Filling the Void: Options for Authentic Investigations in an Online or Hybrid Learning Environment

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What promotes learning is the nature of the interactions that take place between people, ideas, and materials or tools during a learning experience.
Spring 2020

What are we learning this week?
12.3—I can draw Lewis structures for molecular compounds and polyatomic ions
   - Given a chemical formula, provide its Lewis structure
   - Use differences in electronegativity to identify bond dipoles within a molecule

Notes

Interactive

Constructive

Active

Passive
How do we ensure these types of *interactions* occur in an online learning environment?
NGSS Science & Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information
Argument-Driven Inquiry ONLINE
A platform utilizing interactive videos of real events that allows students to conduct authentic science investigations online

- Quality & variety
- Ready-to-go activities
- Teacher-friendly (customize)
- Integrated data recording & analysis tools
- Reflective of science as a process
How are the videos interactive?

Students can use available tools to make their own measurements.
How are the videos interactive?
Experimental variables can be altered, and multiple trials can be performed.
Promoting the interactions we want

Classroom-ready activities combine videos, guided instructions, data tables, graphing, and a variety of questions

**Intro to experimental setup**
- *Usually some kind of upbeat quick intro video*

**Observe phenomenon**
- *Opportunity to become familiar with what’s going on and play around with video parameters (trials, variables, measuring tools, etc.)*

**Observe/measure and record data**
- *Integrated data tables allow easy recording of data*

**Analysis and sensemaking (model development)**
- *Integrated graphs help make relationships easier to see*
- *Opportunities for different curve fits to deduce mathematical relationships*

**Application and prediction (model deployment)**
- *Opportunity to test model in a different scenario*
- *Students see whether their model can make accurate predictions*
“Our goal is to come up with an explanation for this increase in mass that we observe on both scales. If you are like most students, you may not be used to being asked to explain something you haven’t been taught. But this is exactly what scientists do. They try to come up with explanations for why things happen, and then test their explanations by making predictions.”
Examples

1) Conservation of mass
2) Stoichiometry (limiting reactant)
3) Gas Laws
The videos can be used to function as a practicum or assessment
 NGSS & AP Standards (in progress)

- AP Biology (22)
- AP Chemistry (59)
- AP Physics 1 (136)
- AP Physics 2 (40)
- AP Physics C E&M (18)
- AP Physics C Mechanics (116)
- NGSS Science Practices (120)
- NGSS Standards (121)

Subject

- Biology (27)
- Chemistry (75)
- Earth Science (16)
- Physics (199)
Setting up different classes is easy

<table>
<thead>
<tr>
<th>Meacham - Gen Chem - 1st Period</th>
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<tr>
<td>Gas Laws: Pressure vs Volume</td>
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<td>Gas Laws: Pressure vs Temperature</td>
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Customize to fit **your** needs

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If not 100% sure… think about a 30-day free trial

Gas Laws: Pressure & Volume (Scaffolded)

Use bubbles in a vacuum chamber to explore the relationship between pressure and volume.

Subscriptions

Per Student
$5 / student

Flex
Minimum of 250 students
Discounted pricing

College Subscriptions as well
Similar…but different
Eight stages of the ADI Instructional Model

- **Phenomenon**: Students watch a video of a phenomenon.
- **Investigations**: Students plan and carry out investigations.
- **Peer Discussions**: Students participate in discussion with their peers.
- **Writing**: Students create investigation proposals, arguments, and reports.
- **Argumentation**: Students present the arguments they created to others.
- **Peer Review**: Students evaluate and review the work of their peers.
- **Revise**: Students revise their proposals, arguments, and reports based on feedback.
- **Submit Work**: Students turn in all assignments without leaving the system.

<table>
<thead>
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<th>CHEMISTRY TOPICS</th>
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<td>Bond Character and Polarity</td>
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<td>Molarity</td>
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<td>Gas Laws</td>
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<td>Acids and Bases</td>
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<td>Reaction Rates</td>
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<td>Chemical Equilibrium</td>
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<td>Reaction Products</td>
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<td>Thermal Decomposition</td>
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<td>Heat of Solution</td>
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Teachers choose **six** activities
Altering the function of simulations

Use of simulations and online tools to:
- Plan and carry out investigations
- Create artifacts that makes student thinking visible (screencasts, presentations, google slides, etc.)
Lab Groups

Activity 1. Join a group

Pick a tag to join a group. Each group will have about 10 students in it.

Select one

- Group B
- Group A
- Group C

Students can be placed in specific groups or you can allow students to choose what groups they’re in.

- Students in Group A will only see and interact with others in Group A
Activity 2. What do you notice and wonder?

We often see things that look strange or do not make sense in the world around us. Here is an example. Take a few minutes to watch this video. This video shows what happens when someone shines a laser on a block made of glass and a block made of acrylic.

Share some things you noticed as you watched the video, and any questions you may have about what happened by either adding a new topic to discussion or by replying to one of the existing topics by adding a comment. Make sure you read the posts made by others and add your thoughts.
Activity 3. What you need to figure out

The video you watched during activity 2 showed how a ray of light can change direction when it moves through a block made of glass and a block made of acrylic. You now need to design and carry out an investigation to figure out an answer to the following question:

How can we predict where a ray of light will go when it comes in contact with a block made of glass or acrylic?

Activities 4, 5, and 6 will help you prepare to answer this question by highlighting some ideas that you can work with as you make a plan for collecting data, analyze and interpret the data you collect, develop an explanation, and argue from evidence during the rest of this investigation.

Guiding Question
Providing appropriate background knowledge

Activity 4. Some ideas you can use: The nature of light

Early views about light

Our understanding of the nature of light and how it behaves has changed a great deal over the centuries. The first real models for the nature and behavior of light came from the ancient Greeks. Most of these early models describe the nature of light as a ray. A ray moves in a straight line from one point to another. Euclid and Ptolemy, for example, used ray diagrams to show how light bounces off a smooth surface. In the 11th century, other scientists such as the Arabic mathematician, astronomer and physicist, Ibn al-Haytham, took these ideas and refined them to develop mathematical equations that describe how light behaves when it strikes a mirror, a lens, or a prism. This field of study is now called geometrical optics.

Scientists began to use different models to explain the nature of light in the 17th century. For example, Christiaan Huygens claimed that all light, like sound, is a wave that moves through an “invisible ether” that exists all around us. Isaac Newton, in contrast, claimed that light is composed of small particles because it travels in a straight line and bounces off a mirror much like a ball bounces off a wall. Then in the 1860s, James Maxwell created a new model that described the nature of light as electromagnetic radiation.

Light as electromagnetic radiation

Electromagnetic radiation is a wave of energy. Electromagnetic waves travel through a vacuum, such as space, at a speed of 299,792,458 meters per second. According to this model, electromagnetic waves come in many different sizes. Scientists use wavelength and frequency to characterize the different types of electromagnetic waves. The picture below shows the wavelengths of the different types of electromagnetic waves.
**Purpose:** You will design and perform an experiment that can be used to determine the molar mass of butane gas.

**Background**
You can determine the molar mass of an unknown gas by collecting a measurable sample of it above water. If you assume that the gas collected in the container is an ideal gas, you can use the Ideal Gas Law to derive the equation for calculating its molar mass, $MM$ (g/mol). You can view a derivation of this formula in the table on the right.

<table>
<thead>
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<th>Term</th>
<th>Equation</th>
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<tr>
<td>Molar Mass = mass / moles</td>
<td>$MM = \frac{m}{n}$</td>
</tr>
<tr>
<td>Solve for moles</td>
<td>$n = \frac{m}{MM}$</td>
</tr>
<tr>
<td>Substitute into $PV = nRT$</td>
<td>$PV = \frac{m \cdot R \cdot T}{MM}$</td>
</tr>
<tr>
<td>Solve for Molar Mass</td>
<td>$MM = \frac{m \cdot R \cdot T}{PV}$</td>
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As indicated by the equation above, there are several variables for your gas you will need to determine experimentally. Here are some general things to think about as you decide how to structure your experimental design.

- **When the tab on the lighter is pressed down, butane gas is automatically released. As a result, the mass of butane that remains in the lighter will be less than before.**

- **IMPORTANT:** To ensure any difference in mass is solely due to the butane that was released, you will need to take into consideration that your lighter will be wet after collecting your gas.

- **The maximum volume that your eudiometer can measure is 50.0 mL. Since the density of gas is so small, you will want to collect as much gas as possible in order to provide results that are more accurate.**

- **You will want to ensure your eudiometer is 100% filled with water prior to placing it upside down in the water. If you see ANY air bubbles, try this process over again.**

- **Collecting the gas can put your hands in sort of an awkward position. To get a good feel for ensuring all of the butane gas goes into your eudiometer, you may want to try a quick practice run prior to your experimental trial.**

- **IMPORTANT:** You will want to consider the fact that butane will not be the only gas present in your eudiometer. A small amount of water vapor will also be present, which will exert its own additional pressure. This pressure is known as water vapor pressure $(P_{H2O})$ and its value is dependent on the temperature of the water. The vapor pressure of water can easily be looked up [here](#). Since you only want the pressure from butane, you will need to subtract the water vapor pressure from the total pressure.

\[ P_{total} = P_{butane} + P_{H2O} \quad \rightarrow \quad P_{butane} = P_{total} - P_{H2O} \]

- **IMPORTANT:** When you’re ready to measure the volume of butane you have collected, the level of water in the eudiometer will need to be adjusted so that it is equal to the level of water outside the eudiometer. This ensures that the pressure in the eudiometer is equal to the atmospheric pressure outside of the eudiometer $(P_{atm})$. If a classroom barometer is not
Familiarize themselves with the simulation

Throughout the entire investigation, the platform consistently offers guidance to alleviate/reduce “how to” questions
• BIG help for teachers
Students fill out and submit their investigation proposal using a Google Docs template

- Teacher can alter the template as needed
- Students can share this doc with their group members
But how do I...???

A support video is provided any time students are asked to download a proposal, rename it, and save it.
First instance of peer review

Providing opportunities for collaboration

Activity 8. Peer review the investigation proposals

Read the investigation proposals of at least three people in your group and provide them with some feedback about what they could do to make their plan better.

PREREQUISITES

Activity 7. Plan out your Investigation

Your peer reviews

To complete this activity you must do 3 peer reviews. You can make up to 3 additional reviews when you’ve completed the activity.

Review of submission 1

The feedback receiver reflected on your feedback.

Complete

Review of submission 2

The feedback receiver reflected on your feedback.

Complete
Double-blind peer review
Reflecting on feedback

Activity 9. Reflect on what you learned from the peer review

Read over the feedback you received from your classmates and then respond to the reflection questions.

PREREQUISITES

- Activity 8. Peer review the investigation proposals

Received feedback

To complete this activity you must review 3 feedback entries.

Feedback 1
You reflected on this feedback.

Feedback 2
You reflected on this feedback.

Feedback 3
You reflected on this feedback.
Reflecting on feedback

Investigation Proposal

I am trying to answer the following question:
Why does a pencil sitting in a glass of water look like it is broken?

I plan to collect the following observations or measurements:
Use the Ray setting in the PHet simulation to explore the way light interacts with Air, Water, and Glass. We can measure the angles of refraction through the different materials.

I plan to collect these observations and measurements by:
1. Control (Same materials A & B)—Measure all three (air to air, etc), measure angles for reflection and refraction at light source angle of 15, 30 and 60 degrees
2. Air to Water—measure angles for reflection and refraction at light source angle of 15, 30 and 60 degrees; Water to Glass—Measure angles for reflection and refraction at light source angle of 15, 30 and 60 degrees
3. Air to Glass—Measure angles for reflection and refraction at light source angle of 15, 30 and 60 degrees

Q1
What did you learn from the feedback you received about your proposal?
I have the wrong guiding question! I need to change it to:
How can we predict where a ray of light will go when it comes in contact with a block made of glass or acrylic?

Q2
What did you learn from reviewing the other proposals?
That I did a pretty good job with my collection of observations and materials. I was really specific but need to include acrylic instead of water. I can do this by choosing the "custom" setting and typing in the index of refraction for acrylic (n).

Q3
How do you plan to improve your investigation?
I need to include acrylic instead of water. I can do this by choosing the "custom" setting and typing in the index of refraction for acrylic (n). I will also expand my analysis to include density of the material, n, and the angles of reflection and refraction.
Activity 10. Carry out your investigation

Collect the data you need

Now that you have a plan for your investigation, you can carry it out and collect the data you need to answer the guiding question. Don't forget, the guiding question for this investigation is:

*How can we predict where a ray of light will go when it comes in contact with a block made of glass or acrylic?*

Make sure you keep a record of the data you collect while you are using the simulation to test out your ideas.

What you need to submit for this activity

To keep a record of the data you collect, you will need to:

1. Save a copy of the Observations and Measurements Record to your Google Drive folder.
2. Fill it out.
3. Download a PDF copy of your Observation and Measurements Record from your Google Drive folder to your downloads folder.
4. Submit the PDF copy of your observation and measurements record.

You can access the Bending Light simulation below:
Developing draft argument

Activity 11. Create a draft argument

Create a draft argument to share what you figured out. You may want to revisit the following activities before you begin working on your draft argument:

- Activity 4. Some ideas you can use: The nature of light
- Activity 5. Some ideas you can use: Light rays
- Activity 6. Some ideas you can use: The properties of transparent materials

Many of the ideas found in these activities can be used in your argument to help you justify your evidence.

To create your draft argument, you will need to:

1. Save a copy of the draft argument presentation template to your google drive folder.
2. Fill out the text boxes on the first slide and change the graph or table as needed.
3. Delete the other “help” slides.
4. Download a PDF copy or a JPG copy of your draft argument from your google drive folder to your downloads folder.
5. Submit the PDF copy or the JPG copy of your draft argument.
If in class, we use whiteboards...

**How does atom electronegativity affect bond character & molecular polarity?**

**Claim:** Electronegativity affects bond character & molecular polarity in different ways.

**Evidence:**

<table>
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<tr>
<th>A</th>
<th>B</th>
<th>Results</th>
<th>Partial Charge</th>
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**Reasoning:**

Ionic bonds are the result of one atom being significantly more electronegative, because it has a greater pull strength. Covalent bonds are the result of the atoms having similar pull strengths because one atom isn’t strong enough to take from the other.

In an ionic bond the atom with higher electronegativity takes more electrons from the other atom and becomes negative.

*Gabby, Sidney, Alissa, Tori*
Developing draft argument

Watch the help video below if you want to learn more about how to make a draft argument using the draft argument presentation template.
Opportunity to present and review arguments

Activity 12. Present your draft argument

Make a screencast so you can share your draft argument with your classmates. A screencast is a video recording of your screen that also includes audio input from the microphone. A screencast makes it easy to present your argument to other people who are not in the same room as you because you can show them what you made as you talk about it.

Be sure to talk about the following during your screencast:

- The claim you are making.
- The evidence that you have for your claim.
- Your justification of the evidence that you decided to use.

When you are ready to start your screencast, be sure to:

- Open a new window with your draft argument in it.
- Choose this window as your option to record.
- Press "present" in google slides after you start recording to make your slide take up the whole screen.
Reviewing another student’s argument
Explicit & reflective discussion

Giving students the opportunity to engage with the content and practice and apply some of the things they have learned.

With the other people in your group, use this image and what you know about the nature of light to see if you can answer the following question:

*In the introduction video that you watched in activity 1, why was the ray of light from the laser level red?*
Explicit & reflective discussion

If no one in your group has started a topic thread yet, you can get the conversation going by sharing your ideas about what is going on in this image. If someone else has already started a topic thread, read what they posted and then reply with a comment about a way to make the explanation more complete. Keep adding to the topic thread by making comments until everyone agrees on the best explanation for what is happening in this image.

If synchronous, video conferencing info (zoom, google meet, etc.) can easily be posted to allow for students to build their understanding by talking to one another.
Making improvements for next time

Activity 17. Discuss how to get better at planning and carrying out investigations

Now that you have had a chance to discuss two of the core ideas that you used during this investigation, let’s take some time to discuss what we can all do to get better at planning and carrying out an investigation. To start off this discussion, start a topic thread with your answer to the following question:

*What should we do next time we plan and carry out an investigation to make sure that we collect data that is useful and free from errors?*

Be sure to read the topic threads that were posted by the other people in your group. See if you all can agree on one or two “rules” that you should keep in mind the next time you plan and carry out an investigation. Keep adding to the topic thread by making comments until everyone in your group agrees on one or two rules that you all will follow next time you plan and carry out an investigation.
Creating a draft report

Activity 18. Create a draft report

Prepare a report to share what you did and figured out during this investigation. The report will consist of three sections. Each section should provide an answer to one of the following questions:

- What question were you trying to answer and why?
- What did you do to answer your question and why?
- What is your argument?

You may want to revisit the following resources as you write your report:

- Activity 2. What do you notice and wonder?
- Activity 4. Some ideas you can use: The nature of light
- Activity 5. Some ideas you can use: Light rays
- Activity 6. Some ideas you can use: The properties of transparent materials
- Your investigation proposal
- Your draft argument and the feedback you received from your classmates.
- What you learned during activities 15 and 16.

To create your draft investigation report, you will need to:

1. Save a copy of the draft investigation report template to your google drive folder.
2. Rename it.
3. Write your report using the template as a guide.
Title

Introduction

We have been studying [topic] in class. Before I started this investigation, I watched a video about [what was the video about]. I saw [Describe what happened in the video]. My goal for this investigation was to figure out [your goal]. The guiding question was [guiding question].

Method

To gather the data I needed to answer this question, I [describe what you did to collect data]. I decided that this was the best way to carry out the investigation because [give some reasons]. I then analyzed the data I collected by [describe what you did to analyze the data]. I decided that this was the best way to analyze these data because [give some reasons].

Argument

I figured out [your claim]. The [graph or table] below shows [what information is included in the graph or table].

[Insert graph or table here. To insert a graph or table click on "insert" in the toolbar. The choose "chart" for a graph or "table" for a table to add a editable graph or table to this document]

This analysis indicates [explain what trend, difference, or relationships the graph or table shows in words]. This evidence is important because [explain why the evidence matters].

• Scaffolding in place
• Teacher can edit
• Scaffolds can be rolled back as students become better at writing their reports
Reviewing draft report

Activity 19. Peer review the draft reports

Read the draft investigation reports of at least three people in your group and provide them with some feedback about what they could do to make their report better.

PREREQUISITES
- Activity 18. Create a draft report

Your peer reviews

To complete this activity you must do 3 peer reviews. You can make up to 3 additional reviews when you've completed the activity.

Review of submission 1
Start your review now

Review of submission 2
Peer reviews must be done chronologically. Please complete the one above first.
Investigation 1: Reflection and Refraction of Light

Introduction
We have been studying the reflection and refraction of light. The guiding question was *How can we predict where a ray of light will go when it comes in contact with a block made of glass or acrylic?*

Method
To gather the data I needed to answer this question, I used the Phet Interactive Simulation, Bending Light. I decided that this was the best way to carry out the investigation because it was based on reliable data that reflect what would take place in the real world. I decided that this was the best way to collect data because we can observe the changes in speed of light through transparent materials by measuring the different angles of refraction.

Feedback is broken down by sections within the report

Q1

Take a look at the introduction of the investigation report. Did the author:

- Provide a context for the investigations?
- Provide correct information related to the phenomenon?
- Make the guiding question clear?

In the comment box below provide specific feedback for each of the questions below. Provide suggestions for improvement where you see weaknesses and specific compliments for areas of strength.

0 of min. 10 words
Revise
Students revise their proposals, arguments, and reports based on feedback.

Submit Work
Students turn in all assignments without leaving the system.
## Monitoring student progress

<table>
<thead>
<tr>
<th>Name</th>
<th>Course Description</th>
<th>Pick your Class Period</th>
<th>Activity 1: Join a group</th>
<th>Activity 2: What do you notice a...</th>
<th>Activity 3</th>
<th>Scores</th>
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### Monitoring student progress

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Monitoring student progress

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Pricing

INDIVIDUAL
1 TEACHER/COURSE
1 - 9 Courses
$399/COURSE

SMALL TEAM
1 TEACHER/COURSE
10 - 40 Courses
$349/COURSE

LARGE TEAM
1 TEACHER/COURSE
41 + Courses
Includes all features listed above plus up to 1gb file size per student upload.
$249/COURSE
Key Similarities

- Ready-to-go activities for teachers to use and can be customized in any way you like.
- Ability to grade and provide teacher feedback
- Compatible with any device (PHET simulations from ADI Online are in HTML5, which is compatible with apple devices).
- Guided instructions throughout activity
- Students are invited to your class by sharing an activation code
- Activities provide students with experiences for authentic investigation
Key Differences

**Pivot Interactives**
- $5/student (bulk order discount available)
- Students observe, measure, and analyze real events
- Variables can be changed, and multiple trials performed
- Data tools like tables, graphs, equation generators are integrated within platform
- Large variety of chemistry activities to choose from
- Setup and flow of activity is natural, but less formal and time intensive than ADI Online
- Videos available can easily be utilized as an authentic assessments

**ADI Online**
- $349/teacher (each teacher given up to 200 spots)
- Student observations and measurements are based on PHET simulations
- Of the eight possible activities available, teachers can choose which six they want
- Allows for collaboration within platform
- Setup reflects eight-stage instructional model, ensuring students are engaging in a range of essential science practices
- Less frontloading required from teacher to execute entire activity
- Student submission data available to teacher is superior
Key Takeaway

**BOTH** Pivot Interactives and ADI Online serve as an example of a model that can be used to create opportunities for *constructive* and *interactive* interactions within an online learning environment.

- *Engaging with the science practices that we know are at the core of quality science education*
Survey, Certificate, and Downloads

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To Download Resources:


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