

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

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Abstract: During a two-week summer camp designed to promote student visual, scientific, and data literacy through infographics, our team developed a curricular component involving viewing infographics while being recorded by an eye-tracking machine. Students viewed data collected by the eye-tracker and reflected on their own process of visual engagement. This activity enabled students to gain metacognitive awareness of their own perceptual and interpretive processes, supporting their performance during the rest of the summer camp.

Keywords: metacognition, STEM literacy, visualization, learning environment design

Introduction

We articulate our aims for, and preliminary findings from, a digital eye-tracking exercise developed as a curricular component of a ten-day science summer camp, Infographic Expression, (InfoX). The objectives of InfoX were to engage high school students in a meaningful process of analyzing visual representations of quantitative and scientific data and to support student understanding of how they process mixed media information by having them identify a topic of personal or scientific relevance and author a science news infographic. The eye-tracking exercise provided students with an experience in a cognitive development laboratory to analyze their own embodied engagement with diverse visual representations, and produced a large data set for later manipulation, bolstering students' understanding of their visual perception and interpretation.

Theoretical Framework and Related Literature

We utilize a socio-cognitive framework, seeing learning as social or interpersonal activity being appropriated to the intrapersonal or intramental plane (e.g., Wertsch, 1991). Inspired in part by instructional models such as Palincsar & Brown's (1984) reciprocal teaching, we seek to design a learning environment with cognitive tools for metacognitive awareness of visual perception and interpretation. In this effort, we aim to adapt research on metacognition (e.g., Schoenfeld, 1987), and meta-representational competence (e.g., diSessa & Sherin, 2000).

Research Context, Data Sources, and Methods

One objective of InfoX was to expose students to scientific processes and university laboratory experiences. Accordingly, our team developed a curricular component in collaboration with staff trained in eye-tracking from our institution's Cognitive Development Lab. The desired outcomes for this experience were for students to gain deeper insight into how they process visual representations. We developed a series of infographic visualization trials aimed at providing an educative experience for learners (given our relatively small dataset, we did not aim to make generalizable theoretical claims regarding basic perception and cognition). We selected a series of six student-generated infographics, and coded each into four areas of interests (AOI). We developed a set of open ended and closed questions for each. Seven InfoX students participated in two tasks utilizing these prompts.

The first task was for students to answer a series of four pre-assigned questions using an infographic presented to them on a computer screen equipped with an eye-tracker. These questions concerned quantitative and qualitative information, the credibility of the infographic, and data that could only be found in specific data visualization components. There was no time limit. The second task allowed students thirty seconds to study a novel infographic and try to remember what they deemed most important. Students were situated in front of a computer in the Cognitive Development Laboratory and a technician explained the equipment and process to each student individually. The eye tracker would trace a student's gaze in real time, record changes in the dilation of the pupil, and quantify the amount of time spent in each AOI. Afterwards, the quantitative data was stored in a large spreadsheet, and students could watch as a red line overlaying the original image re-created where their gaze went. Students were then escorted to a second room to complete a questionnaire regarding their answers to specific questions, what they recalled, where they believed their attention was focused, and so on.

We, as instructors of InfoX, transformed the raw output data into a series of visualizations to share back with students. Prior to seeing these results, the students presented the infographics they had seen the day earlier to the rest of the class and explained how they believed they had processed the information. Then, through a series of graphs and charts representing data collected from the eye-tracker, the instructors

demonstrated where students' gaze actually went, how they responded to questions, and for how long participants focused on each AOI. 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. Collectively, the class offered feedback for each of the experimental infographics and reflected on how they each processed visual representations differently.

Data sources for this analysis include records of the above interactions from field notes and video recordings of class sessions, informal interviews of participants, artifacts created during the eye-tracking sessions, and students' final infographic products. Our research method involves coding and quantifying instances of student metacognitive reflection regarding their visual processing after the eye tracking activity.

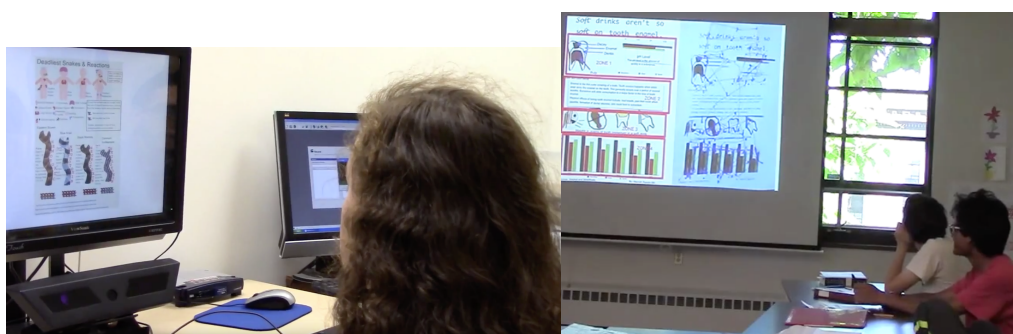


Figure 1. Student viewing an infographic in front of the eye tracking machine. Figure 2. Students debriefing the results of the eye tracking exercise as they observe the AOI's (in red, on left) and gaze tracker (in blue on right).

Analysis & Future Directions

The eye-tracking experiment and analysis took place in the first three days of the ten-day InfoX program. As such, the experience and analysis of the eye tracking exercise illustrated and drew on student intuitions and prior knowledge of visual perception. This provided a springboard for discussion regarding effective presentation of data, visual appeal, and the students' own scientific and visual literacies. Later in the program students participated in activities concerning graphic design, and "good" visual representation practices. The eye tracking activities appeared to provide a useful foundation for students, as they frequently referred back to it while they spent the next seven days of the program developing and designing their own science news infographics. Students remarked about creating visually appealing and diverse AOI's, parsimony through bulleted texts, redundancy in qualitative and quantitative data, and overall 'flow' of their infographic based on the gaze analysis of their own viewing. In several cycles of peer feedback, students referenced their own tendencies as well as trends that they eye tracker captured. Students also recognized variation in these patterns that correlated with gender and age of participants, leading to further discussion about intended audiences and background knowledge of the viewer. It appeared that students' increased understanding of selective and sequenced attention bolstered their metacognitive perceptual abilities and informed the design of their final infographic products.

The InfoX summer camp was part of a larger project exploring how infographics support STEM literacy. In this first iteration of InfoX we found that the eye-tracking activity engaged our students, grounded their understanding of visual literacy in an embodied experience, and offered opportunities to bolster their intuitions of how they typically engage visual data. We see promise in further developing activities capitalizing on the affordances of these technologies to support metacognition regarding visual perception and interpretation, and, ultimately, contributing to scholarship on perception, visual literacy, and data visualization (Lai et al, 2012). Accordingly, we will run a second iteration of InfoX in 2016 to follow up on preliminary findings of this study.

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