Making Use of Student Thinking

How can we use powerful formative assessment tools to inform our teaching?

Presenters: Taylor Langolf, Rachel Longo, Alissa Neff, and Miranda Roberts
Changing Formative Assessments

Traditional methods include:

- thumbs-up or thumbs-down
- fist of five
- etc.

The above methods are shallow and do not show a student’s thought process.

Open-ended formative assessment will allow us to gauge what students actually know.

- Requires students to explain their thinking
- Gives insight into patterns in student understanding
- Allows us to adjust our teaching to fit our students.
Eliciting Individual Student Thinking

Open-ended formative assessments require students to grapple with the subject matter and how they process it. This gives us a lot of valuable information such as:

- Are they just spitting back information? (Vocabulary without context?)
- Can they provide evidence for the way they are thinking?
- Can they summarize what their classmates have said?
How Do We Make Use of the Evidence Students Give Us?

Formative Assessments are a great way to get out what students already know and find out what misconceptions students have, but what do we actually **DO** once we have collected these assessments?
Making Use Of Student Thinking

1. Present your probe, assessment, or assignment to students
2. Collect student responses
3. Pay attention to trends and patterns
4. Use these patterns to inform future teaching?
   ○ This is the tricky part!
How Can We Use These Patterns to Inform Our Teaching?

Four Cases of Using Formative Assessment to Find Patterns
Case #1 - Miranda Roberts

Unit: Genetics

The formative assessment used was based on the open-ended response style found in Page Keeley’s *Uncovering Student Ideas in Science* books. The probe presented can be seen below.

Vocabulary expected: homozygous, heterozygous, dominant, recessive, gene, allele

Mr. Bondy loves gardening. One day, he decided to plant some seeds in his garden. The farmer he bought the seeds from promised him that the seeds were the result of a purple flowered plant crossed with a white flowered plant. It just so happens that white and purple are Mr. Bondy’s favorite colors and he couldn’t wait to see both in his garden. Mr. Bondy planted the seeds and waited patiently for them to grow. When they bloomed, every flower was purple! Mr. Bondy was a little upset. Can you explain to Mr. Bondy what is happening?
A Purposeful Assessment

The purpose was to gauge initial thought processes and understandings early on in the unit.

The goal was to ensure that students had a firm grasp on genetic vocabulary and the basic concepts of inheritance patterns before pushing forward into more complex material.

The specific goal of the probe was to get an explanation of the pattern of inheritance seen in the prompt including concepts of basic Mendelian genetics using appropriate vocabulary.
Categorizing Student Responses

Results were categorized into predetermined, “levels of understanding” based on their explanation of the phenomena.

Three levels:

- Advanced understanding
- Intermediate understanding
- Weak/poor understanding

These categorized data were sorted using Excel spreadsheets.
Student Work Sample
Weak Understanding

- An example of “vocab vomit”.
- This student picked up on *some* ideas.
- Not making connections to patterns of inheritance.

“this is happening to Mr. Bondys flowers because the seeds must have heterozygous genes with dominant purple genes that overpowered the white”
Student Work Sample
Intermediate/Weak Understanding:

- This student uses vocabulary.

- They know that white does not show because it is recessive, but does not seem to know what the parent & offspring genotypes look like.

- Explanation fails to tie the facts to the underlying concepts of patterns of inheritance.

“Homozygous trait that was dominant and purple… heterozygous recessive trait that was recessive and purple… combine and create a white flower but does not show because white is recessive.”
The genotype of the purple flower is homozygous dominant (PP). The genotype of the white flower is homozygous recessive (pp). When they crossed there is a 100% chance of all [offspring] being purple (Pp). Unfortunately for Bondy, the offspring were all heterozygous dominant (Pp) and purple.
Making Sense of Student Data

Placing responses into the three categories of weak, intermediate, and advanced helped in finding general trends across the class and note any severe misunderstandings individual students may have had.

As seen in the student work samples, some concepts clearly needed reteaching and could be approached in a different way.
Making Use of Student Responses

The general trend across the class indicated many students needed more practice utilizing vocabulary.

Many responses were shallow - students may have been using vocabulary correctly, but do they really know the underlying concepts?

Students needed another chance to connect the vocabulary to the concepts.
Encouraging Student Collaboration

To help students that were struggling, students were partnered into groups of four based on ability which was determined by the levels of understanding from the probe.

Groupings:

- 1 Advanced student
- 2 Intermediate/weak Student
- 1 Weak Student

These groupings were intended to have the stronger students help the weaker students.
How to Address Misconceptions

It was clear that some students were using certain terms interchangeably, so starting with a comparison of those tricky terms was the first step to gaining understanding of these terms.
Collaboration Using Visual Methods

Comparing Similar Terms:

Students were asked to make a “T” chart on whiteboards comparing vocabulary (gene vs. allele, homozygous vs. heterozygous, dominant vs. recessive)

As whole group we considered the whiteboard examples and definitions of each group and adjusted as needed.
I opened up a whole class discussion directly after the comparisons to re-address the prompt given to them a few days past. Students really opened up which led to drastically better verbal responses. Students were more confident in their use of the language and were able to use it correctly and make connections between terms in both writing and conversation.
One More “Mini-Assessment”

As a warm up for the next class, to really make sure the students understood the concepts, a new prompt about “Mr. Bondy’s Garden” was asked:

Mr. Bondy crossed some flowers from the all-purple generation of plants he grew. What are the possible genotypes and phenotypes he might see in the next generation of plants? What is the probability of each? Show your thinking with a Punnett Square(s).

This gave students one more chance to express their thinking about the concepts before we moved onto more complex content.
This time around, answers were more thorough.

This student, among many others, was able to make a clear connection with the pattern of inheritance between generations while using appropriate vocabulary.
Case #2 - Taylor Langolf

Unit: Cellular Respiration

This case was not originally designed as a formative assessment probe, but after looking at patterns in student thinking on an ongoing assignment, I decided intervention was needed.
The Case

Students were working on a lab report in regards to the fermentation lab they had just conducted.
Tracking Student Work

Student work was tracked in real time through the use of google classrooms.
Identifying Patterns

As I reviewed student work, I began noticing patterns.

The wide variation in responses led me to believe that students were unsure of what the lab was about.

It became clear that students had just followed a recipe and collected the prescribed data without any thought.

Purpose:
- How does the type of sugar affect the rate of respiration?
- Can any type of sugar be used as a fuel for cellular respiration?
- The purpose is to show which sugar is best for fermentation.
- What effect does the type of sugar have on the rate of respiration?
- The purpose of this experiment is to analyze the effect of different types of sugars in relation to how the rate of respiration changes or remains the same.
- What effect does sugar have on yeast?
- The purpose of this experiment is to try to determine if other types of sugars, other than glucose, can be used to fuel cellular respiration.
- To find out which type of sugar makes respiration occur at a faster rate.

Hypothesis
- If the sugar and water are mixed, then carbon dioxide will be released because of fermentation.
- If a sugar solute and yeast are mixed into a tube, then carbon dioxide will be released due to the process of fermentation.
- If we change the type of sweeteners given to yeast, then the rate of cellular respiration will decrease when the sugar isn't glucose because glucose is the best fuel source for performing cellular respiration.
- If we change the type of sugar, it will affect the rate of respiration because they have different chemical equations.
- If we add different types of sugar to the same amount of yeast then, one sugar will create cellular respiration faster because each sugar has a different amount of carbon dioxide content.

Variables
Independent Variable and its Levels (Include the unit and how the variable will be measured):
- Type of sugar
- Time (minutes)
- Sucrose and sucralose (measured in mL)
- Types of sugar solutions used (mL) - sucralose and sucrose
- Type of sugar: L1 - stevia (3g), L2 - sucrose (3g)

Dependent Variable (Include the unit and how the variable will be measured):
- The rate of respiration
- The change in volume (amount of CO2) How it will be measured: By taking measurements of volume before the test
- Volume of liquid after respiration (mL)
- Amount of CO2 created (measured in mL of liquid displaced)
- Size of the gas bubble (mL) which indicates if cellular respiration is present
- The rate of respiration (the size of bubble is evidence of this occurrence)
Identifying Patterns

This is especially clear when looking at the data tables that students were creating.

SO...

I decided to compile common ideas and work samples and created a single document.

<table>
<thead>
<tr>
<th>Type of Sugar, Trial #</th>
<th>Initial volume (grams)</th>
<th>Final volume (grams)</th>
<th>Change in volume (grams)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose, 1</td>
<td>28 g</td>
<td>18 g</td>
<td>-10 g</td>
</tr>
<tr>
<td>Glucose, 2</td>
<td>28 g</td>
<td>18 g</td>
<td>-10 g</td>
</tr>
<tr>
<td>Sucrose, 1</td>
<td>28 g</td>
<td>19 g</td>
<td>-9 g</td>
</tr>
<tr>
<td>Sucrose, 2</td>
<td>28 g</td>
<td>18 g</td>
<td>-10 g</td>
</tr>
<tr>
<td>Lactose, 1</td>
<td>28 g</td>
<td>24 g</td>
<td>-4 g</td>
</tr>
<tr>
<td>Lactose, 2</td>
<td>28 g</td>
<td>27 g</td>
<td>-1 g</td>
</tr>
</tbody>
</table>

| Glucose (Trial #1)    | 27                      | 24                    | 3                         |
| Glucose (Trial #2)    | 27                      | 24                    | 3                         |
| Sucrose (Trial #1)    | 27                      | 11                    | 16                        |
| Sucrose (Trial #2)    | 27                      | 21                    | 6                         |
| Lactose (Trial #1)    | 27                      | 26                    | 1                         |
| Lactose (Trial #2)    | 27                      | 25                    | 3                         |

| Glucose 1             | 30 mL                   | 8 mL                  | -22 mL                   |
| Glucose 2             | 30 mL                   | 14 mL                 | -10 mL                   |
| Lactose 1             | 30 mL                   | 23 mL                 | -7 mL                    |
| Lactose 2             | 30 mL                   | 25 mL                 | -5 mL                    |
| Dextrose 1            | 30 mL                   | 15 mL                 | -15 mL                   |
| Dextrose 2            | 30 mL                   | 13 mL                 | -17 mL                   |
Helping Students Make Sense of the Lab

Before annotating these compiled samples, students first needed to make sense of the lab.

To do this, in their lab groups, students annotated their procedure, produced whiteboard diagrams, and explained what processes were occurring.

“Yeast is performing anaerobic respiration (alcoholic fermentation).”

\[
\begin{align*}
\text{Glucose} & \rightarrow \text{Pyruvic Acid} \\
\text{Pyruvic Acid} & \rightarrow \text{CO}_2, \text{Alcohol} \\
\end{align*}
\]
Helping Students Analyze Their Own Work

Students were then given the sample document. In their lab groups, students were to annotate these samples, saying what examples were strong or weak, and ways to improve weak samples.

Allows students to engage in:

- Peer Editing
- Collaboration
- Meta Cognition → through self analysis
Annotating in Whole Group

Students analyze samples, ask questions, and make comments and suggestions for improvement.

To identify the purpose and hypothesis, students refer to their diagrams from earlier.

Purpose: To identify how $\text{IV}$ affects $\text{DV}$.
- How does the type of sugar affect the rate of respiration?
- Can any type of sugar be used as a fuel for cellular respiration?
- The purpose is to show which sugar is best for fermentation.
- What effect does the type of sugar have on the rate of respiration?
- The purpose of this experiment is to analyze the effect of different types of sugars in relation to how the rate of respiration changes or remains the same.
- What effect does sugar have on yeast?
- The purpose of this experiment is to try to determine if other types of sugars, other than glucose, can be used to fuel cellular respiration.
- To find out which type of sugar makes respiration occur at a faster rate. Can be tested.

Hypothesis: Prediction format if, then (condition, consequent), based on background info.
- This is not what we are testing. We know this will happen.
- If the sugar and water are mixed, then carbon dioxide will be released because of fermentation.
- If a sugar solute and yeast are mixed into a tube, then carbon dioxide will be released due to the process of fermentation.
- If we change the type of sweeteners given to yeast, then the rate of cellular respiration will decrease when the sugar isn’t glucose because glucose is the best fuel source for performing cellular respiration.
- If we change the type of sugar, it will affect the rate of respiration because they have different chemical equations.
- If we add different types of sugar to the same amount of yeast then, one sugar will create cellular respiration faster because each sugar has a different amount of carbon dioxide content.
Annotating in Whole Group

The order of the annotation was purposeful and meant to scaffold ideas.

Once students could identify a strong purpose and hypothesis, identifying variables became easier.

Variables

Independent Variable and its Levels (include the unit and how the variable will be measured):
- Type of sugar (true, but not specific)
- Time (minutes) (is our constant)
- Sucrose and sucralose (measured in mL)
- Types of sugar solutions used (mL) - sucralose and sucrose
- Type of sugar: L1 - stevia (3g); L2 - sucrose (3g)

Dependent Variable (Include the unit and how the variable will be measured):
- The rate of respiration (true, but not specific)
- The change in volume (amount of CO2) How it will be measured: By taking measurements of volume before the test & after the procedure (not what we are searching for)
- Volume of liquid after respiration (mL)
- Amount of CO2 created (measured in mL of liquid displaced)
- Size of the gas bubble (mL) which indicates if cellular respiration is present
- The rate of respiration (the size of the bubble is evidence of this occurrence)

CONTROL: glucose sugar solution (mL)
Helping Students Make Sense of Their Own Work

After all that, students could see what was lacking in the data table used for raw data collection. (ex. appropriate titles)

Students could also then identify necessary components of tables. (ex. units of measurement)
Results of the Effort

Days after these activities, marked improvements in all sections of the lab reports can be seen.

| Independent Variable and its Levels (Include the unit and how the variable will be measured.) | Type of sugar (14 mL sucrose solution, 14 mL of lactose solution) |
| Dependent Variable (Include the unit and how the variable will be measured.) | CO2 production, mL (air bubble increase) |
| Control Group (if applicable) | Glucose solution (14 mL) |

Students are now using correct units and identifying variables accurately.

“...dextrose... is chemically identical to glucose...”
This student is now trying to use scientific facts to back up their hypothesis.

HYPOTHESIS (B.ii): If we add yeast to different types of sugar then, dextrose will go through cellular respiration at a faster rate because dextrose is a simple sugar, that is made from corn and is chemically identical to glucose, making it easier for yeast to transport it across the cell membrane and break the dextrose down faster.
Implications for Future Teaching

For future labs, to avoid the same mistakes, I would:

- Analyze the procedure and discuss how it relates to underlying concepts before the lab
- Focus on helping students search for more scientifically based background information.
Case #3- Alissa Neff

Unit: Momentum

This took place 2 weeks into the momentum unit

Prompt 1: Explain your egg drop device and the purpose for each feature.

Prompt 2: Explain why a tennis ball launcher recoils after firing a tennis ball.
Prompt 1: Egg Drop

“Explain your egg drop device and the purpose for each feature”

Trends

● Colloquial wording
● Vague explanations
● Few direct connections to the big idea
Student Work Sample

“Inside the cage, the seat was propped up with rubber bands so that whenever the egg was dropped the rubber band was sort of reduce the impact of the fall with a bounce. The plastic bags were to have cushion around the egg if it got loose from the seat and fell out. The rubber bands were as I said earlier, something to reduce the impact of the fall with a bounce.”
Whole Class Reflection

Four student samples were reviewed as a class.

Conclusions

● More detail is better
● Apply unit relevant concepts
● Use scientific terminology
Prompt 2: Impulse

“Explain why a tennis ball launcher recoils after firing a tennis ball using the terms “force” and “mass”.

Trends

● Scientific terminology present
● “Word vomit”
● Clear misconceptions
“It rolls back because the mass x acceleration applies a force onto the machine which causes a change in velocity because when the force is applied the time increases and impulse = F x t”
Results

Prompt 1

- Accurate explanations
- Few connections drawn to key physics concepts

Prompt 2

- Inaccurate explanations
- Use of scientific terminology
- Easy to identify misconceptions
Next Steps

Modify colloquial explanations with accurate, scientific reasoning.

Original

1. The plastic bags were to **have cushion around the egg** if it got loose from the seat and fell out.
2. The rubber bands were as I said earlier, something to **reduce the impact of the fall with a bounce**.

Modified

1. The plastic bags were to **cushion the egg and increase the impact time** if it fell out of the seat.
2. The rubber bands were intended to **reduce the impact force** from the fall by **increasing the time of impact**.
Case #4- Rachel Longo

Background:

Happening in a freshman Biology class using the Next Generation Storyline.

The storyline we are focusing on is Antibiotic Resistance:

- Driving question: Why don’t antibiotics work like they used to?
Student Knowledge

- The students have watched a video about a little girl named Addie who became gravely ill by a pan resistant bacteria.
  - MRSA and Stenotrophomonas

- They then performed a lab of swabbing items in the classroom and swabbing it on agar plate to see if there would be bacterial growth

- Students then drew model of lab and what they predict their plates will look like when we come back to them.
Student Work: First Draft of Model

**Before**
- The computer keyboard was cleaned with an alcohol wipe.
- The group added agar and bacteria to the keyboard in the lab.

**Prediction**
- This is what we think the bacteria will look like after 2 weeks.

**After**
- **Bacteria**
  - After 1 week! (Prediction)

**Group 1**
- Keyboard
- Bacteria

**Group 2**
- Computer keyboard
- Bacteria growing base
Student Work: First Draft of Model

**Group 3**

**What we did:**
We added to each petri dish 3% NaCl to see the bacteria.

**What we think:**
We think the bacteria will make the bacteria visible and be many different colors.

**Group 4**

**Predictions:**
The bacteria from the vent will grow over night.
Helping Students Make Sense So Far

Gallery Walk:

Students realized they should:

- Be able to explain their model in words
- Need to label more
- More scientific terminology
Student Work Revised

**Before**
- Sweated the keypads with a wet rag.
- The keys rubbed the rag on the edges of the keys.

**Prediction**
- This is what we thought the bacteria would look like after 2 weeks.
- The agar would completely absorb the bacteria.

**After**
- The agar absorbed the bacteria.
- The bacteria grew on the agar.

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**Bacteria**
- After 1 week!

**Group 1**

**Bacteria**
- After 1 week!

**Group 2**
**Student Work Revised**

**Group 3**

**What We Did....**

- Swabbed lotion bottle with q-tip
- Rolled q-tip in petri dish of agar

**Predictions**

- The bacterial culture from the vent will grow over night

**What We Think....**

- We think the lotion will make the bacteria stop and become different colors

**What happened....**

- The bacteria won't do it. so we did a visible observation

**Group 4**

**Predictions**

- Cutting bacterial growth

**Before**

○ ○ ○

**After**

○ ○ ○

**Growth**

**Before**

○ ○ ○

**After**

○ ○ ○

**Reagents/Equipment**

- Making visible broth, see the petri dish
Helping Students Make Sense So Far

After revision students still need to:

- Use scientific terminology
- Labels including timing
Making Sense After Completion of Models

Based on the models, I can identify what concepts need to be covered to help students answer the original question, “Why don’t antibiotics work like they used to?”

For example:

○ Replication
○ How this ties to antibiotics
○ Types of bacteria
Discussion
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Thank you!