Conceptual Understanding and Language Fluency in General Chemistry

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Background

- Acid-base titrations is a component of introductory chemistry curricular (Dingrando et al., 2002)
- Experiments involve titration of strong acids with strong bases, tracked with pH changes and/or indicators (Sheppard, 2006)
- Conductiometry can also be used to track progress of acid-base titrations
- Student struggles with acid-base chemistry at this level attributed to

(a) Student misconceptions (Demircioglu, 2005)
(b) Poor understanding of PNM (Nakhleh, 1994)
(c) Academic language of chemistry (Schmidt, 1995)

- Some of the student struggles include the inability to explain pH, neutralization, and strength among others (Shepard, 2006)
- Other student problems in understanding acids and bases involve use of representations, language and terminology, and heuristics in their reasoning (Cooper, Corley, & Underwood, 2013)

Research Question

What is the nature of college general chemistry students' conceptual understanding and language fluency in the context of acid-base neutralization?

Context

- Data came from a general chemistry (II) class of 120 students
- Students covered acids and bases in General chemistry (I)
- Students carried out acid-base titrations with an indicator as part of general chemistry (I) labs
- The data provided required application of acid-base ideas to conductiometry

Methodology

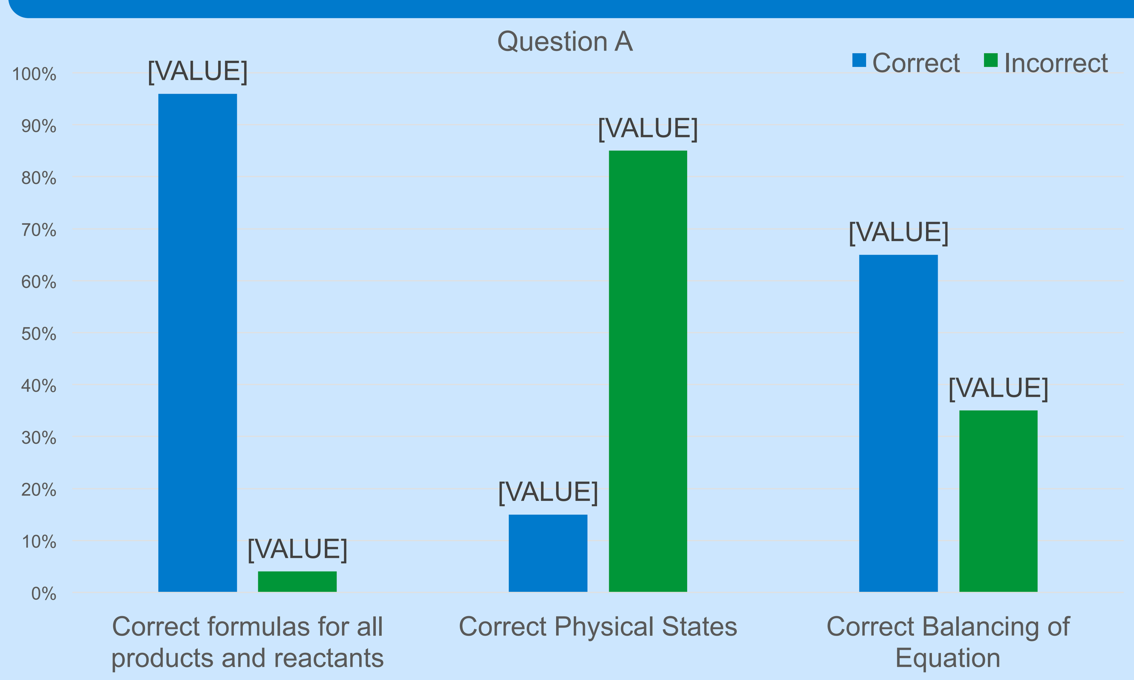
Coding

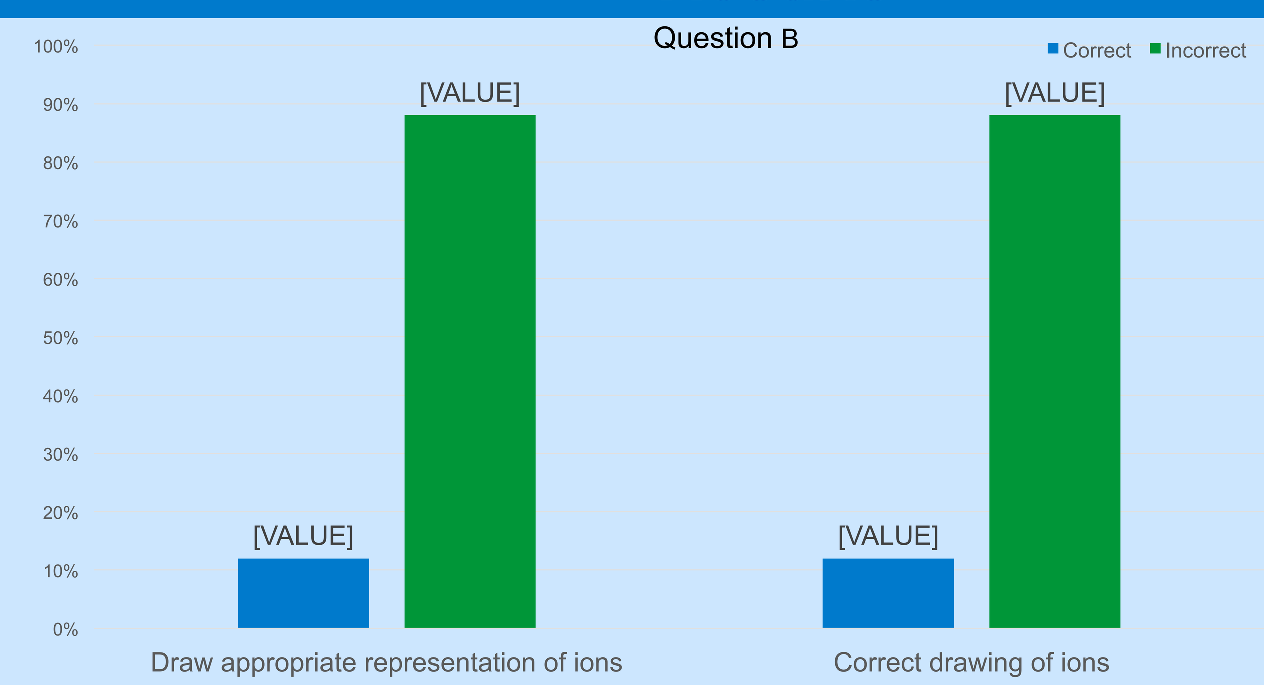
- Grading rubric was developed for written responses
- Correct response received a score of 1, incorrect response got score of 0
- Specific aspects for each question were also evaluated, such as inclusion of state symbols in question 'a'

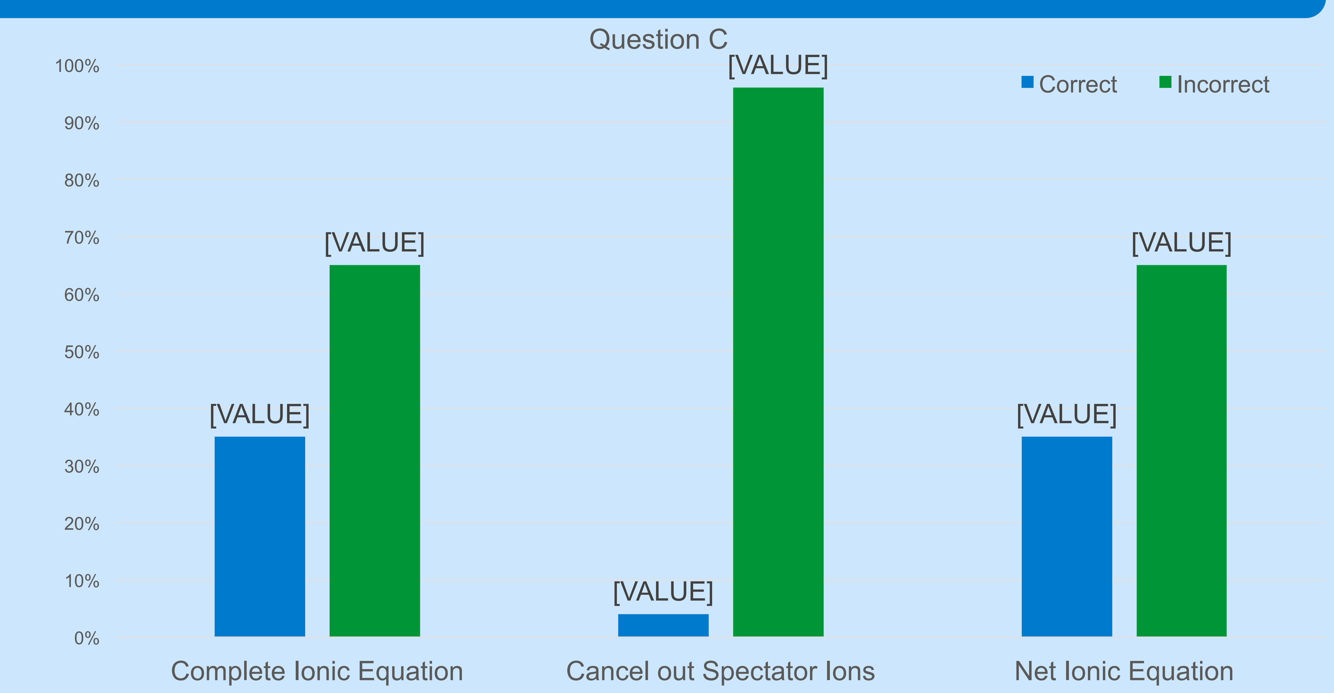
Analysis

- Grounded theory (Cohen, Manion and Morrison, 2011) was used to analyze data
- Categories emerged from data
- Student written responses and conversations in groups were analyzed to decipher both Conceptual understanding and language fluency
- Analyzed group conversations for specific language used such as vocabulary and symbols.
- Determined appropriate and inappropriate language used by groups
- Inferred conceptual understanding from language used

Results







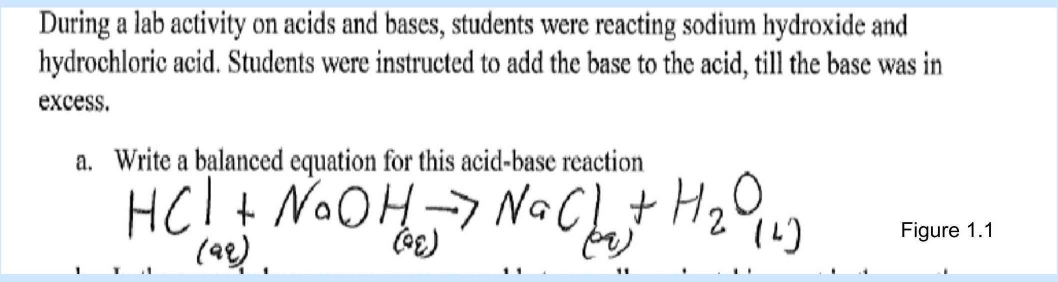


Figure 1.1

Figure 1.1 shows a response with everything correct; the group has all of the correct formulas for the products and reactants, the group knows that sodium chloride and water are the products in the reaction. The group also included all of the physical states (aqueous and liquid)for the products and finally the group balanced the equation correctly.

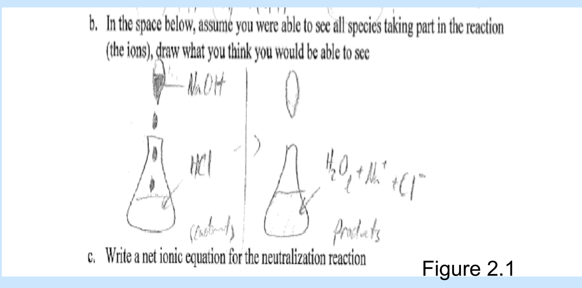


Figure 2.1

Figure 2.1 shows a common answer among where groups interpreted the question to be asking what actually happened at the macroscopic level, specifically what they do in the lab.

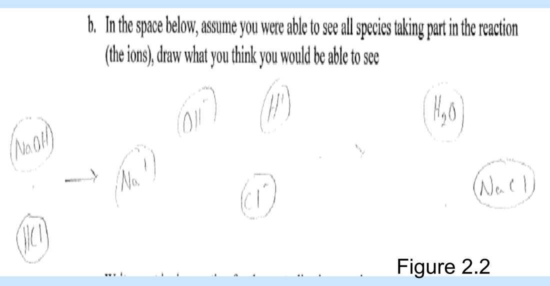


Figure 2.2

Figure 2.2 shows a response that was mostly correct, missing few details. This group drew out and labeled the correct ions with the correct charges for reactants only.

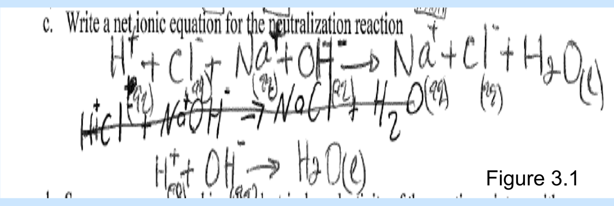


Figure 3.1

Figure 3.1 shows a response that started with the complete ionic equation and then the net ionic equation

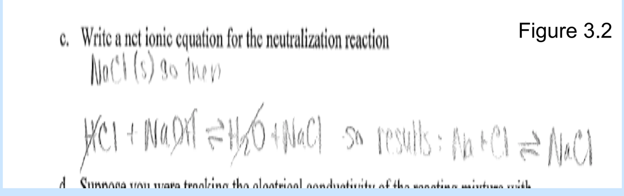


Figure 3.2

Figure 3.2 shows a response with an incorrect net ionic equation. A common response has sodium and chloride ions yielding sodium chloride.

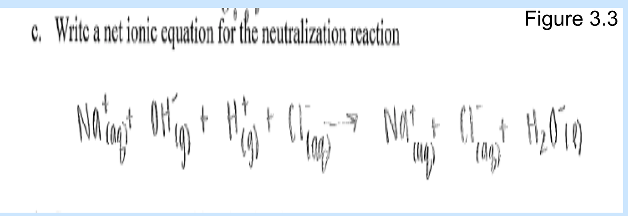
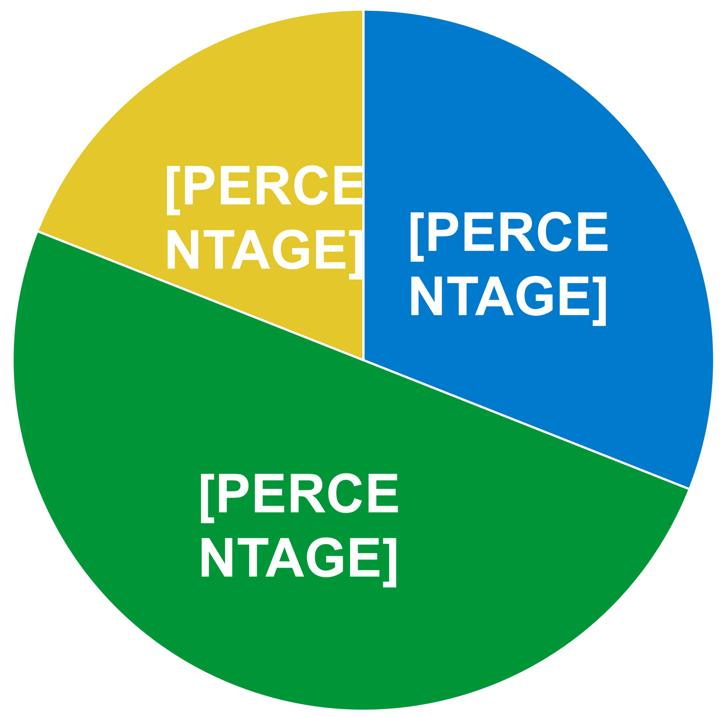


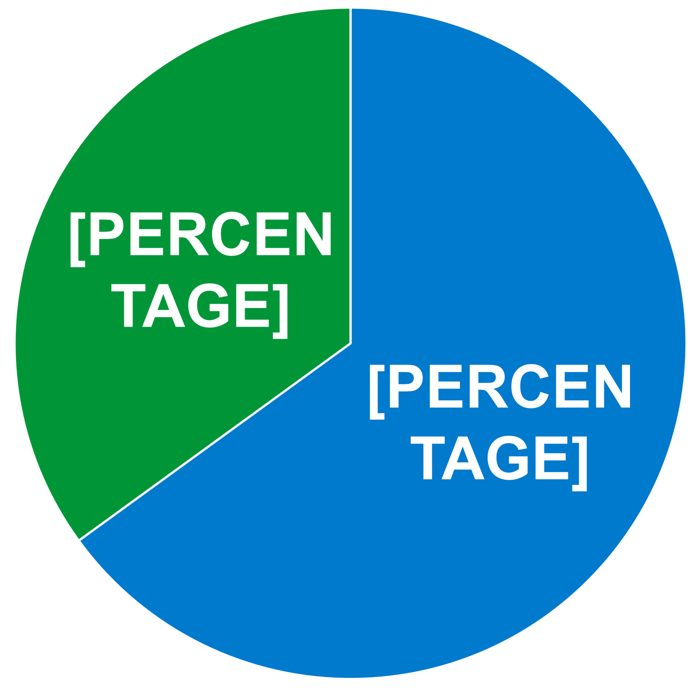
Figure 3.3

Figure 3.3 shows a response from a group that wrote out the complete ionic equation and stopped there. Many groups had this answer.

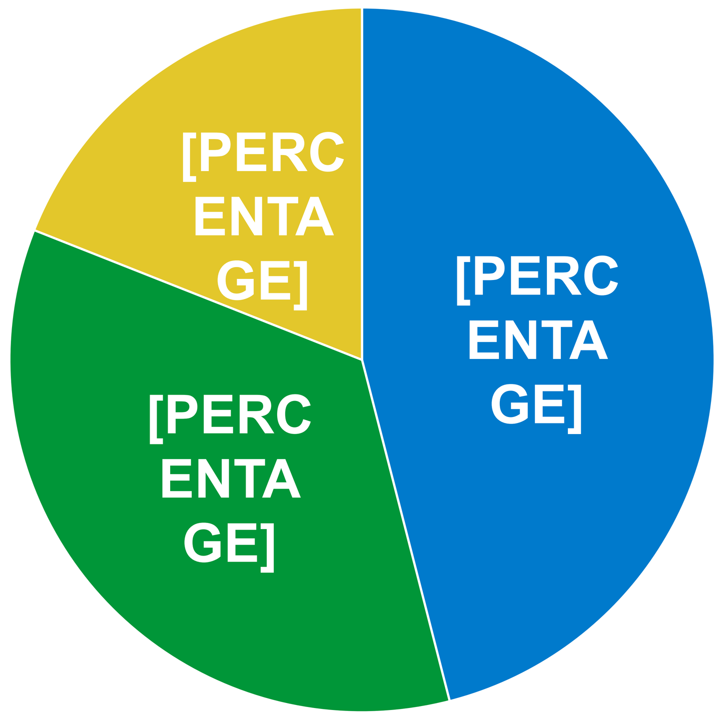
Does conductivity increase or decrease



Is Graph Consistent With Prediction



Correctly Labeled Axis



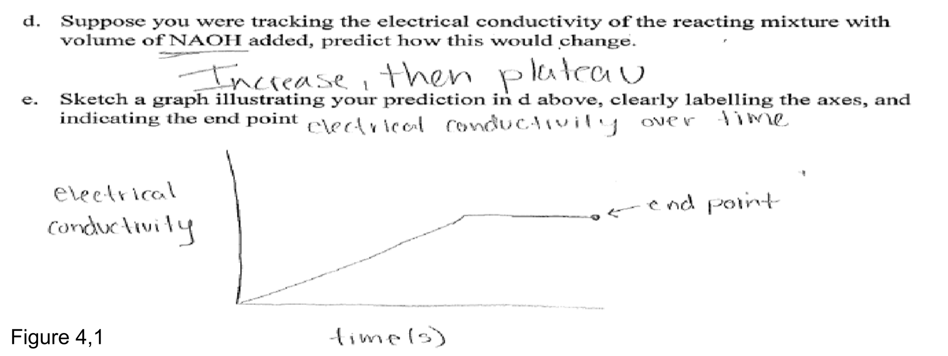


Figure 4.1

Figure 4.1 shows a group that has an incorrect graph but is consistent with the prediction. The axis is also partially labeled with the correct y-axis and incorrect x-axis.

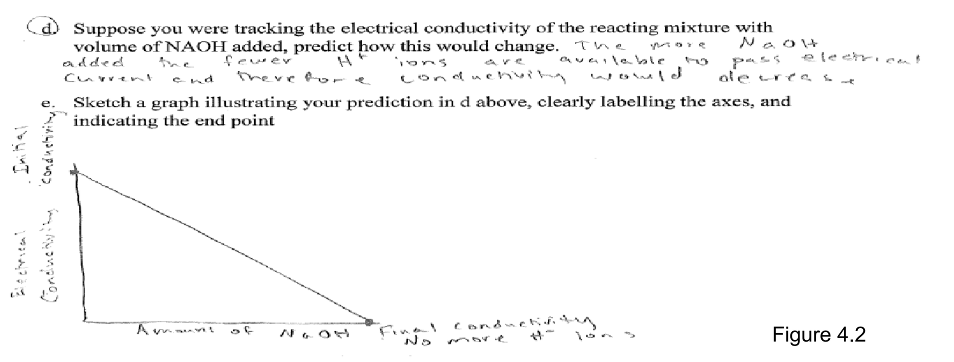


Figure 4.2

Figure 4.2 shows a graph which is consistent with the prediction, has the correctly labeled axes, and a correct prediction. The graph is has an endpoint indicated, but the graph is not correct because it does not increase once the reaction is neutralized.

Language Fluency

-Most students struggled with translating between text and the symbolic language

-Students appropriately used relevant vocabulary

Words Frequently Used by groups include:

- Equilibrium
- Electrolytes
- Amps
- Ionize
- Supersaturated
- Dissolve
- Neutralization

Students' conversations reflected struggles with both appropriate relevant language. For example, students asked a number of questions in their groups:

- What makes a strong or weak acid?
- What does excess mean?
- What does this reaction yield?
- How do you know that these solutions are aqueous?
- How can you tell if it is a strong or weak acid?
- Is there a color change?

Students' reasoning/thought Processes indicate both language fluency and conceptual understanding struggles:

- " Salt water is not as conductive as regular water which makes the solution more conductive."

Discussion and Conclusion

Discussion

- Most Groups were successful in going from written text to writing the correct chemical equation
- Most groups struggled to provide particulate representations of the reaction
- Some groups provided macroscopic view of an actual acid base reaction that one can see with the naked eye and drew the titration happening.
- Many groups confused the Complete Ionic Equation with the Net Ionic Equation
- Most of the groups showed consistency between prediction and graph
- For groups that got the correct prediction, they struggled with explaining their drawings

In conclusion

- ❖ Students struggled to transfer knowledge of acids and bases to the context of conductiometry
- ❖ Student conversations reveled struggles with both conceptual understanding and use of appropriate 'academic language

Implications

- Students need opportunities to apply or transfer knowledge to other contexts
- Alternative forms of assessment, such as evaluating student talk give us a window into student understanding
- Active learning strategies that engage students in talking help students develop language fluency

References

Cooper, M. M., Corley, L. M., & Underwood, S. M. (2013). An Investigtion of College Chemistry Students' Understanding of Structure-Property Relationships. *Journal of Reasearch in Science Teaching*, 699-702.
Jaisen, P. G. (2010). What Do You Mean "Strong" Doesn't Mean Powerful? *Journal of Chemical Education*, 1247
Naah, B. M., & Sanger, M. J. (2012). Student Misconceptions in Writing Balanced Equations for Dissolving Ionic Compounds in Water. *Chemistry Education Research and Practice*, 1-3.
Treagust, D. F., Chittleborough, G., & Mamiala, T. L. (2003). The Role of Submicroscopic and Symbolic Representations in Chemical Explanations. *International Journal of Science Education*, 1353-1356.
Jaisen, P. (2010). You Said "Neutral", but What Do You Mean? *Journal of Chemical Education*, 33-34.
Pyburn, D., Pazinci, S., Benassi, V., & Tappin, E. (2013). Assessing the Relation Between Language Comprehension and Performance in General Chemistry. *Chemistry Education and Research Practice*.

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