JOURNAL OF CHEMICAL EDUCATION

Communication

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ConfChem Conference on Interactive Visualizations for Chemistry Teaching and Learning: A Multimodal Examination of Visual Problem Solving

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Supporting Information

ABSTRACT: This communication summarizes one of the invited papers to the ConfChem online conference Interactive Visualizations for Chemistry Teaching and Learning, held from May 8 to June 4, 2015 and hosted by the ACS DivCHED Committee on Computers in Chemical Education. In our ConfChem paper, we presented a mixed-methods analysis of multimodal problem-solving data to look for themes in problem-solving strategies. We discussed the trends that emerged in how participants represented and interacted with representations of stoichiometry problems. In particular, we focused on the findings that suggested a need for directed reflection on problem-solving strategy and conceptual understanding of conservation. We used multiple, individual assessments to investigate student interaction with chemistry representations which allowed us to identify trends in both conceptual understanding and viewing strategy. Of particular interest were instances where a participant shifted between use of conservation concepts or viewing strategy. The ConfChem discussion provided a forum for deeper exploration of these research findings and future directions.

KEYWORDS: *First-Year Undergraduate/General, Multimedia-Based Learning, Problem Solving/Decision Making, Stoichiometry*

BACKGROUND

Stoichiometry problems can be presented using images, words, numbers, or equations. This offers an excellent opportunity to investigate how students shift between multiple chemistry representations. We investigated student problem-solving strategies using a pre- and postassessment design consisting of a chemistry self-efficacy questionnaire, a multiple choice particulate nature of matter assessment, complemented with a confidence assessment, a representational competency assessment, and a retrospective talk-aloud protocol. Between the pre- and postassessments, participants played the PhET simulation *Reactants, Products, and Leftovers*[1] while eye tracking data were collected. We selected this simulation because it is available free of charge and is open source, allowing us to modify aspects of the simulation (specifically, to remove the random selection of equations and present the same sets of equations for each participant). Verbal responses, drawings, and written responses (both equations and words) from the pre- and postassessments were qualitatively coded for emergent themes using a lens of chemistry misconceptions related to conservation.[2] Additionally, we performed a statistical analysis of the assessment scores and a cluster analysis combined with principal component analysis of the eye tracking gaze patterns. Three themes were found using multimodal analysis (not including the discourse analysis) that were consistent with the findings from discourse analysis: conservation, reflection, and the use of moles versus molecule. Eye tracking analysis revealed four groups of gaze patterns, with most participants shifting between viewing strategies regardless of problem-solving success and fewer students maintaining consistent viewing patterns throughout the PhET simulation.

DISCUSSION TOPICS

This paper was discussed (see the Supporting Information) May 15−22, 2015, during the Spring 2015 ConfChem online conference, Interactive Visualizations for Chemistry Teaching and Learning.[3] The conference was hosted by the ACS DivCHED Committee on Computers in Chemical Education. The online discussion focused on the experimental design of this study, implications for the use of simulations in teaching, clustering methodology, and possible next steps for further investigation of viewing patterns.

One question raised was whether the length of the assessment was possibly tiring to the students. The study employed a variety of tools to investigate and triangulate how students interact with representations of stoichiometry problems, allowing students unlimited time to interact with each step of the study. This resulted in a significant variation between each participant's trial length of study engagement. However, there were no indications from the data analysis or feedback that fatigue was impacting their results.

The orientation of participants to the PhET simulation was also discussed, through the presentation of guided exploration relating to the terms reactants, products, and leftovers. This discussion reflected questions of how to best use these

Received: July 13, 2015
Revised: January 18, 2016

DOI: 10.1021/acs.jchemed.5b00549
J. Chem. Educ. XXXX, XXX, XXX−XXX

simulations in a learning environment by supporting students with step-by-step directions, allowing for unguided exploration, or providing specific, crafted examples to spark student reflection. We noted the variety of teacher created lesson plans and activities on the PhET Web site[1] are useful for K−12 students, but the simulations can also serve large college lecture courses by allowing instructors to present problems using multiple representations.

There was also a discussion of our data analysis methods, specifically our cluster analysis of gaze patterns. As dynamic viewing sessions varied in time (because each participant was allowed unlimited time to solve each problem), we used novel approaches to processing and interpreting the eye tracking data.[4] The interest expressed by the ConfChem commentators in this aspect leads us to consider a future paper outlining the methodology employed in this data analysis approach and the possibility of applying these quantitative methods to more dynamic eye tracking data sets (e.g., animations).

Overall, we had some very positive feedback from the ConfChem contributors. Moving forward, we are particularly interested in exploring the difference between expert and novice strategies to see whether they can be detected by eye tracking, and in performing a deeper exploration of the misconceptions revealed by qualitative analysis.

■ ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available on the ACS Publications website at DOI: 10.1021/acs.jchemed.5b00549.

The ConfChem paper and discussion (PDF, DOCX)

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Notes

The authors declare no competing financial interest.

■ REFERENCES

(1) PhET Simulation: Reactants, Products and Leftovers. https://phet.colorado.edu/en/simulation/reactants-products-and-leftovers (accessed Jan 2015).

(2) Saldaña, J. *An Introduction to Codes and Coding: The Coding Manual for Qualitative Researchers*, 2nd ed.; Sage Pubs. Ltd.: Thousand Oaks, CA, 2013; p 40.

(3) American Chemical Society Division of Chemical Education, Committee on Computers in Chemical Education. 2015 Spring ConfChem: Interactive Visualizations for Chemistry Teaching and Learning. http://confchem.ccce.divched.org/2015SpringConfChem (accessed Dec 2015).

(4) Hansen, S. J. R. Multimodal Study of Visual Problem Solving in Chemistry with Multiple Representations. Ph.D. Thesis, Columbia University, New York, NY, 2014.

DOI: 10.1021/acs.jchemed.5b00549
J. Chem. Educ. XXXX, XXX, XXX−XXX