A picture is worth a thousand words: visualizing collaboration through gaze synchrony graphs

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Introduction and research questions

In our case study, in which we attempt to understand the reasons why collaborative behavior arises, we turned to eye tracking during a live lesson involving a mathematics problem solving session in a classroom, and measured shared attention via gaze synchrony. Gaze synchrony is a measure of how much the locus of gaze of the different participants in the study overlaps. Together with a qualitative analysis of the episode, we tried to determine what produces gaze synchrony and why. Our data collection took place in a classroom and not in a lab, making our results ecologically valid. Our resulting picture, an annotated graph, is worth a thousand words when supplemented with specific knowledge about the key events it identifies. With the graph we are able to locate moments when (gaze) focused communication and interaction takes place, and identify what brings about that communication and interaction.

Background

Collaboration is a process whereby two or more people work together towards achieving a particular goal. Intellectual work has become increasingly collaborative. There is remarkable consensus among educational policy makers, that the future labor market needs primarily non-routine analytic and non-routine interpersonal skills, including problem solving, interpersonal communication, and self-management (OECD, 2013). Although the nature and learning of such 21st century skills (see Binkley et al. 2010) has been studied both in psychological and educational research there are some areas that have received little attention, if any. In our study we address the question of what brings about collaborative behavior during non-routine mathematics problem solving in class.

Methodology

In order to study patterns of collaboration during mathematics problem solving sessions in the classroom, student teachers at the University of Helsinki were asked to solve a non-routine problem during a lesson while wearing mobile eye-tracking devices. The problem consists of finding the optimal way to connect four cities located at the vertices of a square with cable, using the shortest amount of it (the optimal solution is given in Figure 1b). Several kinds of data were collected in addition to the eye-tracking data, such as notebook scribble, screen content when laptops or tablets were used, video, voice, and a stimulated recall interview with the subject wearing the eye-tracking devices during which they could see the eye-tracking recording as a form of stimulus. The students work first alone, then in pairs, and then in groups of four. The role of the teacher is to encourage students to find the best solution possible without providing information about it. Four students were wearing the gaze tracking glasses. The gaze tracking data was processed to measure gaze synchrony and produce the graph in Figure 1a. The red line represents a statistically generated mean of the measure of gaze synchrony. The blue line represents the amount of overlap as given by the gaze tracking data relative to this statistically derived mean, in standard deviation units. The green lines are three standard deviations away from the red mean curve.

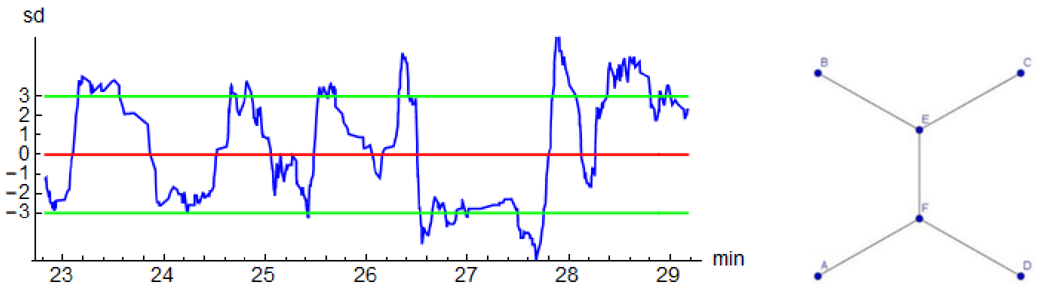

Figure 1: (a) 3-way gaze synchrony graph (b) the optimal solution to the problem

Results and discussion

The graph above and the careful analysis of other audio and video data allow us to construct a storyline that describes the problem-solving episode and which highlights collaborative behavior. Gaze synchrony occurs at the peaks. Leading to these moments is the need of one or more of the students to verify their belief that they have identified a plausible solution (something we call goal proximity). When this belief wanes, students return to work on their own in hope of finding a better solution and gaze synchrony is lost, as indicated by the troughs in the figure. For example, in the picture, towards the right, there is a long trough followed by a high plateau. During the trough, the students are working alone, but then, one of the students thinks he has found the best solution and asks everyone to look at the board to verify this, and the verification process ensues. The graph helped us identify this pattern of collaboration in which discovery and verification alternate, with discovery taking place while students work on their own, and verification signaled by increased gaze synchrony, occurring while the group works together and the visual attention of the group members is more focused on the same targets. We believe that with this tool we might be able to identify, with more data, other collaboration patterns occurring in problem solving sessions in the mathematics classroom and provide teachers with valuable insight informing her interventions.

References

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