Utilizing Eye-Tracking Technology to Promote Students' Meta-Cognitive Awareness of Visual STEM Literacy

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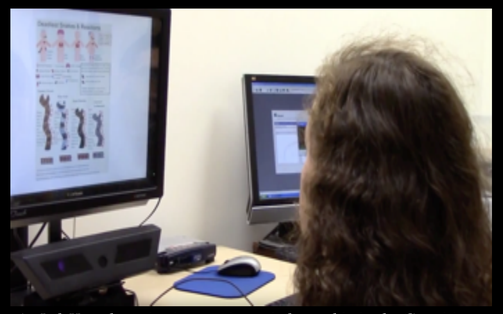
Introduction and Purpose

During a ten day summer camp (Infographic Expression, or *InfoX*) designed to promote student visual, scientific, and data literacy through infographics our team implemented a curricular component involving viewing infographics (IGs) while being recorded by an eye-tracking machine. Students viewed quantitative data collected by the eye-tracker and reflected on their own and peers' process of visual engagement. This activity enabled students to increase their metacognitive awareness of their pre-existing perceptual and interpretive processes, supporting their performance during the rest of the camp and ultimate creation of their own science news IGs.



An InfoX student viewing a science infographic in the Cognitive Development Lab in front of the eye tracking machine

Research Context and Design

- The overall objectives of the *InfoX* summer camp were to engage high school students in a meaningful process of analyzing visual representations of scientific data and to support student understanding of how they process mixed media information by having them identify a topic of personal interest and author a science news infographic.
- The eye-tracking exercise was intended to provide students exposure to scientific procedure, an experience in a cognitive development laboratory to analyze their own embodied engagement with diverse visual representations, and produce a large data set that students could reflect upon to deepen their understanding of their own visual perception.
- We selected a series of six student-generated IGs and coded each into four areas of interests (AOIs). Seven *InfoX* students participated in two IG trials as the eye tracking machine recorded their gaze patterns, saccades, and duration of focus in each AOI. These trials occurred on day two of the camp to highlight students prior knowledge before explicit IG instruction.

References & Acknowledgements

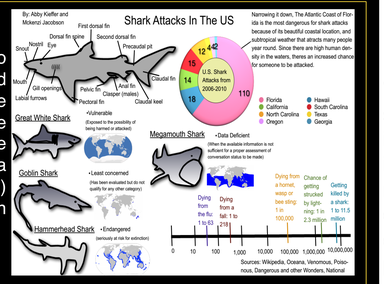
[1]Dalton, B, & Proctor, C.P. (2008). The Changing Landscape of Text and Comprehension in the Age of New Literacies. *Handbook of Research on New Literacies, 297-324*
[2]diSessa, A. A., & Sherin, B. L. (2000). Meta-representation: An introduction. *The Journal of Mathematical Behavior, 19*(4), 385-398.
[3]Kirsh, D. (2005). Metacognition, Distributed Cognition and Visual Design. *Cognition, Education and Communication Technology (2005):147-180*
[4]Lai, M.L et al. (2013)A Review of Using Eye-Tracking Technology in Exploring Learning from 2000 to 2012. *Educational Research Review, 10, 90-115*
[5]Palincsar, A. S., & Brown, A. L. (1984). Reciprocal teaching of comprehension-fostering and comprehension-monitoring activities. *Cognition and Instruction, 1*(2), 117-175.
[6]Schoenfeld, A. (1987). What's all the fuss about metacognition? *Cognitive Science and Mathematics Education* (pp. 189-215)
[7]Stein, P. (2008) Multimodal Instructional Practices. *Handbook of Research on New Literacies, 871-898*

Trial 1

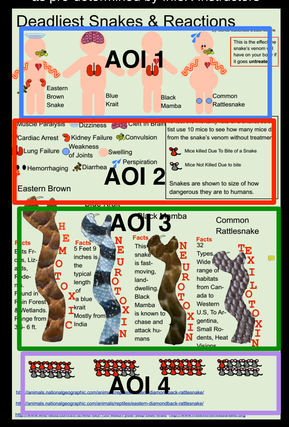
The student is presented with a pre-determined question on the computer screen and then the infographic appears. As soon as the student believes she has found the answer, she hits the space bar, the infographic disappears, and she writes her answer down. When she is ready, the next question appears followed by the IG. There is no time limit. A separate computer captures data about where the student looked.

Trial 2

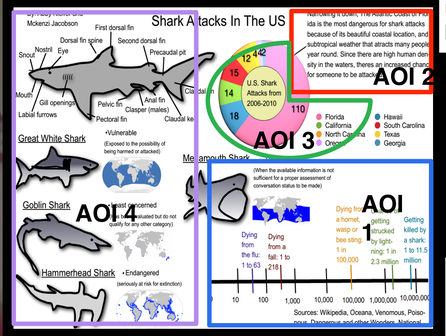
The student is given thirty seconds to observe a new infographic, and prompted to learn as much as she can. Immediately afterwards the student can see a blue line re-trace where her gaze appeared. In a separate room (away from the IG) she is instructed to write down everything she learned from the IG.



Analysis of Trial 1 and Areas of Interest (AOI) as pre-determined by *InfoX* Instructors

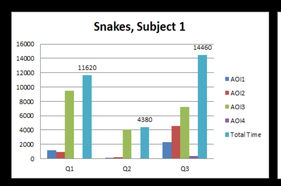


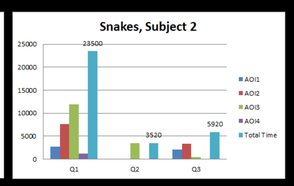
Analysis of Trial 2 and Areas of Interest (AOI) as pre-determined by *InfoX* Instructors



The day after the eye tracking exercise students presented the two infographics they had seen to the rest of the class and explained how they believed they had viewed the IG and processed the information. Then, through a series of raw output spreadsheets and data representations from the eye-tracker, instructors illustrated where students' gaze actually went, our design process for assigning AOIs, how students responded to questions, and duration of focus on each AOI in milliseconds. Students were surprised by some of these results and spent time reflecting on trends in the data. Students then had a second opportunity to explain where they looked and how they engaged the visual information in light of having seen the actual results. Collectively, the class offered feedback for each of the experimental infographics and reflected on how they had processed visual representations differently.

Data Output for Trial 1





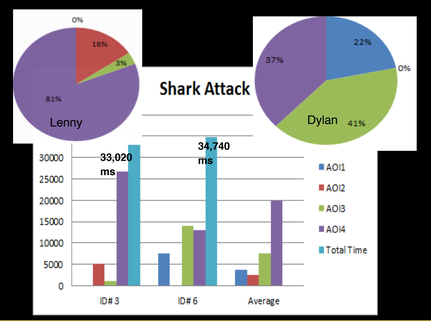
Trial 1 Sample Questions

1.Which snake is the deadliest for mice? Where did you find this data?
2.Where does the Blue Krait inhabit? Where did you find this data?
3. Which snake bite is associated with diarrhea? Where did you find this data?

The bar charts above represent the amount of time in milliseconds each participant focused on a specific AOI for each questions. These students discussed their varied strategies for processing the visual text. 'Subject 2' observed that their strategy was to view the whole IG first, and then answer questions, as evidenced by their increased time spent on question 1.

Data Output for Trial 2

The two students that viewed the thirty second open ended shark IG noted that they both spent less time on the written text, preferring the images and maps on the left. Lenny also noted that he deliberately avoided AOI 1 as he was confused by the scale and labeling.



Theoretical Framework & Scholastic Contributions

We utilize a socio-cognitive framework, seeing learning as social or interpersonal activity being appropriated to the intrapersonal or intramental plane[7]. Inspired in part by instructional models such as reciprocal teaching[5], multimodal social semiotic approaches[7], and distributed cognition[8], we seek to design learning environments with cognitive tools for meta-cognitive awareness of visual perception and interpretation. In this effort, we aim to adapt research on meta-cognition[6] and meta-representational competence[2]. We believe that as available media and data outlets expand the notion of 'text,' further research and development should be conducted to deepen our understanding of 'new media literacies' and inform STEM curriculum design[1, 3, 4]. We believe this continued eye tracking and infographic work will have import in fields of STEM education, data literacy, user interface technologies, critical media studies and beyond.

Analysis and Future Directions

- The eye tracking exercise provided a reference point for discussion regarding effective presentation of data, visual appeal, and the students' scientific, data, and visual literacies as they created their own IGs. This pilot study was intended as a learning experience for students to think about their own visual process; not a scientific research experiment.
- The next *InfoX* camp will occur in July 2016. We have recruited staff of the Cognitive Development Laboratory to aid in systematically designing the next eye tracking experience to focus on particular and varied forms of information representational tools, the visual appeal of data, consider how students respond to redundancy amongst images, and include pupillometry measures as indicators of cognitive effort associated with processing data.
- We hope this work continues to promote student visual meta-cognition and contributes to a deeper understanding of new media and data literacies.

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