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A Qualitative Comparison of General Chemistry and Advanced Placement Chemistry Students' Misconceptions Regarding Solution Chemistry

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A QUALITATIVE COMPARISON OF GENERAL CHEMISTRY AND ADVANCED PLACEMENT CHEMISTRY STUDENTS’ MISCONCEPTIONS REGARDING SOLUTION CHEMISTRY

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BACKGROUND

- **Constructivism & Conceptual Change**
  (Bodner, 2004; Bodner, Klobuchar, & Geelan, 2001; Driver, Rushworth, Piaget, 1966; Posner, Strike, Hewson, & Gertzog, 1982; Squire, & Wood-Robinson, 2005; Vosniadou, 1994, 2007)

- **Construction of Misconceptions**
  (Özmen, 2004; Smith, diSessa, & Roschelle, 1993)
  - What is a misconception?
  - Assembling knowledge based on personal experiences
  - Modification of students’ conceptual framework
Misconceptions in Chemistry  
(Driver, Rushworth, Squire, & Wood-Robinson, 2005; Gabel, 1999; Nakhleh, 1992)

Particulate Nature of Matter  
(Ayas, Ozmen, & Calik, 2010; de Vos & Verdonk, 1996; Yezierski & Birk, 2006)

Sources of Misconceptions  
(Çepni, Taş, & Köse, 2006; Gabel, 1999; Garnett, Garnett, & Hackling, 1995; van den Broek & Kendeou, 2008)

Misconceptions in Solution Chemistry  

3 main Topics:  
- Dissolution  
- Concentration  
- Colligative Properties
PURPOSE & RATIONALE

Purpose
- Identify, analyze & compare misconceptions
- High School AP v. College General Chemistry

Why this focus?
- Lack of research regarding certain topics within solution chemistry
- AP Chemistry expected to be equivalent to college
  (College Board, 2014)

Previous Research
- Adadan and Savasci (2012)
RESEARCH QUESTIONS

- What are the misconceptions that high school students in Advanced Placement Chemistry hold with regards to solution chemistry both before and after instruction?

- What are the misconceptions that college students enrolled in General Chemistry II courses hold with regards to solution chemistry after instruction?

- How do the misconceptions held by AP Chemistry students compare to those held by students enrolled in a collegiate General Chemistry II course?
METHODOLOGY - OVERVIEW

- Qualitative Study
- Sources of Evaluative Data
  - Open-ended questionnaires
  - One-on-One interviews
- Participants
  - AP Chemistry students @ Pleasant Valley, Bettendorf & Moline HS
  - General Chemistry II students @ UNI (Spring 2017)
METHODOLOGY – STAGES OF THE STUDY

- Stage 1: Pre-assessment & Stage 2: Post-assessment
  - All students invited to participate
  - Use Solution Chemistry Questionnaire (SCQ)
  - Coding based on changes in students’ responses

- Stage 3: Interviews
  - Students chosen based upon previous responses
  - Semi-structured, one-on-one interviews
METHODOLOGY – SCQ INFORMATION

- 7 question survey
  - Open-ended
  - Students must include their reasoning

- Validity
  - Created with AP Teacher & UNI faculty member

- Reliability
  - Only 1 individual coding responses
  - Codebook
DATA ANALYSIS – SCQ PRE-ASSESSMENT

- Preliminary Results

- 10 High School Students

- Wide variety of answers & explanations

- Between 0 – 7 students explained correctly
  - Does not include those that were not able to explain the chemical properties or interactions occurring
EXPLAIN THE DIFFERENCE BETWEEN SATURATED, UNSATURATED, AND SUPERSATURATED SOLUTIONS.

Correct idea:
- Unsaturated = able to dissolve more solute
- Saturated = maximum amount of solute is dissolved
- Supersaturated = more solute dissolved than typically allowed

10% correct

Example Incorrect Responses:
- Presence of a starch
- Types of molecules present (oxygen, water, etc.)
- Comparison of how much liquid is present (full, no liquid, etc.)
QUESTION #2
EXPLAIN A SIMPLE LAB PROCEDURE THAT CAN DISTINGUISH BETWEEN THE 3 TYPES OF SOLUTIONS.

Correct idea:
- Add one crystal of the solute to the solution...
  - Crystal dissolves = unsaturated
  - Doesn’t dissolve = saturated
  - Causes more solute to “fall out” of solution = supersaturated

0% correct

Example Incorrect Responses:
- React the solution & see what is left
- Filter the solution
- Allow solution to evaporate
QUESTION #3
EXPLAIN WHY THE SAYING “OIL AND WATER DON’T MIX” IS TRUE.

- Correct idea:
  - Oil is a nonpolar substance & water is a polar substance
  - Polar molecules dissolve/mix with other polar molecules only

- 0% correct

- Example Incorrect Responses:
  - Solubility
  - Differences in density
  - Surface tension
  - Saturated v. Unsaturated
QUESTION #4
WHY WOULD ANTIFREEZE BE PLACED IN THE RADIATOR OF A CAR?

▶ Correct idea:
  ◀ Lowers the freezing point of radiator fluid to keep it from freezing
  ◀ Increases the boiling point to prevent the fluid from turning to a gas
▶ 30% correct

▶ Example Incorrect Responses:
  ◀ Melts (or “undo the freezing”) of radiator fluid
  ◀ Keep windshield clear of ice
  ◀ Many said that it would keep the radiator from freezing but were not able to explain why using properties of chemistry
QUESTION #5
WHY IS SALT PLACED ON THE SIDEWALKS AND/OR ROADS DURING THE WINTER?

- Correct idea:
  - Lowers the freezing point of water
  - Must be a colder temperature before ice will form

- 20% correct

- Example Incorrect Responses:
  - Salt melts ice
  - Salt and water have a chemical reaction that produces heat
  - Salt breaks down ice
  - Salt absorbs the water that would form ice
QUESTION #6
WHICH SALT WOULD WORK BETTER IF PLACED ON THE SIDEWALKS/ROADS DURING THE WINTER: NaCl OR CaCl₂? WHY?

▶ Correct idea:

▶ CaCl₂ would work better
▶ CaCl₂ = 3 particles --- NaCl = 2 particles
▶ More particles = greater freezing point depression = water begins to freeze at lower temperature

▶ 70% correct
▶ only 30% correctly explained why

▶ Example Incorrect Response:
▶ NaCl is table salt which is only used for flavoring food
QUESTION #7
IF A SODA BOTTLE IS PLACED IN THE FREEZER FOR A PERIOD OF TIME IT WILL NOT FREEZE. HOWEVER, WHEN IT IS TAKEN OUT OF THE FREEZER AND THE LID IS REMOVED, THE SODA WILL FREEZE. WHY DOES THIS HAPPEN?

Correct idea:
- When the lid opens, gases can escape (lower concentration)
- Lower concentration = freezing point doesn’t lower as much

10% correct

Example Incorrect Responses:
- Difficult for air to freeze in the bottle
- Cold does not affect liquids in a closed container
- Change in pressure
- Not enough room in the bottle for the soda to freeze
DATA ANALYSIS – PROGRESS

► Stage 1: Pre-Assessment
  ► 10 HS participants from Moline & Bettendorf
  ► Awaiting Pleasant Valley responses
► Stage 2: Post-Assessment
  ► In Progress
► Stage 3: Interviews
  ► College – later this week
  ► High School – next 3-4 weeks
REFERENCES


