Theory, methodology and design as an insightful bundle: a case of dual eye-tracking student-tutor collaboration on an embodied mathematical task

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While the importance of reflection on methodological dimension for the networking theories was already stated (e.g. Bikner-Ahsbahs & Prediger 2014), here we claim that educational design is another essential dimension in distinguishing a phenomenon that might be unattainable as far as it has not been lit by a particular theory-methodology-design bundle. In this poster, we explore a bundle of a culture-historical approach, dual eye-tracking (DUET) method, and action-based interactive design; we argue that these three aspects being taken together form a lens that manifests in the teaching/learning process a perception-action system that is distributed between the tutor and student. The argument is based on multimodal data from student-tutor collaboration on interactive activity, where a student was required to discover a parabola in an embodied way as a set of points equidistant from the focus and directrix (Shvarts & Abrahamson, 2018).

Theory-methodology coupling. A culture-historical approach provides us both with the theory and methodology for investigating the psyche’s development, and yet they are interconnected. Vygotsky proposes an “experimental-genetic method” that aims to restore the development process and to expose the higher psychic functions in the form of moving, “flowing flood” (Vygotsky, 1978). This method involves the active participation of a researcher in interaction with a pupil that, unlikely to natural science, do not distort the data, but on the contrary allow the genesis of mathematical functions to emerge. A theoretical presumption here is the social nature of psychological functions that emerge in intersubjective interactions. In our study, an experimenter interacts with the student as a tutor, and later interaction is reproduced between the just-instructed participant and a new pupil. DUET appears to be a perfect way to investigate this collaboration: while often eye-movements are interpreted with the presumption of the eye-mind hypothesis, the data from DUET might be perceived as evidence of a psychic function as distributed between a student and a tutor. Then joint attention is not a result of initiation or response by single participants, but a functional end that emerges from “the multiple pathways” (Yu & Smith, 2016, p. 18) within their system.

Theory-design coupling. Traditionally from Vygotsky’s point of view, communication between a student and a teacher is considered as mediated by some cultural artifacts, signs. However, Roth argues that in his late writing Vygotsky departures from the mediation as a primary mechanism that serves communication (Roth, 2018). This embodied character of collaboration is particularly accessible in an activity which is deliberately designed so that introduction of mathematical notations is postponed to the moment when a student has experienced mathematical concepts in an embodied way (Abrahamson, Shayan, Bakker, & van der Schaaf, 2015). The involvement of a student and a tutor in a motor problem that required formation of a new sensory-motor coordination allowed us to trace this function as socially distributed.
Method-design coupling. As eye-tracking let us observe oculomotor spatially articulated activity, we shall involve the participants in the design that benefits from an eye-tracking observation. The embodied action-based design is particularly suitable as it provides an opportunity for the learner to elaborate mathematical knowledge at first in the form of sensory-motor coordination. It is through eye-tracking we may gather empirical evidence of attentional anchors — the perceptual aspects of sensory-motor coordination that serves the efficiency of movement (Abrahamson et al., 2015).

Theory-methodology-design bundle. A combination of all three couplings let some phenomena surface; we present the one phenomenon that seems to be of great importance for educational science. While the students’ eye-movements manifested emerging attentional anchors, the same was found in the tutors’ oculomotor behavior, whether they were a researcher or an instructed participant. Thus, we obtained evidence of embodied coupling between the student and tutor: The tutor’s perception is as if it regulates the student’s action. While de facto it is the student who conducts the movements, the tutor enacts these movements in their imagination thus anticipating student’s progress in learning and sensing her micro-zone of proximal development. This coordination between student’s action and tutor’s perception allows us introducing intersubjectively distributed perception-action system that evolves in the teaching/learning process.

Shall this be a local phenomenon of particular activity under the particular lens? We argue that this theory-methodology-design bundle does not limit generalization of the findings: The phenomenon of an intersubjectively distributed perception-action system is made spatially articulated due to the design settings, visible through dual eye-tracking methodology and understood under the light of Vygotsky’s theory of irreducibly collaborative teaching/learning. Finally, it becomes influential far beyond particular experimental settings just like the phenomenon of diffraction of light and its dual wave-particle nature goes far beyond the settings in which it was spotted.


