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# Movement, Authority, and Knowledge: Examining the Relationships in Embodied and Social Positioning for STEM Learning

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**Abstract:** This symposium explores the empirical relationship between two theoretically distinct uses of the construct of *positioning* in the learning sciences. To do so, it brings together different studies that examine teaching and learning in STEM classrooms that incorporate both embodied and social aspects of positioning. These examples contribute to answering the question: How does simultaneously considering students' and teachers' embodied movements and social positioning offer new insights into studies of STEM classroom learning? Together, these studies show how different types of positioning are tightly related to one another, suggesting that more research is needed to understand the complex relationships between the physical, social, and epistemic positions in research and design of learning environments.

## Introduction

Research in the learning sciences has used the construct of *positioning* in a variety of forms to understand teaching and learning in classrooms, often using theoretical perspectives of individual cognition or the sociocultural practices of the classroom community (Cobb & Bowers, 1999). Two common uses of the construct of positioning include embodied cognition, which foregrounds the individual cognition perspective, and social positioning, which foregrounds the sociocultural perspective. Research on these different forms of positioning has previously been separate from one another, taking up one perspective or the other.

Embodied cognition theorizes that human reasoning, no matter how abstract, is ultimately rooted in sensorimotor experience. Past research in this tradition highlights the role of *physical* positioning in teaching and learning. Findings in this area suggest that bodily movement is often inextricably linked to understanding and communicating concepts in algebra (Walkoe, 2015), geometry (Roth & Thom, 2009), chemistry (Flood et al., 2015), and physics (Lindgren et al., 2016), among others. Currently, researchers are using the principle of embodiment to design novel activities that promote mathematical (e.g., Abrahamson et al., 2020) and scientific learning and engagement (e.g., Danish et al., 2020; Lindgren et al., 2016).

In contrast, research on social positioning situates learning as occurring within the context of complex social and interactional dynamics of a classroom. Research from this tradition takes up the idea of positioning *metaphorically* in relation to teaching and learning. As such, this research investigates teachers' and students' social and epistemic roles in interaction in terms of framing, identity, authority, agency, and power. Researchers using this lens have found that opportunities for student learning in STEM classrooms may be afforded by curricular design through redistributed epistemic agency (Ko & Krist, 2019) or constrained by social and epistemic authority assumed by teacher and peers (Langer-Osuna, 2016).

 

While each perspective offers distinctive views of learning, the notion of position, both physically and metaphorically, is central to embodied cognition and social positioning research. Education researchers have begun to ask questions across these traditions while investigating teaching and learning in K-12 STEM classrooms. For instance, how might a teacher's physical position and movement within the classroom space contribute to shifts in the epistemic framing of tasks? (Kelly, 2020). However, research that meaningfully integrates positioning across cognitive and sociocultural theoretical perspectives remains rare. We argue that this integration is important for understanding and designing for learning in STEM classroom environments that account for these connected aspects of positioning.

This symposium brings together research on learning and teaching in STEM classrooms that investigates positioning by integrating multiple perspectives. Collectively, we acknowledge embodied aspects of thinking and acting, while also recognizing the role of interaction in teaching and learning. Individually, we each offer a unique way in which we bring together notions of embodiment and social positioning through theoretical framing and methodological considerations. The session will begin with introductory remarks followed by the presentation of five papers, described below. Then, our Discussants, Dr. Soo-Yean Shim and Dr. Robb Lindgren, will co-lead a discussion around the question: How does simultaneously considering students' and teachers' embodied movements and social positioning offer new insights into studies of STEM classroom learning? Ultimately, this symposium will advance the field of learning sciences by envisioning possibilities for new lines of research that better integrate these distinct traditions through theoretical and methodological bricolage (Cobb, 2007).

## Who gets to hold the counting cubes?: Exploring authority relations among peers during collaborative struggles in K-2 mathematics

Jennifer Langer-Osuna, Rosa Chavez, Jim Malamut, Faith Kwon, Emma Gargroetzi, Kimiko Lange, and Jesse Ramirez

Student-led collaborative mathematical activity involves relationships of power. Relational power among peers, such as status (Cohen & Lotan, 1997) and authority (Langer-Osuna, 2011, 2016), can shape not only who participates and in what ways (Wood, 2013), but also the nature of the mathematical discussions (Esmonde & Langer-Osuna, 2013), the construction of a mathematical solution (Kostopoulous, 2014; Langer-Osuna, 2016), and the development of identities as learners (Anderson, 2009; Bishop, 2012). Yet, the study of relational power in peer-led collaborative learning has been relatively small.

The early elementary years is a time of both introduction to schooling and significant changes in children's socio-emotional development. Studies of how young children come to dominate social situations reveal both prosocial and coercive ways they garner influence with peers (Bohart & Stipek, 2001; Hawley, 2002; Ostrov & Guzzo, 2015). Ostrov and Guzzo (2015) found that the most influential children were the ones who readily shared with others and did so in the absence of a teacher directing them to do so. These findings suggest that the construction of influence among peers can both promote or disrupt possibilities for productive and equitable collaborative learning, depending on the strategies deployed. More disruptive forms of domination serve to marginalize peers rather than regulate shared activity (Langer-Osuna, 2011).

The social construction of influence or marginalization in collaborative learning, in particular, can help to illuminate the processes by which students come to build mathematical knowledge, while accounting for issues of equity. We draw on the Influence Framework (Engle, et al., 2014; Langer-Osuna, 2016), which posits that influence arises from the social negotiation of: (a) the conversational floor and (b) interactional space, (c) the perceived merit of ideas and behaviors, and (d) being positioned with authority. We apply this framework to illuminate young learners' relations of power and how they shape collaborative mathematics learning activity. This paper focuses, in particular, on key moments of interactional struggle and makes visible the sources of authority students drew on to influence the actions of their peers.

This study is situated within a broader Research-Practice Partnership between a university research team and an instructional team of five teachers at an elementary school in Northern California that served predominantly bilingual Latinx and Pacific Islander students. The goal of the broader partnership was to support teachers in implementing student-led collaborative mathematical activity, using the Contexts for Learning Mathematics (CFL) instructional units (Fosnot, 2007) as a curricular resource (see Table 1). The teachers involved in the study worked to create classroom contexts in which students were expected to author and evaluate mathematical ideas and to share this authority with one another productively and inclusively.

We focus on a total of 22 videos of student-led table work across three K-2 classrooms (see Table 1). The research team (authors) created analytic content logs of each video at the 5-minute level, focused in particular on describing student talk, bodily orientation and gaze, and distribution of resources. Each video was content

 

logged by two researchers and reviewed by the entire research team in iterative rounds of discussion and development. We then identified all moments of interactional struggle and inductively coded the struggles by type, resulting in the following categories of struggle: students' access to: (a) materials, (b) the conversational floor, and (c) interactional space, as well as struggles around (d) roles and (e) task expectations. We then coded all moments of struggle for (a) their named source (i.e., teacher, other adult, self, peer) and (b) the response to the directives (i.e., taken up, ignored, resisted).

Table 1: Data Sources and Classroom Context by Grade Level

| Teacher | Grade | Unit | Number of Videos |
|---|---|---|---|
| Ms. Bene | Kindergarten | Bunk Beds and Apple Boxes | 7 |
| Ms. Kim | 1st | Bunk Beds and Apple Boxes | 10 |
| Mrs. De Waal | 2nd | Double Decker Bus | 5 |

Preliminary findings show that drawing on adult sources of authority tended to constrain or dismantle collaboration, while drawing on student sources of authority supported sustained engagement through resolution of interactional struggle. For example, during partner work in a kindergarten classroom, two students were working together when one decided that the other partner should be doing the work, and threatened to tell the teacher that he was behaving inappropriately, resulting in the partner ceasing to participate entirely and folding his body into himself on the desk. In a first grade classroom, one student challenged his partner's authority after a series of slights, to which she responded by singing the lines, "Gonna find out who's naughty and nice," resulting in the student shifting away from the partnership both intellectually and physically. These examples show how students' deployment of adult authority through the perceived threat of getting in trouble can overpower peer resistance and shut down possibilities for shared work. In a second grade small group, one student positioned as slow and hindering completion of the task by his peers consistently resisted his peers' directives by claiming his own competence and right to learn, which sustained his engagement in the task through interactional struggle.

## Teachers' awareness of student multimodal thinking

Janet Walkoe and Margaret Walton

Teacher noticing/ teacher responsiveness has been a focus of math and science teacher learning for the past decade (e.g., Sherin, Jacobs, & Phillip, 2011; Robertson, Scherr, & Hammer, 2015). Working to elicit, attend and interpret the disciplinary substance of students' ideas have been identified as important aspects of teaching. Not only do these practices support student inquiry and learning, it is an activity that is productive for teacher learning (e.g., Franke & Kazemi, 2001). The majority of the work on teacher noticing has foregrounded teacher noticing of student's spoken and written ideas. One example is in video club work (e.g., van Es & Sherin, 2008; Walkoe, 2015). Video club PD involve teachers coming together (usually with a facilitator) to discuss classroom video clips. Video clubs have been effective in supporting teacher noticing of student thinking, in particular, because the video allows teachers to discuss a classroom scene. The video allows teachers to watch and discuss a common classroom scene. In the majority of video club work, teachers watch the video and are given a written transcript of the video to use as reference during the discussion of the student thinking they noticed in the video. The use of a transcript largely focuses teachers' attention to student thinking that is expressed verbally. While this has been productive, the work on student learning makes explicit the role of gesture, action, and other multimodal thinking (e.g. Hall & Nemirovsky, 2012). For instance, gesture can be used not only to communicate student thinking but to help children make sense of ideas (Roth & Thom, 2009). Attending to multimodal student thinking opens up learning opportunities for students in one-on-one tutoring situations (e.g., Flood et al., 2015) and in classrooms (e.g., Shein, 2012). For this reason alone, we should include multimodal thinking when discussing teacher noticing, though it has not been the primary focus thus far. In addition, recent work on multimodal teacher noticing (MMTN) (Walkoe, Williams-Pierce, Flood, & Walton, in progress) has found that when teachers attend to students' gesture in mathematics PD, they also shift the types of questions they pose from a focus on math facts to more open-ended, resources-based questions.

In this talk we will demonstrate how student gesture and action can be deeper windows into their thinking in the classroom. We will present a short video clip to demonstrate student geometric and algebraic thinking that is visible primarily through gesture and action.

We will then provide an example of a video club that was designed to utilize a video annotation tool (www.anotemos.com) to support teachers' noticing of multimodal student thinking. This was the first time the teachers participated in a video club and we found that their discussions about student thinking were productive

and consistent with what we have seen in more advanced video club work. In particular, the teachers took time discussing specific instances of student thinking, as opposed to jumping around from idea to idea. Additionally, they delved deeply into the student thinking they noticed and the discussions were substantial. In prior video club work, we have not seen these rich ways of discussing student thinking until further into the video club sessions (e.g., Walkoe, 2015). The video tagging format also seemed to support teachers in noticing a range of student thinking, including thinking expressed through gesture.

Finally, we will discuss work in progress, that continues to investigate the effectiveness of video clubs designed to support MMTN and the connection between a multimodal focus on teacher noticing and the richness of teacher noticing and video club discussion.

## Social positioning in collective embodied models in an elementary STEM classroom

Nitasha Mathayas, Joshua Danish, Xintian Tu, Mengxi Zhou, and Morgan Vickery

In this paper, we examine the collective embodied activity of students in an elementary science classroom to explore how their dynamic movement within the classroom shifts their social positions as knowledge creators. A core focus of our research is on collective embodied learning: how students' collaborative embodiment of scientific concepts acts as a physical and conceptual tool that mediates their collective efforts to construct understanding about the phenomena they are modeling (Danish et al., 2020). Our research is framed within Cultural Historical Activity Theory as we see classroom learning as inherently sociocultural and imbued with cultural and historical meanings that influence how teachers and students learn in interaction (Engeström, 2018). A key element of this is *social positioning*, which describes how joint interaction dynamically positions participants in different roles during activity, and highlights how these roles are imbued with differing levels of power to make epistemic decisions, even when participants are not consciously aware of them (Davies & Harré, 1990; Miller et al., 2018). In this paper, we explore how first and second-grade learners' knowledge building activities in a mixed reality environment were shaped by their constantly shifting physical and social positioning as they explored states of matter at the particulate level.

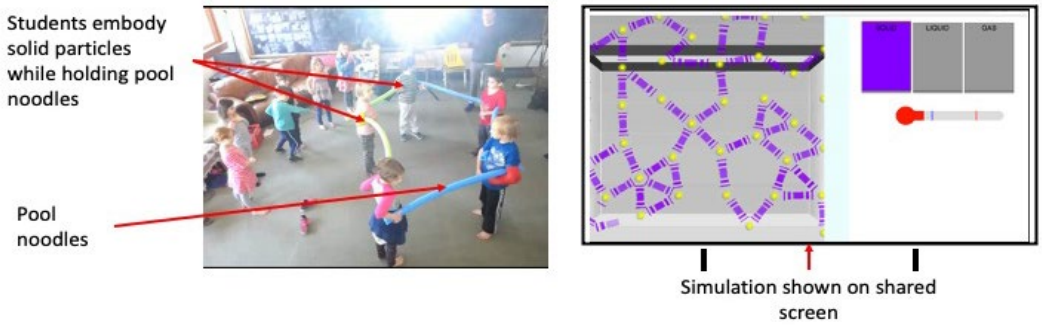


Figure 1. Students-as-particles embody a solid (ice) while holding pool noodles to represent bonds between them. The instructors and other students observe the group and the simulation.

Our current analysis focuses on a seven-day unit about energy and states of matter using a mixed reality simulation called Science through Technology Enhanced Play (STEP; Danish et al., 2020) that was implemented in a mixed first and second grade classroom in a private school in an urban Midwestern city (Tu et al., 2020). STEP lets students explore the relationship between particle behavior and states of matter by collectively enacting how they think particles respond to different amounts of energy and simultaneously observing their movement as molecules in the simulation (see Figure 1). In the unit, students explored different characteristics of molecular movement and intermolecular bonds by acting as molecules and using props such as foam pool noodles to support their collective enactment. Using methods of interaction analysis (Jordan & Henderson, 1995), we analyzed video recordings of the classroom interaction and the simulation across the unit and focused on how students' social and physical positions changed and influenced each other.

Our analysis shows how movements within the collective model simultaneously impact and are shaped by the current social positioning that those very same movements appear to help construct. For example, the instructors shifted at times from taking a "typical" directive teacher role standing outside the model offering suggestions, to actively participating as a particle in the space. When they were in the external teacher role, students tended to listen attentively to them. However, as soon as students began moving, the teachers' role as "external" to the model was reified as the learners oriented toward each other and the projected simulation,

 

limiting the impact of the teacher on their collective modeling until they paused. This led the students to explore their own ideas about particle behavior in-the-moment, and the teacher was limited to helping them reflect on those realizations after-the-fact. Similarly, when one teacher joined in the model as a particle, they began by offering suggestions about the model that led the students to move in response, however, as the students began moving, the teacher also reacted to their motions, creating a more equal footing as the group acted in coordination, and began to recognize underlying patterns in particle movement.

Taken together, these different forms of interaction show how it is impossible to separate the social role of movement within embodied modeling practice from the knowledge building role of that same movement. The continuous movement of participants has cascading effects on their collective embodiment and social positioning. Thus, it is important for educators and designers who aim to leverage whole-body embodied learning to think about the unique way that physical positioning contributes to social positioning that in turn promotes or constrains embodied agency within these contexts.

## Revisiting positioning: How a teachers' physical movements amplify socio-epistemic messages in the classroom

Susan Kelly and Christina Krist

This paper uses both physical and epistemic positioning to track how a teacher's talk and physical movement support students in knowledge building. Students come to understand expectations relative to knowledge building and their role in the process through the interactional routines that occur in the classroom. They pick up how they are expected to respond based on how a teacher frames the environment and the kind of ideas the teacher gives space to in the classroom (e.g., Scherr & Hammer, 2009; Russ & Luna, 2013). A teacher conveys these ideas through the *epistemic messages* they send that emphasize what kind of knowledge counts and how students are expected to participate (Russ, 2018). Because these messages are continuously communicated through teacher and student interactions and are dynamically negotiated moment-to-moment, they work as *socio-epistemic messages* that guide how students interact with each other and with the ideas they are constructing in their work together (Kelly, 2020). In this paper, we explore how Mr. M, an experienced teacher who enacted reform-aligned science instruction, used his physical positioning to amplify and emphasize the discursive socio-epistemic messages he communicated during an eighth-grade science class.

Focusing on one socio-epistemic message, we describe how Mr. M uses his physical movements to amplify the message *Everyone's Ideas are Valued* he communicated (Kelly, 2020). This message conveyed to students that their ideas were important and that their contributions were taken seriously. To do this, Mr. M often used metadiscursive affirmations like "Great idea" or "That's cool" in response to their ideas. He also encouraged students to go public with their ideas by asking students to speak loudly so their ideas would be heard by the classroom community. He also emphasized making ideas public by revoicing their thoughts or by asking students to revoice their peers' ideas.

This video case was drawn from a larger project that investigated middle school students' participation in science knowledge building practices. In our analysis, we examined 15 video recordings of lessons taken from the beginning, middle, and end of a multi-day Earth science unit that investigated the movement of the Earth's plates. The students, who were ethnically and economically diverse, were initially reticent to engage collectively in the intellectual work at the start of the unit, so Mr. M was actively working to develop a classroom community that would encourage their participation as agents in their own learning.

Using a grounded approach, we conducted video analysis to characterize how Mr. M positioned students to do the knowledge building work by tracking his talk and physical movement. To do this, we completed a line-by-line analysis of whole group discussion to identify the epistemic messages Mr. M conveyed (see Kelly, 2020 for additional detail). Concurrent with this analysis, we created a multimodal transcript describing Mr. M's physical movements during each class. Within this transcript, we identified moments with an obvious or dramatic shift in physical position. We then compared whether particular physical movements coincided with the coded epistemic messages and documented these patterns and relationships in analytic memos.\We identified three distinct patterns of physical movement that Mr. M used in conjunction with the message *Everyone's Ideas are Valued.* Each of these movements served to amplify the message, albeit in different ways. We provide a brief example of each. First, one pattern of physical positioning involved Mr. M *moving away from the speaker* while verbally positioning them with intellectual authority. For example, during a discussion in which students were sharing initial ideas, Mr. M acknowledged a student, Vanessa's, idea was interesting and then moved to the opposite side of the room while asking her to repeat her idea in a louder voice. A second pattern involved Mr. M *moving toward the speaker* to emphasize their ideas. In this case, Mr. M moved toward speaker while simultaneously revoicing that speaker's idea to emphasize or clarify it. For example, after Jason shared his idea

 

about how tectonic plates converged, Mr. M moved toward Jason to make sure he was imitating Jason's hand gesture for convection correctly and if he was revoicing his idea accurately. Finally, while Mr. M rarely stood at the front of the room during class activities and instead moved around the room, he would often *move to the side of the speaker(s*), effectively positioning students to take on the intellectual work by physically and discursively giving them the floor. Sometimes Mr. M would sit at or on a table with the rest of the class while students drew and discussed their ideas at the board. In these instances, he physically positioned himself to as member of the community, rather than an authority.

Taken together, Mr. M's physical positioning, moving *away from*, *toward*, or *to the side* of the student(s) speaking served to amplify the socio-epistemic message, *Everyone's Ideas are Valued,* he was communicating discursively. He encouraged students to "go public" with their ideas and act with agency. He reinforced this notion by using physical movements to increase the "airtime" for student's ideas, so their ideas could be examined, critiqued, and modified by the classroom in their knowledge building endeavors. Showing how discursive and physical positioning work together to laminate the socio-epistemic messages conveyed in the classroom is an important consideration for educators who are, knowingly or unknowingly, continuously sending messages about learning to their students.

## Making space for joint exploration: The embodiment of social and epistemic positioning in student-teacher interaction

Erika David Parr, Nessrine Machaka, Elizabeth B. Dyer, and Christina Krist

Across reform efforts in mathematics education is an emphasis on involving students productively in the intellectual work of the discipline. Often, this involves re-negotiating the roles and authority structures typical in school contexts in order to position students and teachers as partners who are jointly exploring disciplinary questions (Scardamalia, 2002). This re-negotiation is both social and epistemic: it is a marked shift from classroom structures in which a teacher holds the majority of intellectual and social authority.

In order to better understand how joint exploration of ideas between students and teachers as partners is established and maintained through interaction (Keifert & Stevens, 2019), we analyzed an episode in a secondary mathematics classroom in which a teacher responded to a student's wondering. We adopt the theoretical framing of positioning (Davies & Harré, 1990) to consider social and epistemic authority, while also foregrounding physical positioning in our analysis. The focal episode comes from a dataset of classroom video of teachers who were developing responsive teaching practices in secondary mathematics. We view responsive teaching practices as pedagogical tools that build on students' ideas, wonderings, and sensemaking; accordingly, the use of such practices requires that teachers establish and maintain moments of joint exploration with students. We selected one teacher, Rachel, as prior analyses demonstrated that she consistently used responsive teaching practices (Dyer & Sherin, 2016). Using "joint exploration" as a sensitizing concept (Blumer, 1954), the research team reviewed Rachel's videos from 10 100-minute class periods to identify potential episodes for close microanalysis.

Figure 2. Four physical positions of the teacher (from left): Position 1- standing upright, Position 2- leaning back, Position 3- standing, leaning over table and Position 4-standing leaning over table with head down

In this paper, we present our microanalysis of one identified episode of "joint exploration" in order to begin to elucidate social, epistemic, and physical patterns around how such explorations are established and maintained. In this episode, Rachel, interacts with two students who are seated next to each other, James and Steven. We analyzed Rachel's physical positions throughout the episode and found that Rachel assumed one of four positions, shown in Figure 2. To analyze social positioning, we considered a person to assume social authority when giving a social directive that was followed by others in the group. Similarly, we analyzed epistemic (intellectual) authority by considering whose mathematical ideas were proposed and taken up by the group.

From this analysis, we identified a strong relationship among physical, social, and epistemic positioning in establishing and maintaining joint exploration of a mathematical idea. Of the 10 shifts in Rachel's physical

 

position in the interaction, 9 were associated with a shift in her social and/or epistemic authority. Conversely, no shifts in Rachel's social or epistemic authority were observed without a shift in physical position. Further, we found that shifting between certain positions often coincided with certain epistemic or social moves.

To illustrate this phenomenon, we focus on one shift in physical positioning (from position 1 to 2; see Figure 2) and describe the change in epistemic positioning that served to ***establish*** joint exploration. We argue that this shift involved a concurrent release of epistemic authority by Rachel and an uptake of epistemic authority by James and Steven. As James asked the teacher a question about whether there is "a natural log that is equivalent to e" while "messing around with [his] calculator" and looking up at her, Rachel restated James' question, paused, stepped back, and shifted from physical position 1 to position 2. The question appeared to catch Rachel off guard, as she did not provide an immediate response. Rachel then remained in position 2, leaning back, as she tried to understand James's question by asking clarifying questions. Steven then intervened to affirm Justin with "I mean yeah, cuz it'd be a power" to which Justin replied "of e, right?" leading to a discussion between Steven and James with little feedback from Rachel. Notably, Steven and James arrive at a solution to James' question that they were both satisfied with, without any affirmation from Rachel.

During this episode, Rachel's shift backward created space, both physically and metaphorically, for James and Steven to take up the intellectual authority within the conversation. Through our analysis of an episode that contained joint exploration, we found that shifts in the teacher's physical positioning were highly correlated with shifts in social or epistemic positioning within the group. Furthermore, patterns have begun to emerge among certain positions and their associated shifts in authority and interactional dynamics. We illustrated one such shift here, demonstrating how a particular shift in the teacher's physical positioning, coupled with verbal and other interactional dynamics, served to create space for students to take up intellectual authority. These findings suggest that shifts in a teacher's physical positioning may be a strong indication of changes in social or epistemic positioning and/or are an important part of conveying social and epistemic messages. We offer the suggestion of triangulating physical, social, and epistemic positioning to develop in-depth analysis of how authority is negotiated to establish and maintain moments of joint exploration in mathematics classrooms.

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