Enriching Formative and Summative Assessment in Chemistry

Vicente Talanquer

Department of Chemistry and Biochemistry
University of Arizona

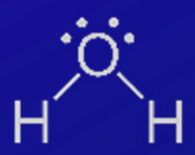
Central goal

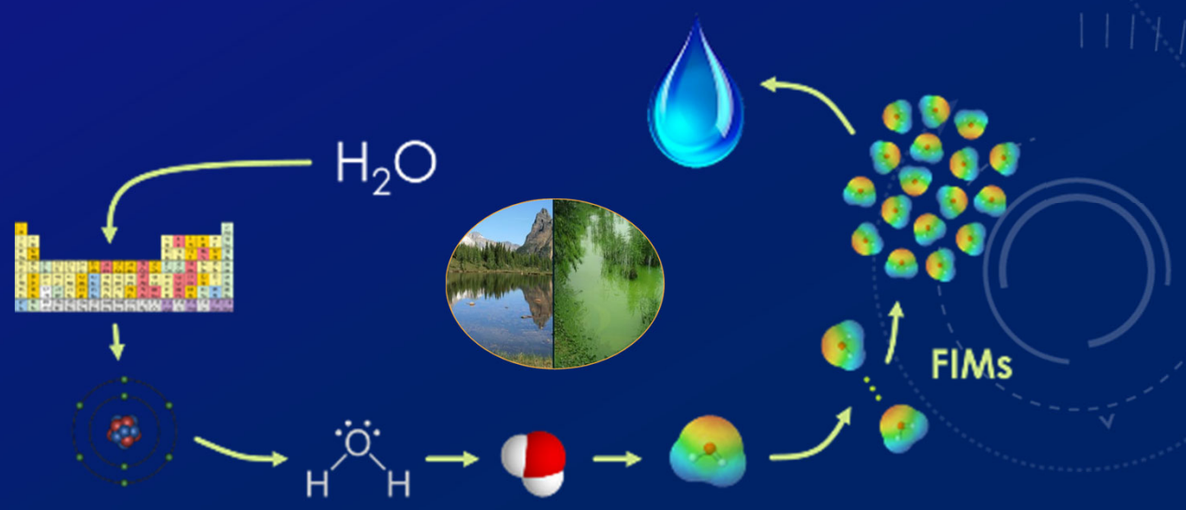
- Describe a **guiding framework for enriching assessments** in chemistry and discuss what these enriched assessments reveal about our students' learning

The challenge

FROM THE DEMONSTRATION OF FRAGMENTED KNOWLEDGE

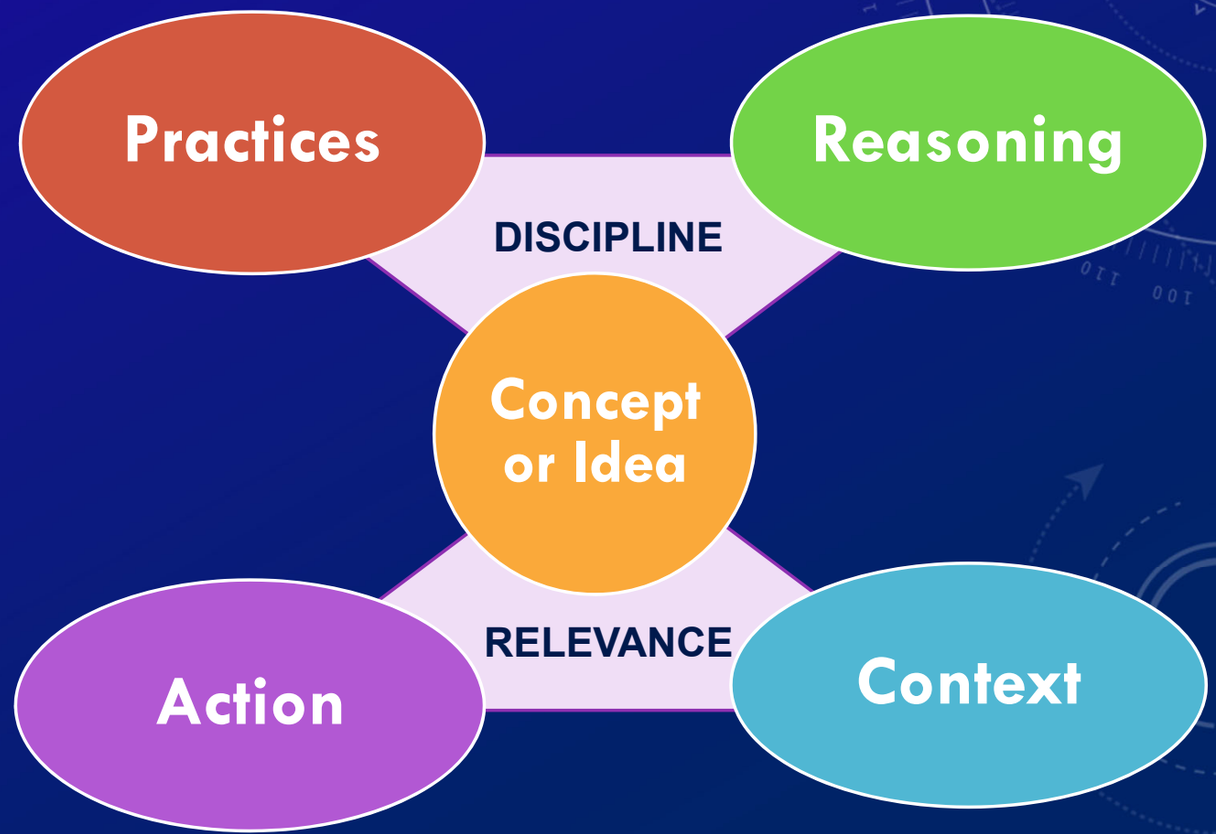
TO THE INTEGRATION AND APPLICATION OF IDEAS AND WAYS OF THINKING IN RELEVANT CONTEXTS





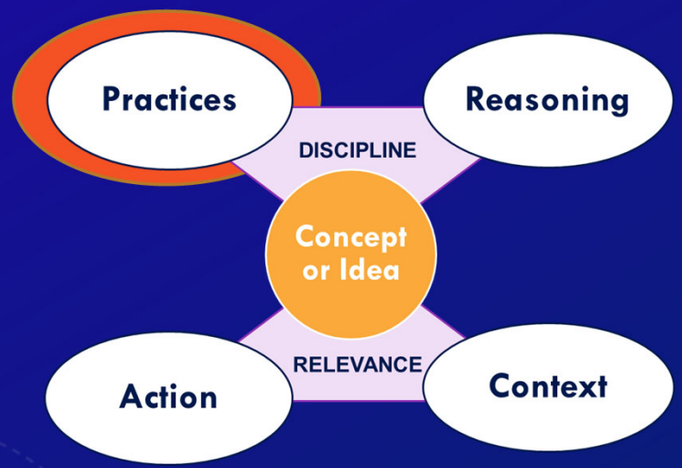
Guiding framework

Major dimensions for enrichment of chemistry assessments



The tradition

Traditional assessment questions target knowledge acquisition and comprehension

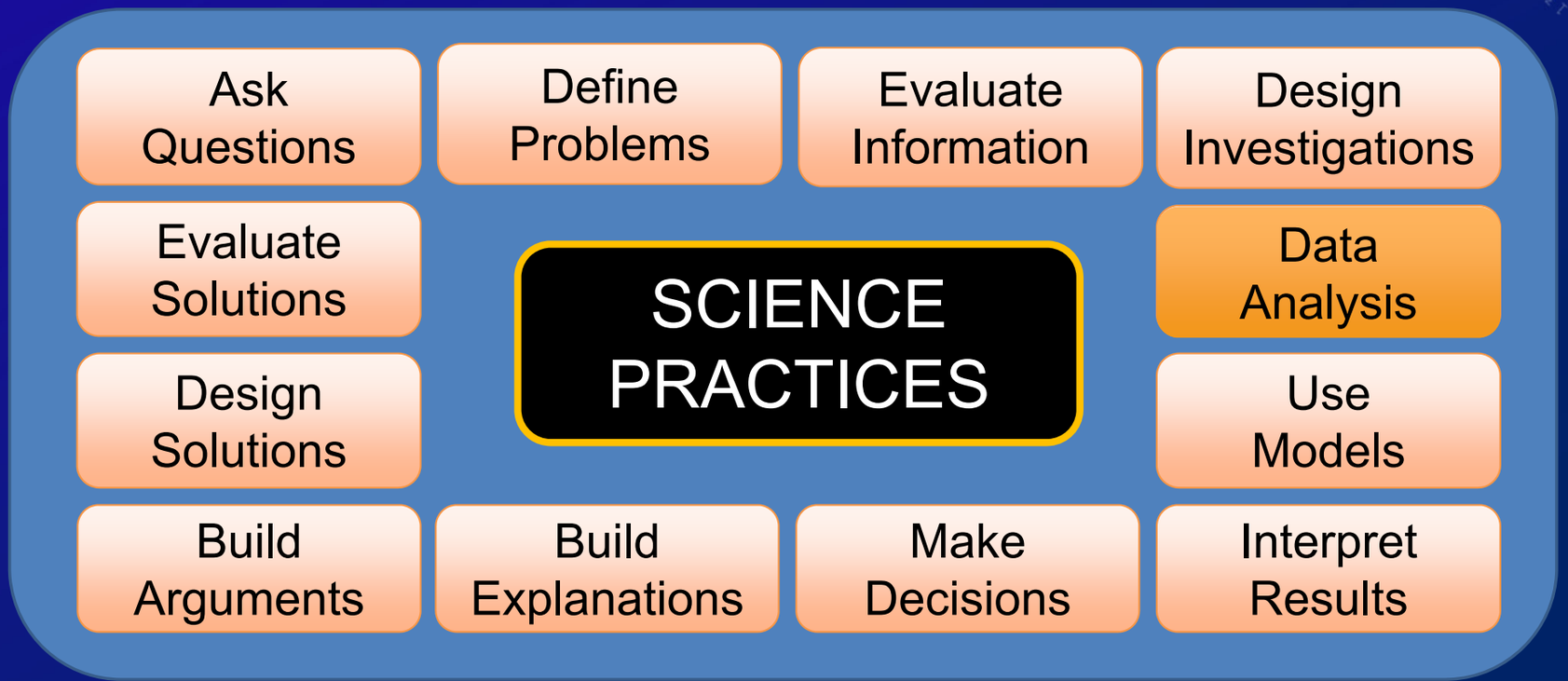


The solubility of a substance is a measure of:

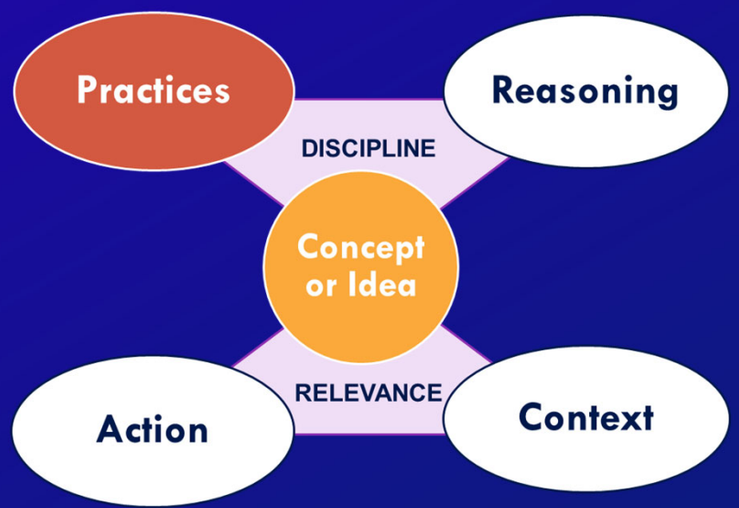
A. The amount of substance in a solvent
B. The maximum amount of substance that dissolves in a given volume of solvent
C. The amount of substance that dissolves in one liter of solvent

Knowledge in action

Develop questions that assess students' ability to properly use knowledge when engaged in a science practice:

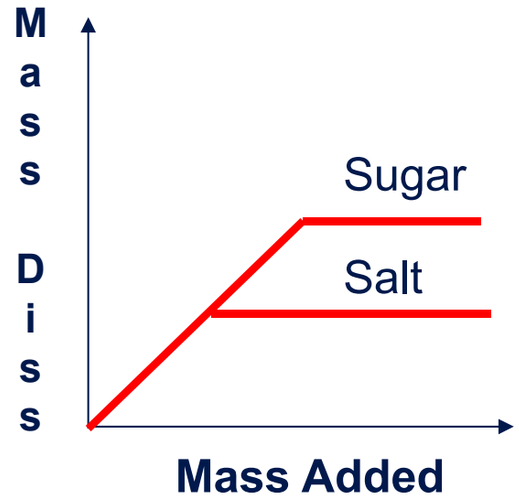


Practices dimension



The graph to the right represents the mass of sugar and salt dissolved in water as a function of the mass of each substance added to 100 mL of water. **Which of these substances is more soluble in water?**

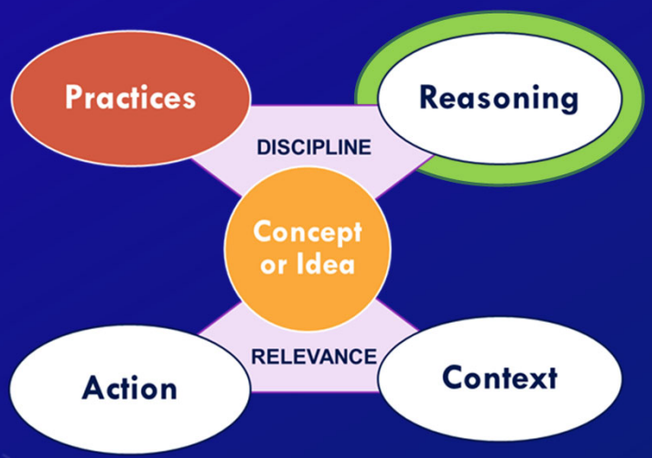
A. Sugar
B. Salt
C. More information is needed



Data Analysis and Interpretation

The tradition

Traditional assessments typically evaluate if students know **WHAT** happens but not necessarily **WHY** it happens



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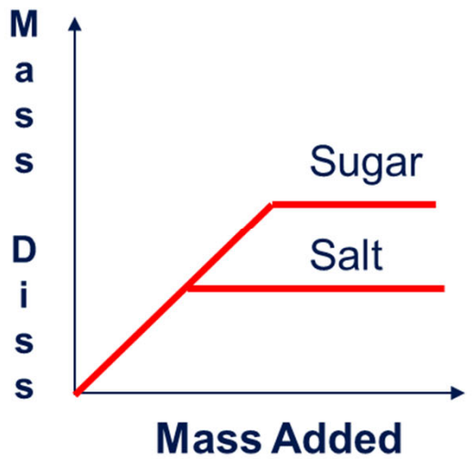
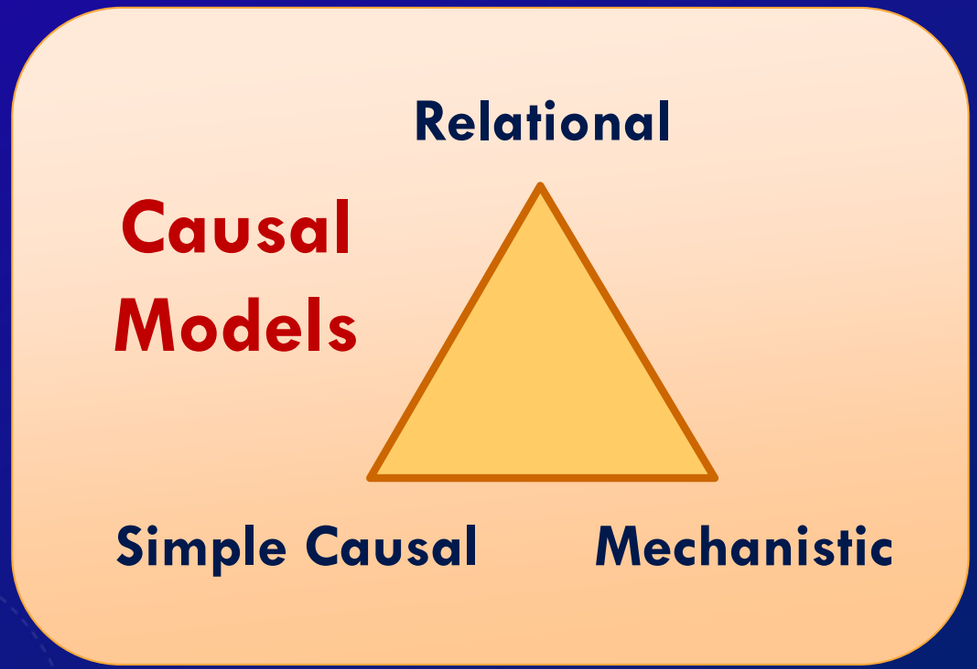
Which? What?

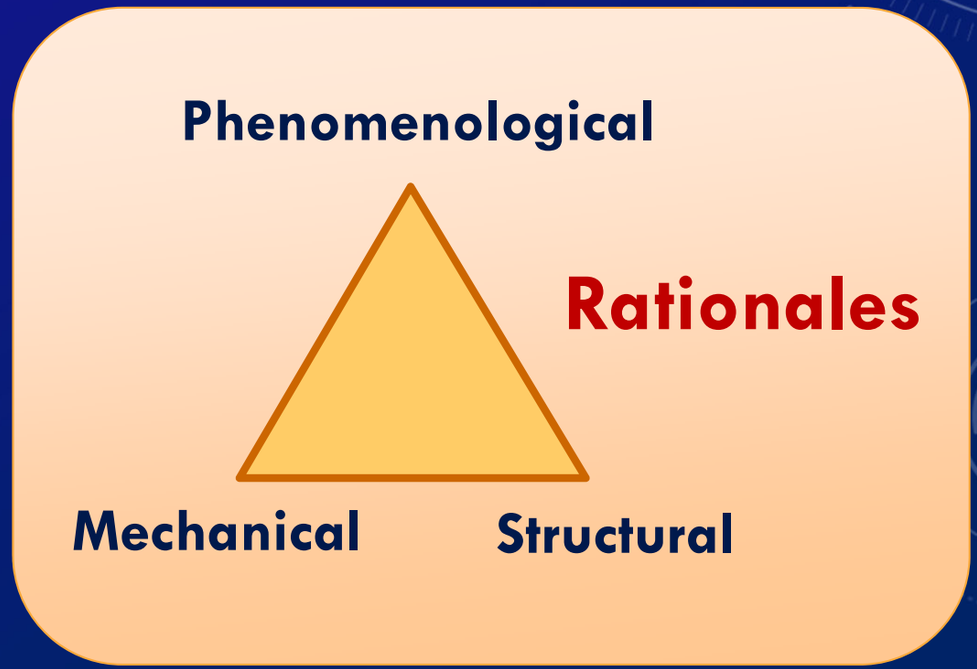


Chemical reasoning

Design questions that purposely require students to demonstrate different ways of reasoning in the discipline



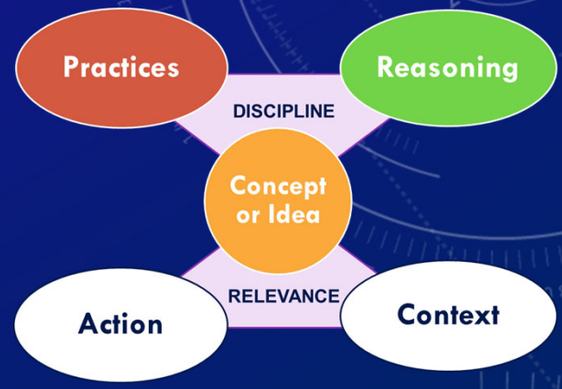
Sevian & Talanquer, CERP, **2014**, *15,* 10-23



Talanquer, IJSE, **2018**, *40,* 1874-1890

Reasoning dimension

Laverty et al., PLOS. **2016**, *0162333*



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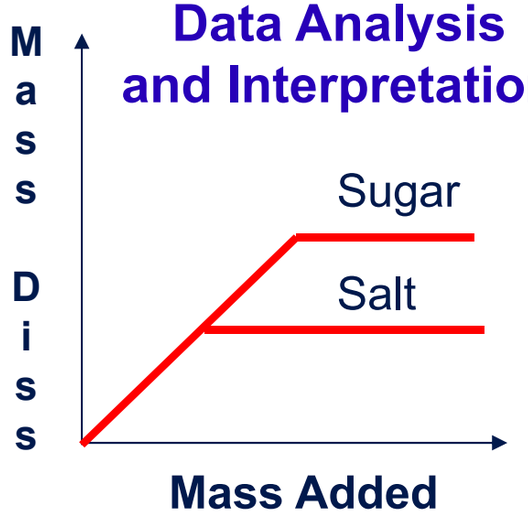


Why? **Explanation**

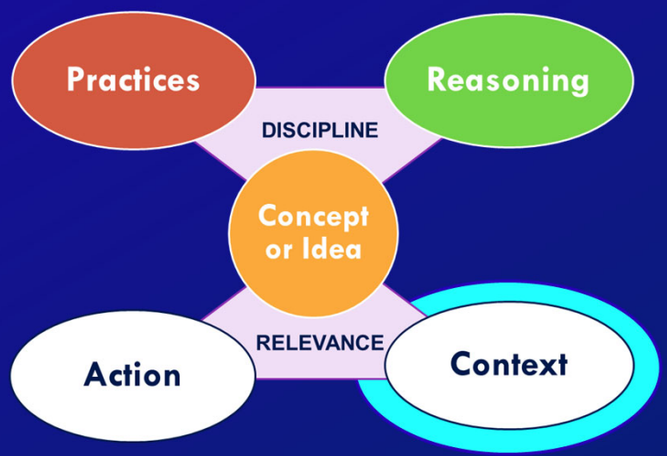
I. Because it takes more time for the salt to dissolve
II. Because more sugar can be dissolved in the same volume of water
III. Because more salt can be added to the same volume of water
IV. Because we need to know the actual amounts that were used

Phenomenological Rationale

Relational

Academic contexts

Chemistry assessments tend to be set in academic rather than relevant contexts



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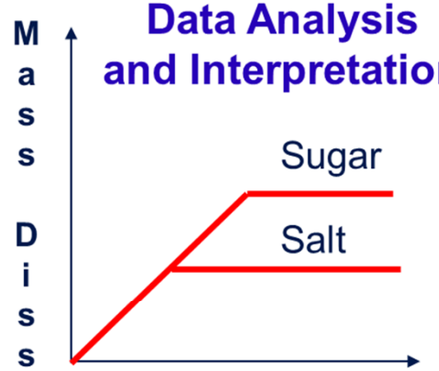

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Contextual reasoning

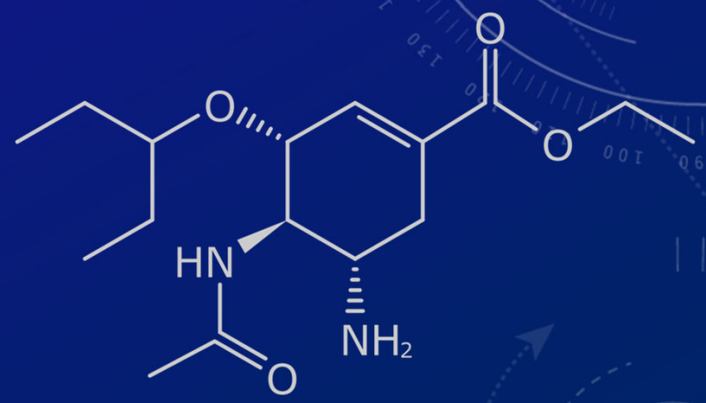
Situated in relevant scenarios:

Broman, Bernholt, & Parchmann,
Res. Sci. Tech. Educ. **2015**, 33, 143–161

A medical drug against swine flue frequently discussed in media this year, Tamiflu (an antiviral agent), is unfortunately spreading in the environment. Explain how this can occur:

a) **What** features and properties do the molecules of this drug have that will make them spread in the environment?

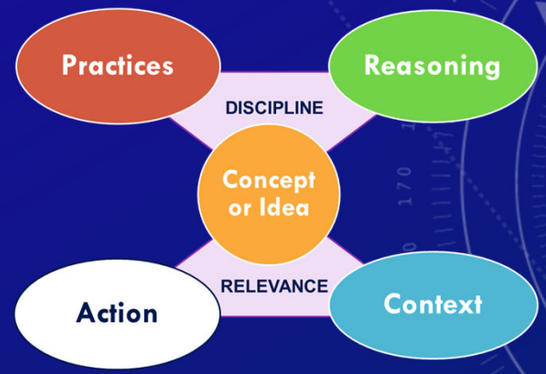
b) **How** and **why** will those features and properties facilitate the spreading?



Structural Rationale

Mechanistic

Context dimension



Broman & Parchmann,
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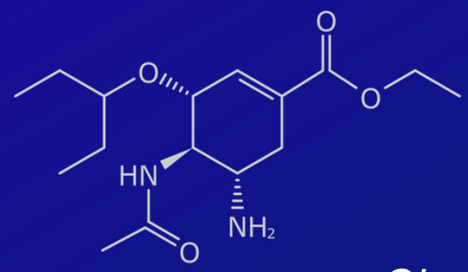

When medical drugs are used in society, there are always effluents in the environment, partly from the surplus from drugs taken by humans, partly from industries when producing the drugs.

a) **What** features and properties do these types of molecules (e.g., Alvedon, Treo, Ipren) have that will make them spread in the environment?
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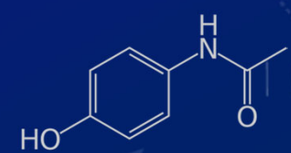

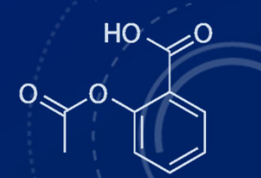

Specific → General

Socio-ecological reasoning

Chemistry assessments do not often engage students in decision-making based on benefit-cost-risk analyses

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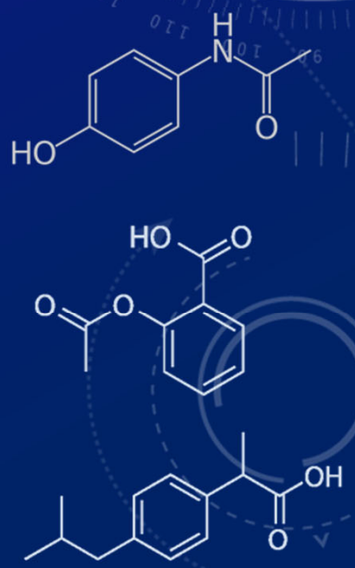
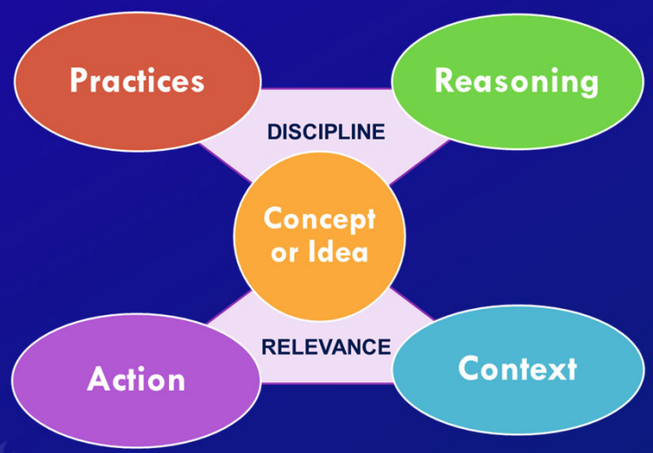


Action dimension

Require students to apply their knowledge to evaluate options and make decisions:



In a battery factory workers are exposed to ZnS and $CdCl_2$, HCl, oily grease, CH_2Cl_2, and H_2S. A suggestion was made to replace water with petroleum for washing the employers' work clothes.

a) **Identify benefits-costs-risks** of replacing the water with petroleum from the point of view of cleaning the clothes and of the environment outside the factory. **Justify your claims based on the composition and structure** of the substances involved

b) Use the results of your analysis to **make a recommendation** about the suggested replacement and clearly justify your reasoning

Zoller, *J. Chem. Educ*. **2012**, 89, 297−300

Chemical thinking curriculum

Talanquer, & Pollard
CERP, **2010**, *11*, 74-83
J. Chem. Educ. **2017**, 94, 1844-1851

What is this made of?

What are its impacts?

What properties does it have?

How can we control it?

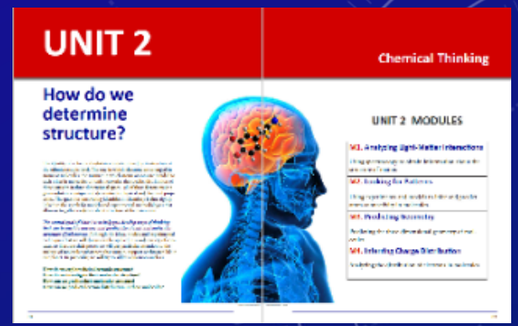
Why does it happen?

How does it happen?

https://sites.google.com/site/chemicalthinking/

Instructional tasks

What is in your breath?



DATA ANALYSIS

MODELING

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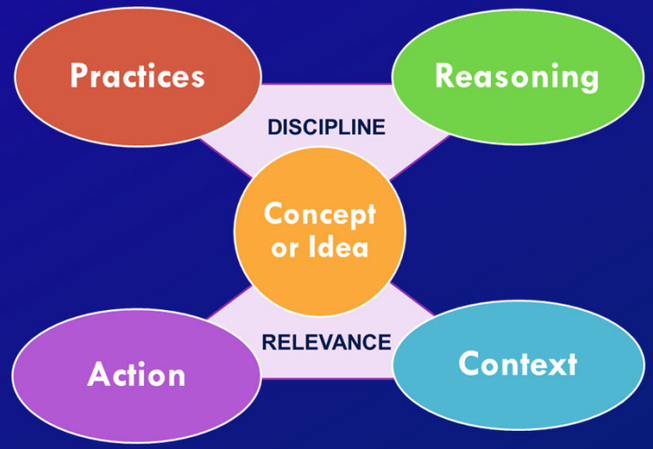
What can be probed?
How is it probed?

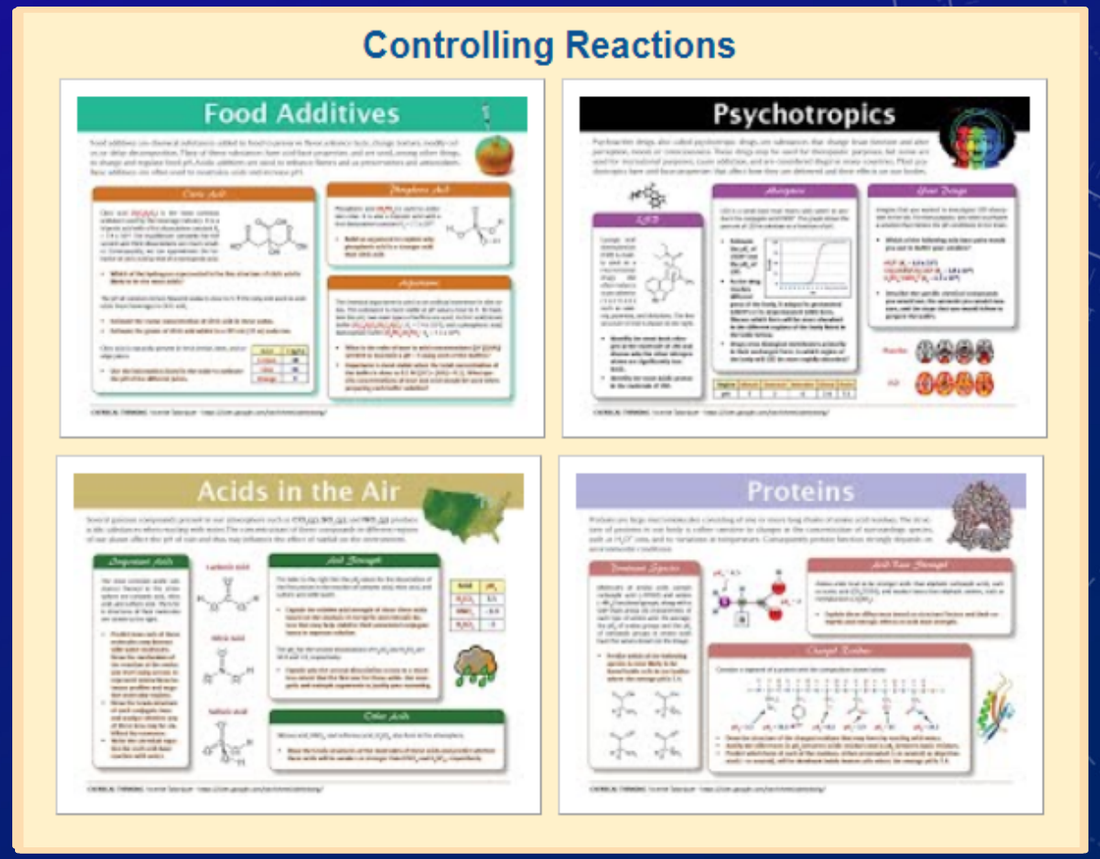
What can be inferred and how?
How is it justified?

ARGUMENTATION

Scenario-based assessments

Used both in the design of formative and summative assessments





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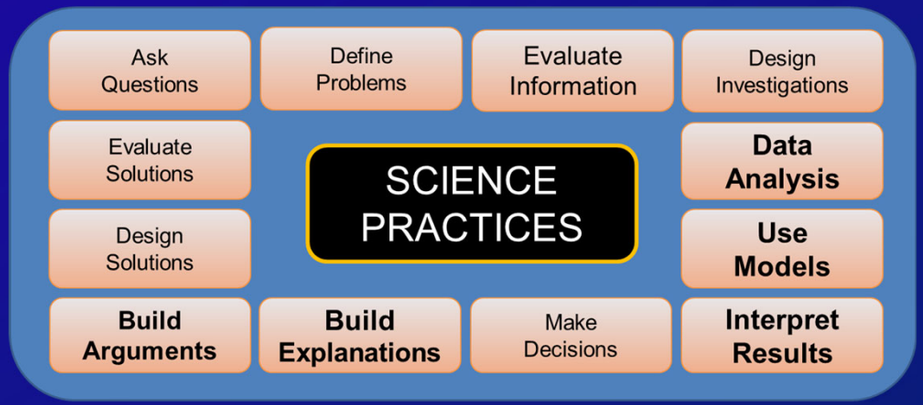
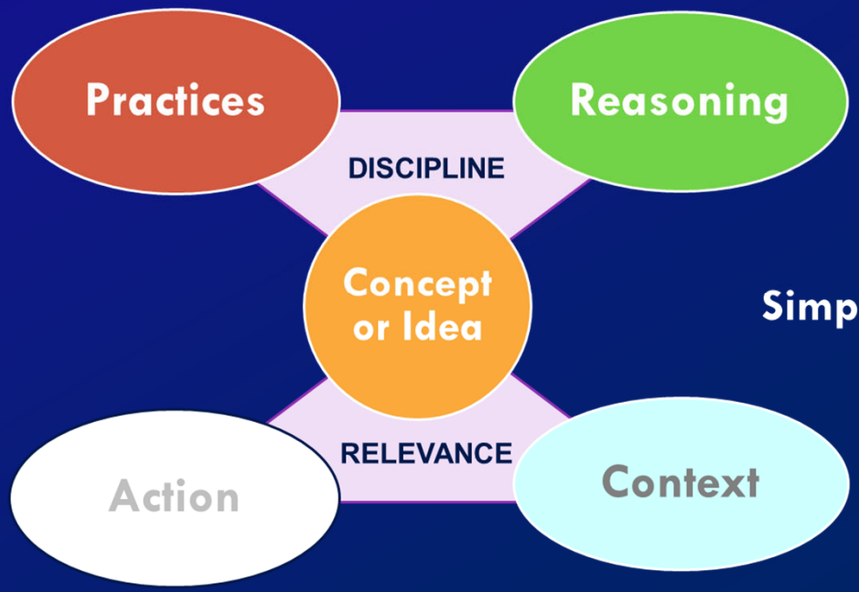
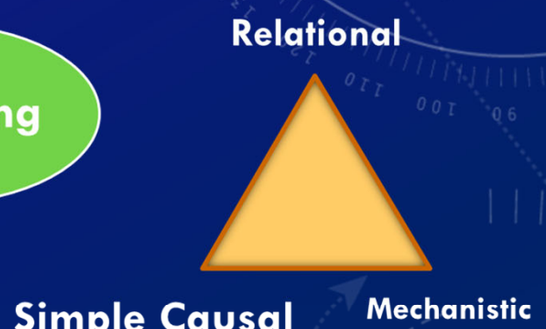
Strengths and weaknesses

The framework is also useful in the educational impact of our program







Talanquer, *J. Chem. Educ.*, **2019**, 96, 2918−2925

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Brian Zacher

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Thank You

Contact

Vicente Talanquer
vicente@u.arizona.edu

https://sites.google.com/site/talanquerchemed/

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Questions? Comments?