Title
Enabling and understanding embodied stem learning

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Enabling and Understanding Embodied STEM Learning

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Abstract: Theories of embodiment offer challenges to educational research and practice in ways that could potentially both reveal and support processes of teaching and learning in populations otherwise underserved. In particular, we focus on the 2017 conference theme *Making a Difference: Prioritizing Equity and Access in CSCL* by sharing with the CSCL community our varied approaches for designing learning contexts that provide diverse students movement-based experiential entry points to STEM content. In our pursuit, we recognize that core content notions may initially emerge for students through participating in problem-solving activities that complement traditional verbal and symbol sign systems with corporeal–dynamical modalities. Drawing on our workshop participants' research goals, we will facilitate activities oriented on grasping key ideas for theory, methods, and design.

Perspective

Embodied cognition offers learning scientists new perspectives on design, research methods, and learning theory. Embodied cognition is growing in theoretical importance and as a driving set of design principles for curriculum activities and technology innovations for STEM education. The central aim of this workshop is to attract engaged and inspired colleagues into a growing community of discourse around theoretical, technological, and methodological developments for advancing the study of embodied cognition and STEM.
This workshop focuses more precisely on three aspects of embodied cognition and STEM:

1. Rationale

An important consideration in embodied cognition for STEM is the interplay between disciplinary STEM content and theoretical apparatus (e.g., supporting physics vs. engineering learning may have different constraints). Embodiment offers a powerful alternative way of framing the interplay of subject matter content for education and learning theory. One way it does this is by identifying STEM notions and systems of notation (e.g., diagrams and symbolic formalisms) as shared physical experiences rooted in our common physiology, such as articulated hands (gestures), bilateral organization (symmetry), stereoscopic vision (perspective), and ambulation (navigation in 3D space). Abstractions in math, science, engineering, and art arise from these common experiences as grounding forms of lived, phenomenological experiences, rather than transcendent idealizations. In sum, we highlight the importance of bringing novel approaches to the critical area of STEM education.

2. Design Frameworks and Technical Instrumentation

We are also interested in the nitty-gritty details behind designing and analyzing interventions and classrooms with embodied cognition as the driving theory. A variety embodied interventions for STEM learning have recently emerged, using devices like digital dance mats (Fischer, Link, Cress, Nuerk, & Moeller, 2015), motion capture technology (Nathan & Walkington, in press; Smith, King, & Hoyte, 2014; Trninic & Abrahamson, 2012), touch screens (Ottmar, Landy, & Goldstone, 2012), mixed reality simulations (Enyedy & Danish, 2015; Lindgren, 2015), global positioning systems (Hall, Ma, & Nemirovsky, 2015), and video game consoles (Williams-Pierce, 2016). We acknowledge the enormous amount of design work that goes into creating embodied STEM interventions, in particular as this is a recent, rapidly developing area with an extremely limited knowledge base. Designing learning environments for embodiment necessitates designs for motor and sensory systems that are not merely perceiving and acting *in service of* cognition, but *as* cognition. Environments with these design considerations attend to the ways new forms of enactment of our body-minds register with our learning objectives (Abrahamson & Bakker, 2016).

3. Equity

Embodied cognition calls for expanded ways of assessing knowing and learning, as it looks to nonverbal conceptualizations, and challenges assessment practices that disengage and penalize body-based ways of expressing and communicating (such as computer-based typing). This workshop will focus on ways in which the CSCL community can widen definitions of learning to encompass new environments, methods, and ways of demonstrating understanding. We believe that this widening will also support the CSCL and broader communities in perceiving knowledge in learners that may otherwise go unnoticed and un-valued. This is relevant given the importance of promoting achievement for students from many ethnic backgrounds, geographic regions, and socioeconomic circumstances. There is a need to articulate evidence-based findings and principles of embodied cognition to the research and development communities who are looking to generate and disseminate innovative programs for promoting STEM learning through embodiment.

Audience

The intended audience for this workshop is CSCL attendees who are looking to expand the notion of learning to further provide for body-based action and communicative gesture, as they struggle to account for certain learning phenomena that are generally analyzed with spoken and written language as the primary assessment orientation. We are also aiming for researchers who are conducting STEM research with an embodied cognition perspective, or are new to the field but interested in better accounting for components of embodied cognition within their STEM work. In particular, we anticipate attendees who wish to engage in hands-on activities that support learning about the practicalities of doing embodied cognition research and analysis in STEM.

Event Description and Schedule

This workshop is designed as a full day event crafted around the participants' interests, as determined through the online application. Participants will be asked to state: which of the STEM fields have they conducted research in, and which they are interested in; what their previous experience with embodied cognition is; what aspects of STEM and embodied cognition research they are particularly interested in learning more about (e.g., coding gesture data; coding multimodal discourse and video data; designing embodied technology interfaces such as iPads or Kinect, etc.); and whether they have artifacts or research goals they would like to contribute to.

The workshop will be designed based upon the collective responses from the application form. For example, if a participant who has become newly interested in embodied cognition would like to examine their previously collected data through a new lens that places value upon nonverbal communication, and other participants indicate interest in coding that type of data, we will organize an activity around analyzing those data, with guidance from the appropriate workshop organizer(s) to assist in developing a productive small group. Another example might be a participant who has a research question they would like to design a learning environment around – and others who would like to experience the process of designing learning environments for embodied STEM experiences. We have a strong team who can facilitate these types of experiences, as well as provide data, research questions, and design challenges if the applicants are unable to do so. We also anticipate the following broader areas of interest may emerge: how supporting STEM learning through movement can increase more equitable participation in STEM fields; the "Internet of Things" (physical and digital blending), and how it might influence learning across people who are not co-located; the role of haptic feedback (or lack thereof); the role of communicative gestures in revealing learning; the design-based research cycle when designing for embodied cognition and STEM learning; and designing embodied coordination spaces that explicitly construct and provide access to connections across and between representations.

Proposed schedule:

- 8:30 am: Welcome; Quick framing of the workshop; Organizers' introductions
- 8:45 am: Minute Madness – each participant presents 1 slide about themselves in 1 minute
- 9:15 am: Demonstration activities – the organizers will provide three different examples of STEM activities designed to support embodied learning (for example, Candace Walkington will demo a motion capture Kinect game for learning geometry), and participants will rotate through
- 10:00 am: Break
- 10:15 am: Participants will be organized into small groups based upon their application forms, and engage in their first hands-on workshop
- 12:30 pm: Lunch/break
- 1:30 pm: Participants will be organized into different small groups based upon their application forms, and engage in their second hands-on workshop
- 3:30 pm: Break
- 3:45 pm: Participants will convene in small jigsaw groups and share what they learned and did thus far.

The groups will be designed to be cross-cutting in thematic way, likely by STEM content group, so that those interested in Science, for example, can share their workshop experiences and discuss the application of what they learned to embodied cognition science research

- 4:45 pm: Small groups will share out to the whole group, and discuss ways to continue as a community after CSCL. Participants will discuss their research interests moving forwards related to embodied STEM, discuss opportunities for cross-institutional collaboration on educational research, create a list of research questions they are interested in exploring, and discuss inter-relations among different participants' interests
- 5:30 pm: Conclusion

As a narrative illustration of a participant's experience, we present a short vignette. Meet Jordan, a hypothetical assistant professor who studies engineering education, and is in the midst of developing a professional development (PD) course for high school engineering teachers. Jordan has read Nathan et al.'s (2013) article, and is looking for the opportunity to discuss how *threading through* could be supported in PD contexts.

Jordan's application asked for hands-on experience analyzing multi-modal gestures in video data, and that is the first workshop they are assigned to. Another participant brought data of a dyad playing a video game together, and hands out a single page handout that introduces the framing of the study the data is from. Two of the organizers facilitate the workshop, discussing different approaches to analyzing the data. For example, analyzing the gesture without sound, first, so the focus is purely on the physical gestures, then analyzing the sound without the video, then combining the two, so that physical gesture and verbal language are each given equal weight in the analysis. Another method focuses on the digital actions within the game itself, and treats those actions like gestures. The workshop participants are split up into small groups that each take a different method of analysis to the same video clip, and guided by an organizer. After hands-on analysis, the groups come back and discuss their impressions of the data, and the group as a whole discusses how the different approaches influence what is revealed in the data. Jordan leaves the workshop with a specific plan for analyzing the PD data, and an understanding of what that approach will privilege in the data.

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