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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

BACKGROUND

▶ 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; Yeziarski & Birk, 2006)

▶ Sources of Misconceptions

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

▶ Misconceptions in Solution Chemistry

(Adadan & Savasci, 2012; Driver, Rushworth, Squire, & Wood-Robinson, 2005; Pinarbasi & Canpolat, 2003; Smith & Metz, 1996)

▶ 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?
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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
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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
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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 CaCl_2 ? WHY?


- ▶ Correct idea:
 - ▶ CaCl_2 would work better
 - ▶ $\text{CaCl}_2 = 3$ particles --- $\text{NaCl} = 2$ 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
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