1.3K members". A row of member profile pictures is shown, along with an "Invite" button and a "Manage" link. The main content area features a "Write something..." text box, a "Photo/video" upload button, and a "Room" button. A "Featured" section contains an "Events" card with an illustration of students in a classroom and a "Create event" button. To the right of the events card is a post by "Eugenia Etkina" dated "September 12, 20...". The right sidebar contains an "About" section with a description of the group's purpose, a "Private" status indicator, and visibility settings set to "Visible". A "Learn more" button is located at the bottom of the sidebar. The bottom navigation bar includes icons for "Home", "Rooms", and "Events".

Switch communities **PHYSICS** EXPLORE and APPLY Edit

Exploring and Applying Physics  
Private community · 1.3K members

Home Rooms Events

Write something...

Photo/video Room

Featured 1 Add

**Events**  
When events are created or shared, they appear in this card.

Create event

Only admins can see this.

**Eugenia Etkina**  
September 12, 20...

Hi all, we have lots of n...  
Announcements to lear...  
is about, what philosop...  
try to promote and wha...  
posted here (I > M...  
to FILES to dow... d w...  
there. If you do not hav...  
College Physics: Explor...  
(regular or AP edition),  
Pearson rep for a free €...  
All other materials are 1...  
Physics Platform of Pe...  
any issues finding your...

**About**  
This is a group of people who are using or pla...  
to use materials created by the team led by...  
Eugenia Etkina: the textbook "College Physics...  
Explo... See more

**Private**  
Only members can see who's in the...  
community and what they post.

**Visible**  
Anyone can find this community

**General**

Learn more

**Rooms**

<https://sites.google.com/site/scientificabilities/>

- Scientific Abilities
- Introduction**
- The Abilities
- Rubrics
- Formative Assessment Tasks
- ISLE-based labs
- Kits
- Modeling Tasks
- Online labs
- Publications

# Introduction

**Instructor site access:** If you are an educator and would like access to additional instructor resources you can [request it by email](#). Please include your name and affiliation along with the email address you'd like the invitation sent to (this works best if the email address is associated with a Google account). *If you had instructor-level access on the previous version of this site you still need to request access to this site.*

## Introduction to Scientific Abilities

Welcome to the website of the Rutgers Physics and Astronomy Education Research group dedicated to "Scientific Abilities". This project was originally sponsored by the National Science Foundation program "Assessing Student Achievement" (NSF-ASA) but over the years it became a self-sustaining project and now Scientific Abilities are a component of ISLE philosophy. Many people contributed to this project over the years. The list of names is very long and includes: Eugenia Etkina, Alan Van Heuvelen, Suzanne Brahmia, David Brookes, Michael Gentile, Anna Karelina, Michael Lawrence, Marina Milner-Bolotin, Sahana Murthy, Maria Ruibal-Villasenor, Aaron Warren, Xueli Zou.

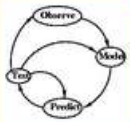


<http://islevideos.net/>

GERS

## Physics Teaching Technology Resource

**Users**  
Log in  
or password?  
me up  
sign up?



### Introduction

This is a long introduction for physics teachers and those interested in [Prof. Etkina's](#) teaching methods.

**Information**  
out us  
AQ  
the videos  
ght notice  
edgments  
l videos



### Motion

Learning cycles on the subject of Kinematics.

**AS SPORE**  
rner



### Newton

Learning cycles on Newton's Laws

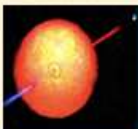
**al Links**  
ics Network  
c Abilities  
padre  
RA



### Circular and Rotational Motion

Learning cycles on circular and motion and motion with rotation in it

**e update**  
ia on 2012-  
13:22:13



### Energy

Learning cycles on work and energy.



### Harmonic Motion and Waves

Learning cycles on simple harmonic motion, travelling and standing waves



# ISLE-oriented physics teaching computer games



<http://www.universeandmore.com>

Matt Blackman, Ridge High school

## Few points to take away

Learning means physical change in the brain and body of the learner.

Brain cycle proceeds from sensory experiences to reasoning and to motor functions for active testing.

Scientific inquiry engages similar processes.

ISLE is the real path that scientists take!

Students can participate in real science making!

The ISLE approach is designed to empower all students to learn physics creatively – it is an example of the UD for education.

# Thank you

[Eugenia.etkina@gse.rutgers.edu](mailto:Eugenia.etkina@gse.rutgers.edu)

# When students design their own experiments they

are guided by questions that tell them what to think about not what to do;

self-assess their work and improve it with the help of rubrics

Etkina, Murthy and Zou, 2006

# Scientific habits of mind – scientific abilities

Scientific Abilities (work started in 2003) include the abilities to:

represent information in multiple ways

design and conduct an experiment to investigate a phenomenon

develop and test models/hypotheses/explanations

design and conduct a testing experiment (testing a model/hypothesis/explanation or mathematical relation)

design and conduct an application experiment

collect and analyze experimental data

evaluate models, equations, solutions, and claims

communicate scientific ideas

# Questions that guide students what to think about

## *Testing experiments*

Propose experiments to test the explanations (do not perform them).

Use the explanations to make predictions of the outcomes of these experiments before you perform them. Write them here.

Perform the experiments and record the outcomes.

Make a judgment about the explanations.

# Self-assessment rubrics

<https://sites.google.com/site/scientificabilities/>

Scientific ability	Missing	Inadequate	Needs Improvement	Adequate
<b>Is able to identify the hypothesis to be tested</b>	No mention is made of a hypothesis.	An attempt is made to identify the hypothesis to be tested but is described in a confusing manner.	The hypothesis to be tested is described but there are minor omissions or vague details.	The hypothesis is clearly stated.
<b>Is able to design a reliable experiment that tests the hypothesis</b>	The experiment does not test the hypothesis.	The experiment tests the hypothesis, but due to the nature of the design it is likely the data will lead to an incorrect judgment.	The experiment tests the hypothesis, but due to the nature of the design there is a moderate chance the data will lead to an inconclusive judgment.	The experiment tests the hypothesis and has a high likelihood of producing data that will lead to a conclusive judgment.

# Basic rubric structure (total of 39)

<b>LEVEL</b> <b>ABILITY</b>	<b>Missing</b> <b>(0)</b>	<b>Not adequate</b> <b>(1)</b>	<b>Needs improvement</b> <b>(2)</b>	<b>Adequate</b> <b>(3)</b>
<b>Small sub ability</b>  <b>Drawing a force diagram</b>  <b>Comparing results of two experiments</b>	A student does not know that they need to address this issue	A student knows that they need to write something but what is written is vague <i>(description of what is missing)</i>	A student writes relevant things with some minor omissions <i>(description of what is missing)</i>	As perfect as we can expect <i>(a list of all good stuff)</i>