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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
QUESTION #1
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


