Tracing Bodies Through Liminal Blends During Play-Based Inquiry in a Mixed-Reality Environment

Danielle Keifert, Noel Enyedy, Maggie Dahn, Christine Lee, and Lindsay Lindberg
keifert@ucla.edu, enyedy@gseis.ucla.edu, maggiedahn@gmail.com, clee@labschool.ucla.edu, lindsay.lindberg@ucla.edu
UCLA

Joshua Danish, University of Indiana, jdanish@indiana.edu

Abstract: We demonstrate how a Mixed Reality (MR) environment supported blending semiotic resources with embodied representations of water particle motion. Our analysis demonstrates the importance of a) providing a rich set of resources, b) the centrality of the body as a sensemaking resource, c) supporting students in iterative inquiry, and d) helping students to transition from unique classroom resources like MR into more normative accounts.

Introduction

We explore iterative cycles of inquiry within a Mixed Reality (MR) learning environment to examine how students used their bodies to develop an understanding of water particle behavior relating to states of matter. In progressive symbolization, learners iteratively refine and re-represent ideas to deepen understanding (Lehrer & Schauble, 2006) during which representations gather meaning through use and its relation to other representations (Hall, 1995). We traced students' evolving understanding by documenting how they leveraged multiple resources (the semiotic ecology; Enyedy, 2005). A blending framework was particularly powerful as it helps map lamination of virtual semiotic resources onto material structures like embodied activity to support unique forms of reasoning. We examined the (de)construction of these blends over time to examine the role of the body as representations are taken up and transformed over inquiry cycles. We claim a) students actively blend semiotic resources together to create meaning and b) throughout inquiry cycles and re-representing, material resources may go *underground* (become no longer materially present; Wertsch & Stone, 1999). However, c) resources that go underground are still implicated in practice and are recoverable when current representations and practice are not enough.

Methods

We analyze data from the Science through Technology Enhanced Play (STEP) project (Enyedy, Danish, & DeLiema, 2015). STEP is designed to privilege embodied inquiry by using OpenPTrack MR technology (Munaro, Horn, Illum, Burke, & Rusu, 2014) to follow students' movement and communicate it to a simulation that is projected (Figure 1, left). The visualization shows students as particles (yellow dots) with colored-rings determined by the state of matter students collectively make (red for gas, blue for liquid, white for solid).

We use interaction analysis (Jordan & Henderson, 1995) to analyze lessons from one first and second grade classroom. We identified a consistent pattern—iterative cycles of inquiry—in students' interactions as they explored out how particles behaved by noticing and proposing potential *recipes* to explore—verbal directions for how to move their bodies to produce a particular reaction in the MR visualization—and moved over time towards proposing the testing of rules (Figure 1, right). We examine *how students use bodies to create and refine liminal blends as they develop rules for states of matter during collaborative embodied inquiry?*

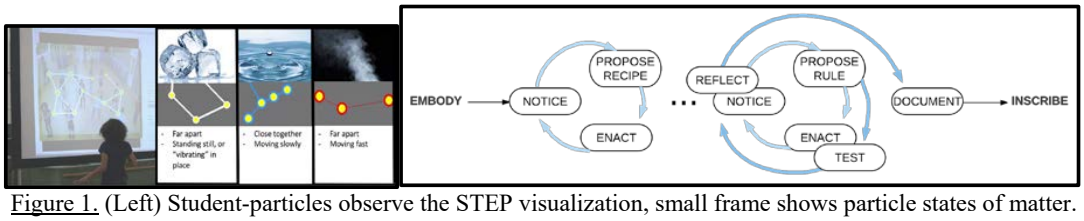

Figure 1. (Left) Student-particles observe the STEP visualization, small frame shows particle states of matter. (Right) Students' iterative cycles of inquiry.

Findings

Students embodied experience remained important throughout inquiry and after inquiry. Early cycles of inquiry consisted of proposing and enacting a recipe "move fast," followed by students' movement (students running), and students narrating "I'm red" illustrating the lamination of representational forms. During discussion, Cora, a

 © ISLS

student, drew upon her own and classmates' bodies to re-enact related rules for red which Ms. Jones inscribed in documentation as "close to somebody + far from somebody else". The body no longer played a material role in this representation, but the phrasing nonetheless was based on prior embodied experience. Thus, while the body and the STEP visualization had gone underground, they remained representationally present. In later cycles of inquiry, students tested and confirmed rules for making gas, once again laminating the STEP visualization's representations (particle, color, attraction lines, state-meter) onto their movement with the explicit purpose of affirming their rule for making gas. Cycles of pushing semiotic resources underground (moving from embodied activity to gesture to written representation of embodied activity) and resurrecting resources (e.g., making sense of current embodied activity by drawing upon documentation) continued throughout inquiry, and afterwards. During her post-interview, Sarah, a student, struggled to accurately remember how water particles behaved in each state of matter until she was asked to embody particulate motion herself. Sarah explained her understanding to the researcher in reverse, to stand still to make gas. However, when Sarah was prompted to stand up and show a solid particle *with her own body* and explain her motion, Sarah quickly revised her response. She explained by describing what happened on the screen ("vibrating in place" but "staying in one place"). It was not until Sarah embodied being a particle again and was asked to explain her movement as a particle, that she recovered her understanding of solid and gas particles' motion.

Discussion

By combining students' embodiment and programmed-rules for making states, the STEP simulation provided feedback to students that allowed them to engage in iterative cycles of inquiry as they developed ideas or recipes for making states of matter. Each iterative cycle supported students to articulate rules for particle movements. Because students become particles themselves, they developed an understanding of the rules for states based on their own embodied experience. These representational forms, starting with the embodied experience and STEP visualization of student-particles, were progressively built upon and coordinated with new representational forms through inquiry, discussion, and documentation (Enyedy, Danish, & DeLiema 2015). These blends might re-appear across several sequential cycles of inquiry before the representational forms and semiotic resources were deconstructed and blended in new ways. However, the body was *central in forming these representational understandings.* Thus, even as students moved from embodied to inscribed representations of rules for making states of matter, the experience of *being* water particles and *moving* like water particles was codified in students' representations. Furthermore, the body was recoverable when words were not enough (Lindberg & Danish, in preparation); when students struggled to make sense of new ideas or prior experience, their bodies became resources for conveying understanding.

References

Enyedy, N. (2005). Inventing mapping: Creating cultural forms to solve collective problems. *Cognition and Instruction, 23*(4), 427-466.

Enyedy, N., Danish, J. A., & DeLiema, D. (2015). Constructing liminal blends in a collaborative augmented-reality learning environment. *International Journal of Computer-Supported Collaborative Learning*, *10*(1), 7-34.Goodwin, C. (2013). The co-operative, transformative organization of human action and knowledge. *Journal of pragmatics*, *46*(1), 8-23.

Hall, R. (1995). Exploring design oriented mathematical practices in school and work settings. *Communications of the ACM*, *38*(9), 62.

Lehrer, R., & Schauble, L. (2006). Scientific thinking and science literacy. In R. W. Damon, K. Lerner, A. Renninger, & I. E. Sigel (Eds.), Handbook of child psychology, 6th edition, (vol. 4). Hoboken, NJ: Wiley.

Lindberg, L., Enyedy, N., Danish, J. (in preparation). *When words are not enough: What students gestures and embodied responses tell us about understanding science through dance.*

Munaro, M., Horn, A., Illum, R., Burke, J., & Rusu, R. (2014). OpenPTrack: People tracking for heterogeneous networks of color-depth cameras. In IAS-13 Workshop Proceedings: 1st Intl. Workshop on 3D Robot Perception with Point Cloud Library, Padova, Italy.

Wertsch, J. V., & Stone, C. A. (1999). The concept of internalization in Vygotsky's account of the genesis of higher mental functions. *Lev Vygotsky: Critical assessments*, *1*, 363-380.

Acknowledgements

We are immensely grateful to the teachers and students of the UCLA Lab School who engage so joyfully in STEP. We are also thankful for the entire collaborative teams at UCLA REMAP and the STEP teams at UCLA and Indiana University. We also wish to thank the National Science Foundation (grants # IIS-1628918, # IIS-1522945).