University of Minnesota Rochester

Assessing Experts Representational Schema of Protein Structure with Respect to the Vertical Translational Visual Literacy Skill

Brandy Hensch[1], Amanda Erickson[1], Abner Aguirre Lopez[1], Natalie A. Bobick[1], Cole R. Fondie[1], Andrea E. Lawrence[1], Xavier Prat-Resina[1], Cassidy R. Terrell[1]

1. University of Minnesota– Rochester, Center for Learning Innovation, 111 S. Broadway #300, Rochester, MN 55904.

Abstract

For many undergraduate students and experts, biology, chemistry, and biochemistry courses are difficult because they involve conceptual understanding of ideas that require assimilation of new knowledge with pre-existing knowledge from prior courses. Misconceptions increase cognitive load and interrupt the mental framework, making it difficult for individuals to learn and master course material. Adding to the complexity of these disciplines, individuals are presented with a variety of representations of abstraction which adds to the already high cognitive load of these courses (Schönborn et. al 2002; Offerdahl et. al, 2017). Intentional development of individuals' visual literacy skills has the potential to increase conceptual understanding while also decreasing cognitive load. Although research suggests that developing learners' mental models can help overcome misconceptions, little to no evidence exists in the chemistry and biochemistry education literature on student and experts structural knowledge related to visual literacy skills, specifically with vertical translational visual literacy skills for protein structure (Chi, 2008; Gilbert & Boulter, 1998; Cranford et. al, 2014, Schönborn and Anderson, 2010). A study was conducted in 2021 in which students and experts were administered four surveys of (bio)chemical models and were asked to scale their similarities from 0-9. This research leads the way for the development of novel targeted learning assessments that address misconceptions and integrate active learning into the undergraduate biochemistry curricula to increase undergraduate student understanding of different chemical and biochemical processes

Research Aims

This research aims to (1) assess the similarities and differences between experts' representational schema of protein structure and (2) assess whether Qualtrics is an acceptable tool to measure structural knowledge with respect to vertical translational protein structure concept.

Study Timeline

Study Design
- Fall 2020 - Spring 2021
- Background Research
- Write UROP Grant Proposal

Learning Assessment
- Fall 2021
- Identify and analyze results
- Synthesize data

Figure 1. Study Timeline. Timeline of this research project from Fall 2020 to Fall 2021. Current study is in the data collection and analysis section, with more data collection underway and analysis progressing.

Data and Results

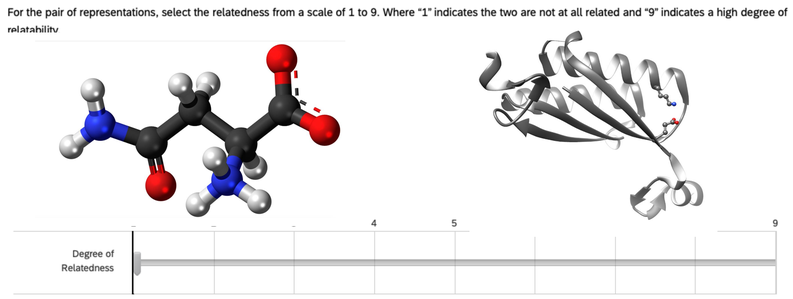

Figure 2. Sample Question from Qualtrics Survey. Questions from the survey asked participants to rank two images in similarity with a 0-9 scale, with 0 being not similar and 9 being the most similar. Images chosen for survey are common protein structure images used in many (bio)chemical classes.

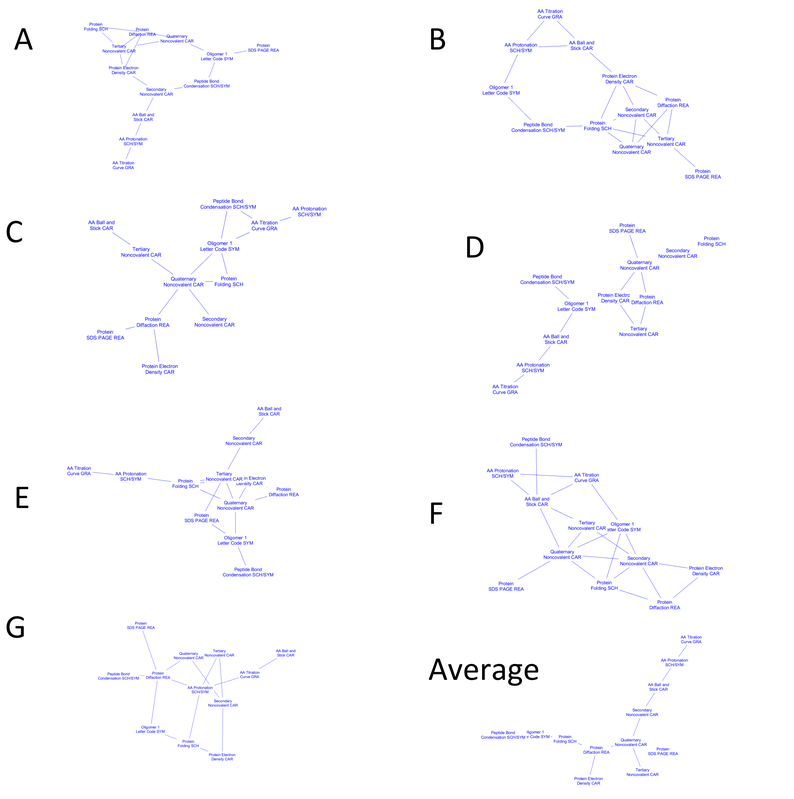

Figure 3. Average Neural Networks of Experts A-G, with Average Display Net of All Experts. Display nets were composed of experts A-G from a primarily undergraduate institution (PUI) where they teach a variety of STEM courses. Display nets show the neural connection that individuals make between (bio)chemical visuals and how they connect to each other.

Preliminary Results and Future Directions

Results

- The expert data was used to validate the vertical translational schema of protein structure survey.
- The data provided by the experts showed minimal similarities between their display networks, showing the differences between experts organizational schemas.
- Using the knowledge of experts neural networks could lead to improvements in teaching (bio)chemical concepts.

Future

- Increase sample size and diversity of participants
- Increase data collection from other sources
- Determine how to use this information to change student study curricula

References and Acknowledgements

We would like to thank the chemistry and biochemistry experts at the University of Minnesota Rochester who participated in our study. This project was supported by the University of Minnesota's Undergraduate Research Opportunities Program. The project was approved by the UMN IRB under STUDY00012054.

Neiles, K. Y. (2012). An Investigation of the Effects of Reader Characteristics on Reading Comprehension of a General Chemistry Text. ProQuest LLC., Ann Arbor, MI.
Neiles, K. Y., Todd, I., & Bunce, D. M. (2016). Establishing the Validity of Using Network Analysis Software for Measuring Students' Mental Storage of Chemistry Concepts. Journal of Chemical Education, 93(5), 821-831.
Neiles, K. Y. (2014). Measuring Knowledge: Tools to Measure Students' Mental Organization of Chemistry Information. American Chemical Society, Washington, DC.
Offerdahl, E. G., Arneson, J. B., & Byrne, N. (2017). Lighten the Load: Scaffolding Visual Literacy in Biochemistry and Molecular Biology. CBE—Life Sciences Education, 16(1), 1-11.
Schönborn, Konrad J, & Anderson, T. R. (2010). Bridging the Educational Research-Teaching Practice Gap: Foundations for Assessing and Developing Biochemistry Students' Visual Literacy. Biochemistry and Molecular Biology Education, 38(5), 347–354.