Investigating Child Interaction Across Face-to-face and Virtual Spaces: Case Study of Mobile Eye-tracking Analysis

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Abstract: In a hybrid CSCL afterschool program with Minecraft, children simultaneously built artifacts in the virtual world and made interactions with their peers in person. We used mobile eye-tracking to examine the dynamic and multifaceted forms of children's interactions (visual, verbal, and physical) during their collaborative design activity with Minecraft. This poster highlights benefits of using mobile eye-tracking in hybrid settings and contributes to the theoretical understanding of children's diversified interactions.

Minecraft Edu© has been utilized by educators and researchers to support children's learning in diverse domains, including mathematics (e.g., Bos, Wilder, Cook, & O'Donnell, 2014), maker culture (e.g., Niemeyer & Gerber, 2015), arts or STEAM (e.g., Overby & Jones, 2015), and design thinking (Borge et al., 2020). Because this game allows multiple learners to work in the same virtual space simultaneously through its server, it has been used to support learners in distance (e.g., for a child in a hospital; Hollett & Ehret, 2014); for other cases, it has been also used for hybrid environments where multiple learners physically sat together and, at the same time, built their artifacts together in the virtual world. We focus on the latter case where Minecraft supported diverse interaction channels for learner collaboration so that learners make simultaneous face-to-face and virtual interactions.

In the meantime, eye-tracking has been utilized in many educational studies especially about online education, but it entails some limitations to adaptation in face-to-face or hybrid settings because it can only capture the learner's visual interactions within the monitor frame. However, the development of *mobile* eye-tracking has allowed researchers and educators to utilize it in more diverse educational settings, including informal educational settings (Jung, Zimmerman, & Pérez-Edgar, 2018) like afterschool clubs. Mobile eye-tracking can measure not only learners visual interactions with the online or virtual objects but also with other people (e.g., peers, teachers) and other objects beyond the monitor. In this regard, by utilizing mobile eye-tracking, this study aims to investigate how children navigated diversified and multifaceted interactions during a hyprid computer-supported collaborative learning (CSCL) activity.

Research setting and data collection

This study is part of a larger design-based study with a weekly afterschool program where children at an elementary school engaged with collaborative design activities with Minecraft and LEGO (Borge et al., 2020). This program was designed on the basis of embedded design, so that children as active participants could experience human-computer interaction (HCI) practices and develop domain knowledge. Children were in groups of 3-5 students, and each group worked collaboratively for their projects. They were asked by virtual clients to build a garden or library (Jung, Yan, & Borge, 2016), and they planned and prototyped with LEGOs first, then moved to Minecraft Edu to build their work in the virtual world. This particular study focuses on the activity from one week of one group consisting of 5 students.

Along with the video recordings collected from multiple angles, we collected mobile eye-tracking data from one student of this group, Anuj (pseudonym), who shared a laptop with his partner. We used PUPIL mobile eye-tracker developed by Pupil Labs (Kassner, Patera, & Bulling, 2014). Due to the limited number of our mobile eye-tracker prototypes, we were not able to let all students wear the device. This mobile eye-tracker utilized two-sided cameras: one captured the view that Anuj was looking at, and the other captured the movements of the child's pupil. Using Pupil Labs' software, recordings from each camera could be merged (see Figure 1) so that researchers could see one video recording of the first person's view layered with dots and lines, which indicate the locations and paths of the child's gaze. Also, an audio recorder was attached to capture the child's verbal interactions in accordance with their mobile eye-tracking footage.

Analysis, findings, and implications

In this hybrid CSCL setting, we posited that there could be three channels of interactions: verbal interactions, visual interactions, and physical (i.e., hands) interactions. By employing video-based interaction analysis (Jordan & Henderson, 1995), we identified and tagged certain targets that Anuj interacted with in each category: peers and teachers in verbal interactions; teachers, peers, computer keyboards, Minecraft tools, and Minecraft blocks in

visual interactions; keyboards, screen, and peers in physical interactions. We repeatedly viewed video recordings with mobile eye-tracking footage, and analyzed when and how he navigated his interaction channels differently.

Mobile eye-tracking data was helpful for fully understanding the situated context of the child's interactions. It provided detailed information about the targets of the child's attention. In Figure 1, both screenshots were from Arjun's similar angle of view, but mobile eye-tracking footage showed precise information of his gaze; the left screenshot indicated that his attention moved from the screen to his peer while the right screenshot showed that he focused on the screen. Such information could not be attained from normal video data or screen recordings. Our preliminary analysis shows that the child's gaze mostly focused on the screen showing his virtual project or computer keyboards although he verbally talked with other peers in his group. When he was struggling with some problems, however, all of his physical, visual, and verbal interactions were targeted toward his peers. Our study adds to an embodied and holistic understanding of children interaction (Marshall et al., 2009) especially in hybrid CSCL settings, and provides implications of using mobile eye-tracking for related research.

Figure 1. Screenshots from the mobile eye-tracking recordings. Red dots and lines indicate the locations and paths of the child's gaze. The left figure shows that the child was looking at his peers in his group, and the right shows that the child's attention was focused on the virtual blocks in the Minecraft world.

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