ASSESSING STUDENTS’ CONTENT KNOWLEDGE AND SCIENTIFIC REASONING THROUGH WRITTEN EXPLANATIONS

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Overview of Session

- What are scientific explanations?
- How do you assess scientific explanations?
- How do you provide students with feedback?
- How do you create assessment tasks for scientific explanations that align with Framework for K – 12 Science Education?
7th Grade Chemistry Unit

- **Substances and Properties**
  - Describe observable properties of fat and soap.
  - Determine the density, solubility, and melting point of fat and soap.

- **Chemical Reactions**
  - Investigate three different chemical reactions, boiling, and mixing.
  - Use molecular models to explore whether new substances are produced.
  - Conduct chemical reaction to make soap from fat.

- **Conservation of Mass**
  - Investigate if mass changes in chemical reactions.
  - Use molecular models to explore why mass is conserved during chemical reactions.
Key Content Learning Goals

• Substances and properties
  – Substances are made up of the same type of atom or molecule throughout and can be identified and distinguished by their properties.

• Chemical reaction
  – Chemical reactions are a process in which two or more substances interact to form new substances with new properties. At the atomic level, this means that the atoms of the old substances rearrange to form the new substances.

• Conservation of mass
  – Mass is neither created nor destroyed in chemical processes; atoms simply rearrange to form new substance.
Activity: Critique Students’ Explanations

• Examine two students’ explanations

• Questions:
  – How would you assess these responses?
  – What feedback would you give these students?
Importance of Scientific Explanations

• Science is about explaining phenomena
• Key to the science education standards and the Framework for K-12 science education
• Change students’ image of science
• Enhance students’ understanding of the nature of science
• Foster deeper understanding of important science concepts
Essential Features of Classroom Inquiry and Their Variations

Learners

• Engage in scientifically oriented questions
• Give priority to evidence in responding to questions
• Formulate explanation from evidence
• Connect explanations to scientific knowledge
• Communicate and justify explanations

From the National Science Education Standards
## Essential Features of Classroom Inquiry and Their Variations

<table>
<thead>
<tr>
<th>Essential Feature</th>
<th>Variation</th>
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<tbody>
<tr>
<td>Learner engages in scientifically oriented questions</td>
<td>Learner poses a question</td>
</tr>
<tr>
<td>Learner selects among questions, poses new questions</td>
<td>Learner sharpens or clarifies question provided by teacher, materials, or other sources</td>
</tr>
<tr>
<td>Learner gives priority to evidence in responding to questions</td>
<td>Learner directed to collect certain data</td>
</tr>
<tr>
<td>Learner directed to collect certain data</td>
<td>Learner given data asked to analyze</td>
</tr>
<tr>
<td>Learner determines what constitutes evidence and collects it.</td>
<td>Learner given data and told how to analyze</td>
</tr>
<tr>
<td>Learner formulates explanation from evidence</td>
<td>Learner given data and told how to analyze</td>
</tr>
<tr>
<td>Learner guided in process of formulating explanation from evidence</td>
<td>Learner provided with evidence</td>
</tr>
<tr>
<td>Learner formulated explanation after summarizing evidence</td>
<td>Learner guided with evidence</td>
</tr>
<tr>
<td>Learner directs to areas and sources of scientific knowledge</td>
<td>Learner given possible connections</td>
</tr>
<tr>
<td>Learner independently examines other resources and forms the links to explanations</td>
<td>Learner given possible connections</td>
</tr>
<tr>
<td>Learner coached in development of communications</td>
<td>Learner provided broad guidelines to sharpen communications</td>
</tr>
<tr>
<td>Learner Communicates and justifies explanations</td>
<td>Learner given steps and procedures for communications</td>
</tr>
</tbody>
</table>

### More-------------------Amount of Learner Self Direction-------------------------------Less

### Less------------------------Amount of Direction from Teacher or Material---------------------------More

Adapted from the National Science Education Standards
Explanation Framework

- **Claim**: a conclusion about a problem
  - Often answers a question
- **Evidence**: scientific data that supports the claim
  - Sufficient and appropriate evidence
- **Reasoning**: a justification that shows why the data counts as evidence to support the claim and includes appropriate scientific principles
- Consider alternative explanations
Write a scientific explanation that states whether any of the liquids are the same substance. Liquid 1 and 4 are the same substance. They both have a density of 0.93 g/cm³, have no color, and start to melt at -98°C. For substances to be the same, they must have the same properties. Since liquids 1 and 4 have the same properties, they are the same substance. The other 2 liquids are different substances because they have different properties.
# Base Explanation Rubric

<table>
<thead>
<tr>
<th>Component</th>
<th>Level 0</th>
<th>Level 1</th>
<th>Level 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Claim</strong></td>
<td>Does not make a claim, or makes an inaccurate claim.</td>
<td>Makes an accurate but incomplete claim.</td>
<td>Makes an accurate and complete claim.</td>
</tr>
<tr>
<td>A statement that responds to the question asked or the problem posed.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Evidence</strong></td>
<td>Does not provide evidence, or only provides inappropriate evidence (Evidence that does not support claim).</td>
<td>Provides appropriate, but insufficient evidence to support claim. May include some inappropriate evidence.</td>
<td>Provides appropriate and sufficient evidence to support claim.</td>
</tr>
<tr>
<td>Scientific data used to support the claim.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Reasoning</strong></td>
<td>Does not provide reasoning, or only provides reasoning that does not link evidence to the claim.</td>
<td>Provides reasoning that links the claim and evidence. Repeats the evidence and/or includes some scientific principles, but not sufficient.</td>
<td>Provides reasoning that links evidence to claim. Includes appropriate and sufficient scientific principles.</td>
</tr>
<tr>
<td>Using scientific principles to show why data count as evidence to support the claim.</td>
<td></td>
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<td></td>
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</tbody>
</table>
Activity: Assessing Students’ Explanations

- Examine student explanation
- Assess student explanation
  - How would you assess this student’s response in terms of the claim, evidence and reasoning? What are the strengths? What are the weaknesses?
- Provide feedback and strategies
  - What feedback would you provide this student? Why would that feedback be helpful?
  - What strategies might you use to help this student construct a stronger explanation?
Providing Students Feedback

• What to Comment on:
  – Components of the explanation - claim, evidence, and reasoning
  – Science content of explanation
  – Holistic quality of explanation

• How to Comment:
  – Explicit and clear feedback
  – Point out strengths and weaknesses
  – Provide suggestions on how to improve
  – Ask questions to promote deeper thinking
Creating Assessment Tasks

- Step #1 Identify and unpack the content idea
- Step #2 Unpack the inquiry practice
- Step #3 Create learning performance
- Step #4 Write the assessment task
- Step #5 Review the assessment task
Unpacking Standards

1. Interpreting the Standard
   - Decompose into related concepts
   - Clarify the different concepts
   - Consider what other concepts are needed
   - Make links if needed to other standards

2. Consider students prior knowledge
   - Students prior knowledge
   - Possible non-normative ideas
Creating Learning Performances

• What are Learning Performances?
  – Describes what it means for learners to “understand” a scientific idea
  – Clarifies how the knowledge is used in reasoning about scientific questions and phenomena
  – Specifies how we want students to use the content knowledge

• Why Learning Performances?
  – Know or understand is too vague

• Use constructs (verbs) that describe what you want students to be able to do.
  – Identify, Define, Analyze and Interpret data, Explain, Design investigation, etc.
Content is not enough!

- Understanding content is inexplicitly linked to practices! Otherwise, declarative, isolated ideas.
- Science is both a body of knowledge and the process whereby that body of knowledge is developed. Both elements are essential: cannot make progress in science without an understanding of the other.
- The learning of science is similar: you cannot learn one without the other.
## Creating Learning Performances

<table>
<thead>
<tr>
<th>Content Standard</th>
<th>Practice</th>
<th>Learning Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>A substance has characteristic properties, such as density, a boiling point, and solubility, all of which are independent of the amount of the sample (NRC, 1996, B:1A/ 5-8).</td>
<td>Develop...explanations... using evidence. (NRC, 1996, A: 1/4, 5-8) Think critically and logically to make the relationships between evidence and explanation. (NRC, 1996, A: 1/5, 5-8)</td>
<td>Students construct a scientific explanation that includes a claim about whether two items are the same substance or different substances, evidence in the form of density, melting point (boiling point), solubility, color and hardness of the substances, and reasoning that different substances have different properties.</td>
</tr>
</tbody>
</table>
Writing Assessments

Learning Performance
Students construct a scientific explanation that includes a claim about whether two items are the same substance or different substances, evidence in the form of density, melting point (boiling point), solubility, color and hardness of the substances, and reasoning that different substances have different properties.

Assessment Task
Examine the following data table:

<table>
<thead>
<tr>
<th></th>
<th>Density</th>
<th>Color</th>
<th>Mass</th>
<th>Melting Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid 1</td>
<td>0.93 g/cm³</td>
<td>no color</td>
<td>38 g</td>
<td>-98 °C</td>
</tr>
<tr>
<td>Liquid 2</td>
<td>0.79 g/cm³</td>
<td>no color</td>
<td>38 g</td>
<td>26 °C</td>
</tr>
<tr>
<td>Liquid 3</td>
<td>13.6 g/cm³</td>
<td>silver</td>
<td>21 g</td>
<td>-39 °C</td>
</tr>
<tr>
<td>Liquid 4</td>
<td>0.93 g/cm³</td>
<td>no color</td>
<td>16 g</td>
<td>-98 °C</td>
</tr>
</tbody>
</table>

Write a **scientific explanation** that states whether any of the liquids are the same substance.
Review Assessment Item

• Is the knowledge needed to correctly respond to the task?
• Is the knowledge enough by itself to correctly respond to the task or is additional knowledge needed?
• Is the assessment task and context likely to be comprehensible to students?

(George Deboer, Project 2061)
Activity: Create Assessment Tasks

- Work with your content group to create an explanation assessment item
  - Step #1 Select and unpack the content standard
  - Step #2 Use scientific explanation framework
  - Step #3 Create learning performance
  - Step #4 Write the assessment task
  - Step #5 Review the assessment task
Creating Assessment Tasks

- Step #1 Unpack and select the content standard/core idea
- Step #2 Unpack the inquiry practice
- Step #3 Create learning performance
- Step #4 Write the assessment task
- Step #5 Review the assessment task
Instructional Strategies

1. Make the framework explicit
2. Discuss the rationale behind explanation
3. Model the construction of explanations
4. Discuss similarities and differences with everyday explanations
5. Provide multiple opportunities to construct explanations
6. Have students critique explanations
7. Provide students with feedback
Reflection and Application

• How will you make use of these ideas in your classroom?
• What challenges might you have in using and assessing scientific explanations and how might you overcome them?
• What do you need to know more about? What questions do you still have?
Thanks to many

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Many teachers with whom I work

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Supporting Grade 5-8 Students in Constructing Explanations in Science

*The Claim, Evidence, and Reasoning Framework for Talk and Writing*

More Information

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Questions and comments????