

Teaching Strategies to Support Middle School Students in Constructing Evidence-Based Scientific Explanations

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Overview of Session

- Critique examples of student writing
- Discuss importance of scientific explanation and scientific explanation framework
- Observe videoclips from science classrooms of teaching strategies
- Reflection and Discussion

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Context: 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.
  - Key learning goal -Different substances have different properties
- Chemical Reactions
  - Investigate three different chemical reactions, boiling, and mixing.
  - Use molecular models to explore whether new substances are produced.
- Conservation of Mass
  - Investigate if mass changes in chemical reactions.
  - Use molecular models to explore why mass is conserved during chemical reactions.

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Activity: Critique Students' Explanations

- Examine the two students' explanations
- Questions:
  - How would you assess these responses?
  - What are the strengths of each example?
  - What are the weaknesses of each example?

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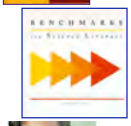
Importance of Scientific Explanations

- Science is about explaining phenomena
- Stressed in the science education standards
- Students should generate and evaluate scientific evidence and explanations
- Change students' image of science
- Enhance students' understanding of the nature of science
- Foster deeper understanding of important science concepts



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Essential Features of Classroom Inquiry and Their Variations

Essential Feature	Variation			
Learner engages in scientifically oriented questions	Learner poses a question	Learner selects among questions, poses new questions	Leaner sharpens or clarifies question provided by teacher, materials, or other sources	Learner engages in question provided by teacher, materials, or other sources
Learner gives priority to evidence in responding to questions	Learner determines what constitutes evidence and collects it.	Learner directed to collect certain data	Learner given data and asked to analyze	Learner given data and told how to analyze
Learner formulates explanation from evidence	Learner formulates explanation after summarizing evidence	Learner guided in process of formulating explanation from evidence	Learner given possible ways to use evidence to formulate explanation	Learner provided with evidence
Learner connects explanations to scientific knowledge	Learner independently examines other resources and forms the links to explanations	Learner directed toward areas and sources of scientific knowledge	Learner given possible connections	
Learner Communicates and justifies explanations	Learner forms reasonable and logical arguments to communicate explanation	Learner coached in development of communications	Learner provided broad guidelines to sharpen communications	Learner given steps and procedures for communications

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

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

Adapted from the National Science Education Standards

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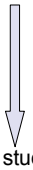
Learner gives priority to evidence in responding to questions

- Learner determines what constitutes evidence and collects it.
- Learner directed to collect certain data
- Learner given data and asked to analyze
- Learner given data and told how to analyze

- Greater amount of student direction



- Less student direction

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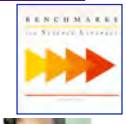

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Scientific Explanation Framework

- **Claim**
  - a conclusion about a problem
- **Evidence**
  - scientific data that supports the claim
- **Reasoning**
  - a justification that shows why the data counts as evidence to support the claim and includes appropriate scientific principles
- **Rebuttal**
  - describes alternative explanations and provides counter evidence and reasoning for why the alternative is not appropriate.

Scientific Explanation Framework

Explanation Exemplar

Liquids 1 and 4 are the same substance. (Claim) They both have a density of .93 g/cm^3, have no color, and start to melt at -98 C. (Evidence) 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. (Reasoning)

Teaching Strategies

1. Discuss the framework ⇨
2. Connect to everyday examples ⇨
3. Provide a rationale ⇨
4. Connect to other content areas ⇨
5. Model and critique examples ⇨
6. Provide students with feedback ⇨
7. Have students engage in peer critique ⇨
8. Debate student examples ⇨

Conclusion

- Make the scientific explanation framework explicit (claim, evidence and reasoning)
- Incorporate a variety of teaching strategies in your classroom instruction
  - Discuss the framework
  - Connect to everyday examples
  - Provide a rationale
  - Connect to other content areas
  - Model and critique examples
  - Provide students with feedback
  - Have students engage in peer critique
  - Debate student examples

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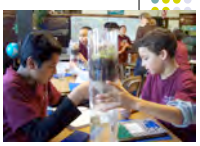

More Information

- Contact us
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  - krajcik@umich.edu
- Powerpoint from today
  - http://www.katherinelmcneill.com/workshops.html
- See curriculum materials on KNOW
  - www.hice.org/know

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Hyperlinked Slides

Discuss the Scientific Explanation Framework

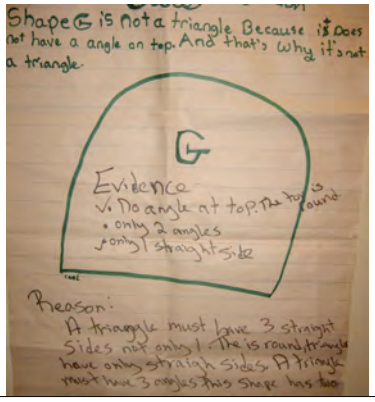
Connect to Everyday Examples

Connect to Everyday Examples

Provide a Rationale

Connect to Other Content Areas

Connect to Other Content Areas



Model and Critique Examples

Providing Students With Feedback

Have Students Engage in Peer Critique

Debate Student Examples

Question:

How can you design a car to go the fastest?

CLAIM
Circle ONE of the following.

A. My car will go the fastest, because I will make it really strong.
B. The car with the lightest load being pulled by the largest force will go the fastest.
C. How fast a car goes is determined by how far it travels in a certain time.

EVIDENCE
Circle TWO of the following.

A. The car with only one block on the car took 1 second to travel across the table while the car with three blocks took 3 seconds.
B. We always built our cars carefully and they traveled really fast.
C. Car companies, like Ford, try to build light cars because they will travel faster.
D. The car that was pulled by 5 washers took 2 seconds to travel across the table while the car with 1 washer took 7 seconds.
E. Our group had a lot of fun building and testing our cars, except for the one day that our car kept breaking.
F. Our experiments showed that light cars travel faster.

REASONING
Circle ONE of the following.

A. The data from our experiments shows us how to build our car. Since the data shows that fast cars have a light load and fast cars are pulled by a large force then this is how we should build our car.
B. Since car companies and race cars have cars that are really light and have large engines this means we should design our car in the same way. It should have a light load and be pulled by a large force.
C. The speed was determined by how many seconds it took for the car to travel across the table. The car with less blocks had a lighter load and it traveled faster. The car that was pulled by more washers was pulled by a greater force and it traveled faster.