Tracking Growth in Students' Understanding of the Particulate Nature of Mater

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Background

Chemistry is commonly represented at three levels[1]

Students struggle with the particulate level the most as shown in high school and college settings [2, 3, 4]

- Many misconceptions for both ionic & covalent reactions
- Particulate level is the most cognitively demanding

Tracking student particulate representations over the course of the semester can give us a sense of growth in understanding

Research Questions

How does the students' understanding of the particulate nature of mater change over the course of a general chemistry course? What aspects do students have difficulty with throughout the course, and which aspects do students master?

Methodology

Context

- Study took place in a general chemistry class in Fall 2014
- Students demonstrated their knowledge of the particulate nature of matter by drawing representations throughout the course
- 53 students took part in the study
- One semester of HS chemistry required
- 5 assessments taken throughout the semester focusing on representations

Assessment

Compound and Equations Analyzed	Assessment Dates
$N_2O_{(g)}$ / $N_2O_{(aq)}$	9/6, 10/25
$CaCl_{2\,(s)}$ / $CaCl_{2\,(aq)}$	9/6, 10/9
$CH_{4\,(g)} + 2O_{2\,(g)} \rightarrow CO_{2\,(g)} + 2H_2O_{(g)}$	10/4
$2AgNO_{3\,(aq)} + CaCl_{2\,(aq)} \rightarrow 2AgCl_{(s)} + Ca(NO_3)_{2\,(aq)}$	10/4, 10/25
$2CH_3CH_{3\,(g)} + 7O_{2\,(g)} \rightarrow 4CO_{2\,(g)} + 6H_2O_{(g)}$	10/9
$2HCl_{(aq)} + CaCO_{3\,(s)} \rightarrow CaCl_{2\,(aq)} + H_2O_{(l)} + CO_{2\,(g)}$	12/6

Coding and Analysis

- Coded specific errors as well as aspects they are understanding
- Checked for prevalence of errors and changes over time for equations of similar type

Discussion

Growth in understanding was noted in:

- Molecular geometry
- Understanding that ionic compounds have charges and that aqueous ions are separated and solid compounds form a lattice
- A statistically significant number of students are understanding that molecular compounds do not ionize.

Continued struggle with:

- Oxidation number
- Using covalent bond model for ionic compounds
- Nature of particles in aqueous solution

Student understanding stayed constant in

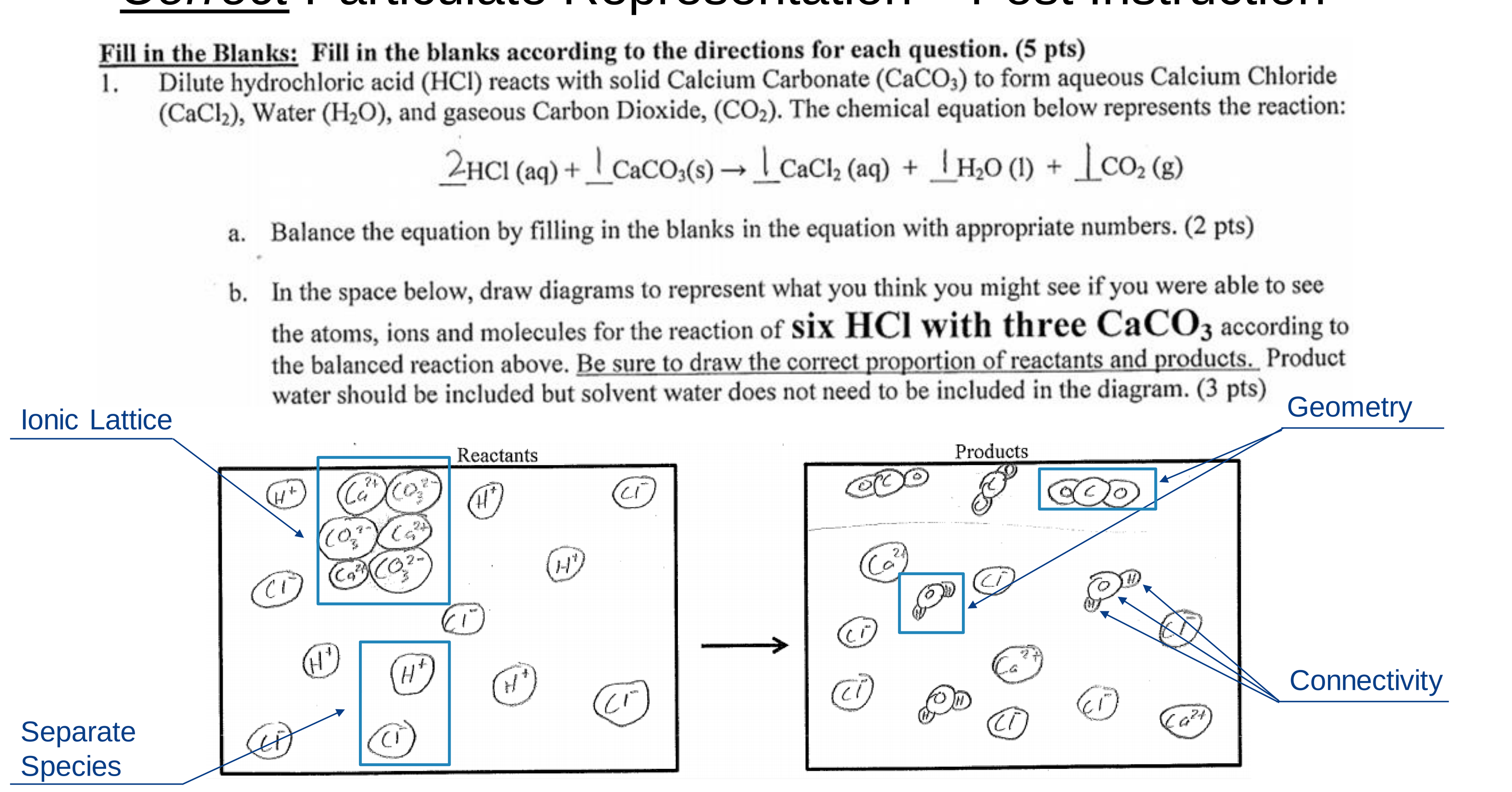
- Atomic size for covalent compounds
- Balancing the particles

Future Work

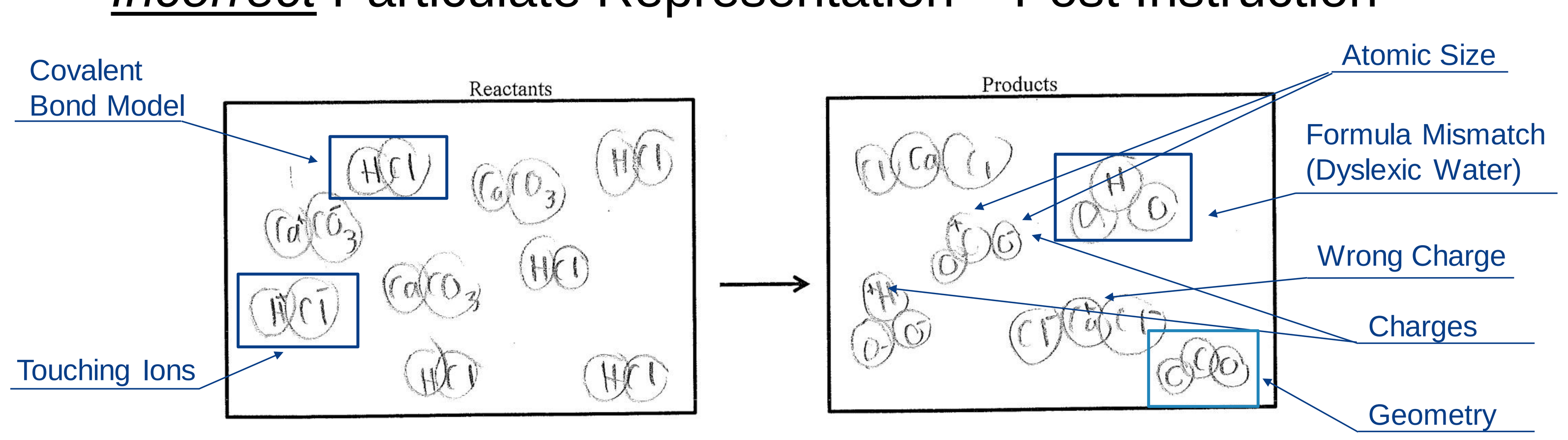
- Compare Fall 2013 data with Fall 2014 data for trends
- Determine if other questions are having an influence in how the students answered their particulate representation questions
- Determine if order of instruction has impact on understanding
- Include student reflections in analysis

Results

Correct Particulate Representation – Post Instruction

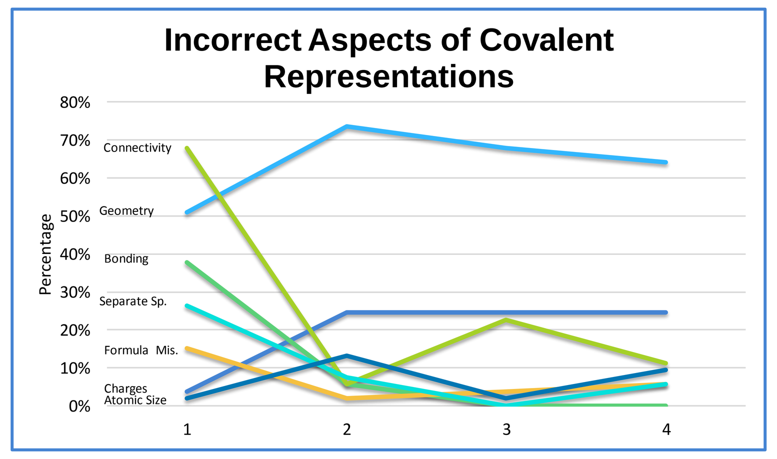


Incorrect Particulate Representation – Post Instruction



Error Percentages and P-Values

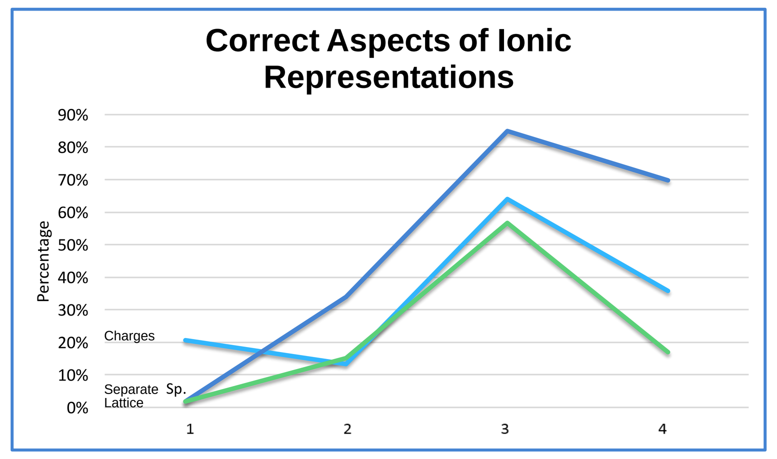
Covalent	Pre-Test 1	Exam 3	P-Value	Post-Test 1	Exam 2	P-Value
Geometry	50.9	32.1	0.0488	73.6	67.9	0.5222
Atomic Size	0	0	1.0000	24.5	24.5	1.0000
Connectivity	67.9	58.5	0.3125	5.66	22.6	0.0121
Formula Mismatch	11.3	3.77	0.1416	1.89	3.77	0.5552
Separate Species	11.3	28.3	0.0285	7.56	0	0.0414
Charges	0	15.1	0.0033	13.2	1.89	0.0271
Ionic	Pre-Test 1	Exam 2	P-Value	Post-Test 1	Exam 3	P-Value
Covalent	43.4	20.8	0.2420	69.8	22.6	<0.0001
Touching Ions	0	66.0	<0.0001	24.5	30.2	0.5157
Neutral Species	13.2	0	0.0061	11.3	17.0	0.4009
Wrong Charges	0	7.56	0.0414	9.43	24.5	0.0385
Ionic Lattice	-	0	-	75.5	5.66	<0.0001
Connectivity	0	0	1.0000	13.2	1.89	0.0271



- Most areas improved following the first assessment
- Students struggled with molecular geometry throughout
- Ionic properties such as charges and separate species in representations decreased and hardly became prevalent

Understood Concept Percentages and P-Values

Covalent	Pre-Test 1	Exam 3	P-Value	Post-Test 1	Exam 2	P-Value
Geometry	20.8	30.2	0.2670	22.6	18.9	0.6312
Atomic Size	0	17.0		75.5	62.3	0.1416
Ionic	Pre-Test 1	Exam 2	P-Value	Post-Test 1	Exam 3	P-Value
Charges	1.9	77.3	<0.0001	34.0	84.9	<0.0001
Separate Species	-	-	-	13.2	64.2	<0.0001
Ionic Lattice	-	-	-	15.1	56.6	<0.0001



- The third test showed dramatic increase in correct aspects, yet this was the students' second time with this equation
- The fourth test involved both ionic and covalent compounds which could have influenced the decline in correct aspects

References

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