From Cookbook to Inquiry in STEM Classroom

“I hear... I forget; I see... I remember; I do... I understand.”
- Chinese proverbs.

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As presented by teachHOUSTON at the University of Houston
<table>
<thead>
<tr>
<th>Engage</th>
<th>Introduces the lesson and <strong>captures student’s attention</strong></th>
</tr>
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<tbody>
<tr>
<td>Explore</td>
<td><strong>New concepts are discovered</strong> through inquiry-based activities</td>
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<tr>
<td>Explain</td>
<td>Building <strong>new concepts through discussion</strong></td>
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<tr>
<td>Elaborate</td>
<td><strong>New learned concepts will be applied to new situations</strong></td>
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<tr>
<td>Evaluate</td>
<td><strong>Assesses</strong> students’ <strong>new knowledge</strong></td>
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Engage: Cookbook Lesson Example

- What are some teaching strategies you observed in this lesson?
- What are the advantages?
- What are the disadvantages?
- From a student’s perspective, what do you think of this lesson’s setup?
- From a teacher’s perspective, what are your thoughts on this lesson?
Explore: Getting Wired for Circuits

- In a **group at your table**, explore the Getting Wired for Circuits activity.
- You will have **15 minutes** for this activity.
- While you participate in the explore activity; **observe the differences between the cookbook video and inquiry explore activity.**
- Write your observations on the two sheets provided!
Explain: Cookbook vs. Inquiry

- We gave you a mystery card and the card’s content should have either the characteristics of a cookbook lesson or an inquiry lesson.
- Our room will be divided in half.
- The left side of room will be cookbook, and the right side of the room will be inquiry.
- Your task is to determine which side of the room you belong to.
- It’s time for Family Feud
## Explain: Cookbook vs. Inquiry

<table>
<thead>
<tr>
<th>Cookbook</th>
<th>Inquiry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driven with <strong>step-by-step instructions</strong> requiring minimal intellectual engagement.</td>
<td>Driving by <strong>questions requiring ongoing intellectual engagement using higher-order thinking skills</strong>.</td>
</tr>
<tr>
<td><strong>Verifying information previously communicated</strong> in class. <em>(Abstract to Concrete)</em></td>
<td>Collecting and interpreting data to discover new concepts, principles, or laws. <em>(Concrete to Abstract)</em></td>
</tr>
<tr>
<td>Students <strong>execute imposed experimental designs</strong> that tell students which variables to hold constant, which to vary, which are independent, and which are dependent.</td>
<td>Students <strong>create their own experimental designs</strong>; independently identify, distinguish, and control pertinent independent and dependent variables.</td>
</tr>
<tr>
<td>Rarely allow students to confront and deal with error, uncertainty, and misconceptions.</td>
<td>Allow for students to learn from their mistakes and missteps; provide opportunity recover from mistakes.</td>
</tr>
<tr>
<td>Show the work of math and science to be <strong>unrealistic linear process</strong>.</td>
<td>Show the work of math and science to be <strong>recursive and self-correcting</strong>.</td>
</tr>
</tbody>
</table>

Adapted from “Experimental inquiry in introductory physics courses”  


### Inquiry Continuum

<table>
<thead>
<tr>
<th>Topic</th>
<th>Traditional Hands-on</th>
<th>Structured Inquiry</th>
<th>Guided Inquiry</th>
<th>Student Directed Inquiry</th>
<th>Student Research Inquiry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher</td>
<td>Teacher</td>
<td>Teacher</td>
<td>Teacher</td>
<td>Teacher</td>
<td>Teacher/Student</td>
</tr>
<tr>
<td>Question</td>
<td>Teacher</td>
<td>Teacher</td>
<td>Teacher</td>
<td>Teacher/Student</td>
<td>Student</td>
</tr>
<tr>
<td>Materials</td>
<td>Teacher</td>
<td>Teacher</td>
<td>Teacher</td>
<td>Student</td>
<td>Student</td>
</tr>
<tr>
<td>Procedures/Design</td>
<td>Teacher</td>
<td>Teacher</td>
<td>Teacher/Student</td>
<td>Student</td>
<td>Student</td>
</tr>
<tr>
<td>Results/Analysis</td>
<td>Teacher</td>
<td>Teacher/Student</td>
<td>Student</td>
<td>Student</td>
<td>Student</td>
</tr>
<tr>
<td>Conclusions</td>
<td>Teacher</td>
<td>Student</td>
<td>Student</td>
<td>Student</td>
<td>Student</td>
</tr>
</tbody>
</table>

Explain: Cookbook to Inquiry Process

• Questioning
  • Avoid answering directly
    • Student’s Question: “What is the Voltage in a circuit?”,
    • Teacher’s Answer: “What do we need to determine the Voltage of a circuit?”

• Taking data/Experimenting/Analyzing data
  • Allowing students to come up with alternative solutions or methods to get the same results.

• Encouraging active participation
  • Set clear rules such as:
    • Must participate for credit, individual participation grades, structure for presenting results, time limits for individual participation within a group.
Elaborate: Cookbook to Inquiry

- Each group will have a cookbook sample lesson in either Math, Chemistry, or Biology.
- Your task is to convert the cookbook lesson into an inquiry lesson.
- You will have 10 minute for this activity
- Be prepare to share with your peers.
Elaborate: Biology Cookbook to Inquiry

Darwin’s Natural Selection Worksheet

Name __________________________

Read the following situations below and identify the 5 points of Darwin’s natural selection.

1. There are 2 types of worms: worms that eat at night (nocturnal) and worms that eat during the day (diurnal). The birds eat during the day and seem to be eating ONLY the diurnal worms. The nocturnal worms are in their burrows during this time. Each spring when the worms reproduce, they have about 500 babies but only 100 of these 500 ever become old enough to reproduce.

   a. What worm has natural selection selected AGAINST? __________
   
   FOR? __________

   b. Darwin’s 5 points: Identify the 5 points in the scenario above.
      Population has variations.
      ________________________________________________________________
      Some variations are favorable.
      ________________________________________________________________
      More offspring are produced than survive.___________________________
      Those that survive have favorable traits.
      ________________________________________________________________
      A population will change over time.
      ________________________________________________________________

A cookbook lesson where the students are expected to read scenarios and answer the same questions repeatedly.

Build Your Own Beast

In your groups, use the materials in the boxes provided to build an organism that best suits the environment given. Get ready to defend your choices!

Now that you have created an organism that suits your environment, share with the class the characteristics of your environment and why the traits you chose best suit that area.

What do you think would happen if we put Group A’s organism in Group B’s environment?

In an inquiry lesson, students are hands on and build on previous knowledge through an interactive activity.
Addressing Common Misconceptions

• Cookbook lessons do not address the misconceptions with evolution and natural selection

• Natural selection DOES NOT lead to perfection- it’s best suited in that environment!

• This is portrayed when they talk about moving the organisms to different environments
Below is an example of a cookbook investigation leads students through a step-by-step process.

**Sketch and Investigate:**

- Construct triangle $ABC$ in the box provided below.
- Construct the midpoint of segment $AB$. Label it $D$.
- Construct the midpoint of segment $BC$. Label it $F$.
- Construct the midpoint of segment $CA$. Label it $E$.
- Construct a line from vertex $A$ to point $F$. (the median of $BC$).
- Construct a line from vertex $B$ to point $E$. (the median of $AC$).
- Construct a line from vertex $C$ to point $D$. (the median of $AB$).
- A centroid of a triangle is the point where the three medians of the triangle meet. (point $G$)
- The centroid is also called the center of gravity of the triangle.
Elaborate: Math Cookbook to Inquiry

Pin held by clamp

hole

plumb line
Below is the Inquiry version of finding the centroid

A new life in Houston, TX

Your old friend from college need your help about planning to move to Houston, TX. He is looking for a house equidistant to the University of Houston, downtown, and the zoo and museum district (using the map provided on the right). Locate such a site or sites on the map and let him know how you located where your friend should live. Be prepare to present your solution in class by showing your work using GeoGebra.
Student incorrect conjecture that the house lies within the triangle formed by connecting the three schools with the line segments.
Elaborate: Math Cookbook to Inquiry

Student utilized GeoGebra to find the midpoint of each line segment and connect them to each points to determine the centroid.
Elaborate: Chemistry Cookbook to Inquiry

### Balancing Equations Worksheet

1) \( \quad \text{Na}_3\text{PO}_4 + \quad \text{KOH} \rightarrow \quad \text{NaOH} + \quad \text{K}_3\text{PO}_4 \)
2) \( \quad \text{MgF}_2 + \quad \text{Li}_2\text{CO}_3 \rightarrow \quad \text{MgCO}_3 + \quad \text{LiF} \)
3) \( \quad \text{P}_4 + \quad \text{O}_2 \rightarrow \quad \text{P}_2\text{O}_3 \)
4) \( \quad \text{RbNO}_3 + \quad \text{BeF}_2 \rightarrow \quad \text{Be(NO)}_3\text{}_2 + \quad \text{RbF} \)
5) \( \quad \text{AgNO}_3 + \quad \text{Cu} \rightarrow \quad \text{Cu(NO)}_3\text{}_2 + \quad \text{Ag} \)
6) \( \quad \text{CF}_4 + \quad \text{Br}_2 \rightarrow \quad \text{CBr}_4 + \quad \text{F}_2 \)
7) \( \quad \text{HCN} + \quad \text{CuSO}_4 \rightarrow \quad \text{H}_2\text{SO}_4 + \quad \text{Cu(CN)}_2 \)
8) \( \quad \text{GaF}_3 + \quad \text{Cs} \rightarrow \quad \text{CsF} + \quad \text{Ga} \)
9) \( \quad \text{BaS} + \quad \text{PtF}_2 \rightarrow \quad \text{BaF}_2 + \quad \text{PtS} \)
10) \( \quad \text{N}_2 + \quad \text{H}_2 \rightarrow \quad \text{NH}_3 \)
Evaluate (Closure): Think-Pair-Share

• In your groups talk for 2 minute about some of the things you learned today and/or enjoyed from this presentation.

• You will share 1 thing as a group, so get your group’s speaker ready as well.
“Sometimes it is the people no one imagines anything of who do the things that no one can imagine.”

- Alan Turing
Acknowledgements:

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Dr. Jeff Morgan
Dr. Cathy Horn
References:


Thank you!

- Questions?
- Feedback?
- Noyce 2017 Survey Link: http://tinyurl.com/wrni17fb

- Presentation will be available on: http://www.uh.edu/nsm/physics/undergraduate/noyce-scholarship/