Transforming eye-tracking data to compare undergraduate students and professors' understanding of chemistry symbolism in organic chemistry mechanisms

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Introduction

- It is important for students to understand symbolism of curved arrow formalism as it can affect a student's approach to organic chemistry questions and overall results.

- The research question is: "How does undergraduate organic chemistry students' attention differ from experts when interpreting the meaningful information and the organic chemistry language of curved arrow formalism in mechanisms?"

- Participants consisting of both students and professors were asked to solve a set of chemistry mechanism questions, and their eye-tracking data was recorded. This data was then transformed into excel data sheets which took into account look zones, which are basically areas of interest.

- Expected results were for novice students to superficially gloss over the questions and avoid analysis of chemistry symbolism as opposed to professors.

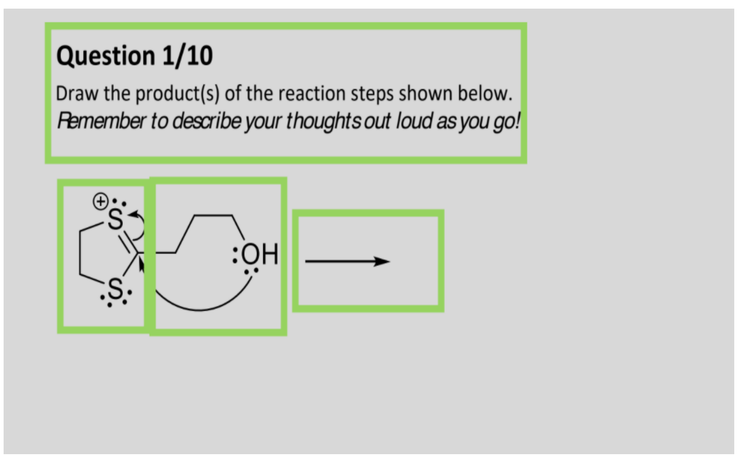

Figure 1. Look zones set for all participants for question 1. Demonstrates instructions, starting materials, and reaction arrow look zones.

Methods

- The research initially consisted of transforming and analyzing eye-tracking data from interviews of 10 undergraduate students and 3 professors who were selected through convenience sampling.

- The data consisted of 10 questions for each participant pertaining to curved arrow formalism in chemistry mechanisms. An eye tracking software called gaze tracker was used in order to transform the raw data from these interviews into excel sheets and heat maps.

- The look zones for each question were generally divided into: instructions, starting materials, products, and the reaction arrow.

- The initial time set to capture the number of fixations in each look zone was the first ten seconds from when questions were asked. However, this was later proven ineffective as ten seconds provided insufficient data to be analyzed.

- Through the first analysis of data sets, it was possible to recognize the participant data sets that were unable to capture sufficient data by analyzing the number of fixations. Sets with more fixation points per question, on average, tended to have more accurate results.

- Two methodological changes were made:

- The time set per question was from its introduction to completion. This allowed for more data to be captured.

- The number of participant data sets transformed and further explored went from 13 to 4. The chosen data sets were the ones with the most precise data in order to minimize error. These consisted of participants 4 and 8, who were students, and 11 and 13 who were professors.

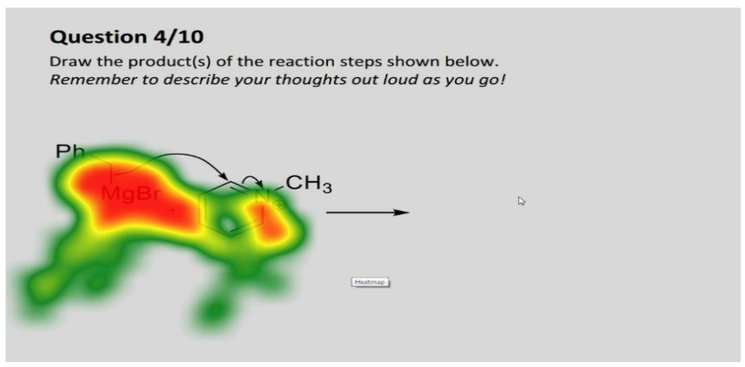

Figure 2. Heat Map for Participant 4, Question 4. This heat map was created when time captured set was for 10 seconds. It clearly shows starting material as the first look zone.

Results

- The average number of fixations for the participants were: 92 for participant 4, 54 for participant 8, 113 for participant 11, and 10 for participant 13. Participant 13 is the least accurate data set as it has the least number of fixations.

- The average first look zone for participant 4 and 8 for all questions tended to focus on starting materials first. Participant 11 tended to focus on instructions first, as opposed to participant 13 which initially focused on starting materials.

- Student participants had similar data trends while the professors had contrasting results.

- The average number of fixations for all questions was highest for the starting material. The second most focused area was the products and reaction arrow, with the instructions look zone coming in last.

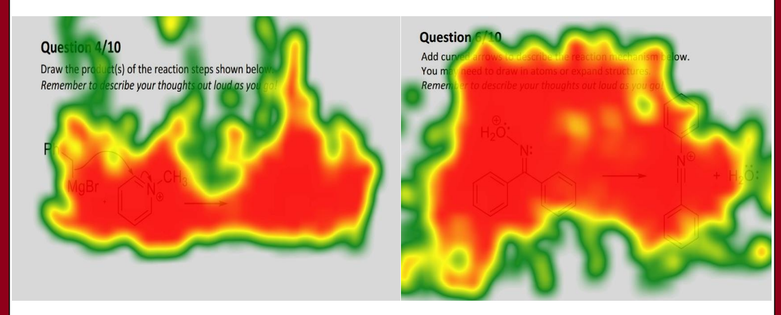

Figure 3. Heat Maps for Participant 8, Question 4 and Participant 11 Question 6. The student participant tended to focus on starting materials while the professor focused on both instructions and starting materials.

Conclusions

- As expected, the student participants tended to superficially gloss over the questions as opposed to the professors.

- No large inferences can be made. However, the results of the student participants may indicate the importance of learning how to approach chemistry questions. It may even be possible that their results can differ through having a better understanding of chemistry symbolism. This argument can be supported by looking at the difference in results between the students and professors.

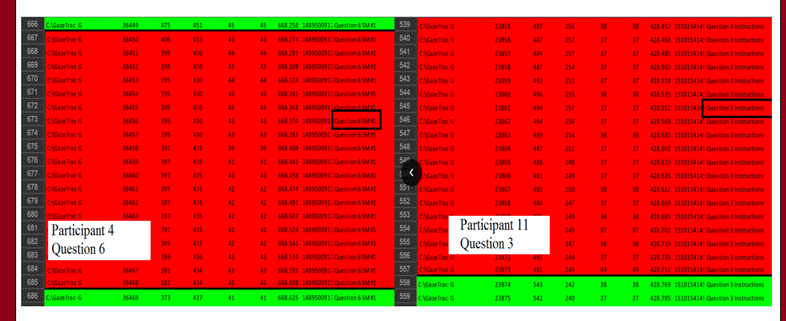

Figure 4. Excel data for questions from participants 4 and 11. This demonstrates how the students tended to look at starting materials as opposed to instructions like the professors.

- Contrarily to the students, the professors data sets were individually different. This variability may have been a result of the lack of fixation points for participant 13. Perhaps the eyes of the participant were wandering too much as a result of nervousness or other factors influencing their ability to fixate on the different look zones.

- Some next steps to take are to analyze the precision of answering questions when the participants' first fixation is on the instructions instead of the starting materials. If the results are more accurate when initially focusing on the instructions, it is then possible to analyze whether or not learning curved arrow formalism questions in chemistry questions can change how the questions are approached. This could consist of a change from initially fixating on starting materials, to eventually fixating on instructions first whenever a chemistry question arises..

Participants	Average Initial Look Zones Fixated On	Number of Questions Answered Fully Correctly (out of 10)
4	Starting Material	4
8	Starting Material	3
11	Instructions	10
13	Starting Material	8

Figure 5. Table of results vs. initial average look zone fixated on. It is an example of a next step to take after this experiment. Higher results may indicate that the specific look zone is most important and should to be focused on.

References

1. Tools of Chemistry Education Research. (n.d.). Retrieved December 5, 2017, from http://pubs.acs.org/isbn/9780841229402

2. Clayden, J., Greeves, N., & Warren, S. (2012). *Organic Chemistry* (2nd ed.). Oxford University Press.