Assessing Young Children's Cognition through Multi-Modal Interviews

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Abstract: Designs that leverage embodiment argue that embodiment supports students' cognition and learning. However, it is unclear how we might assess the role of embodiment in supporting student learning as compared to other modes of expression, such as verbal or visual. Furthermore, computer-supported learning activities that rely upon embodiment may be best evaluated with measures that allow students to continue to embody their knowledge during assessments. Our study presents early efforts to understand how embodiment might support or hinder 2nd graders' expressions of states of matter (N=18). Results indicate that when students are less familiar with content or provided fewer details in other modes of communication, embodiment provides an alternative way to express their understanding. Moreover, the intervention familiarized students with how to use embodiment to express themselves which led students to yield responses which were just as nuanced as other modes of communication.

Keywords: embodiment, assessments, multi-modality, young children, interviews

Introduction and background

Embodiment, including both gesture and whole-body activity, plays a critical role in cognition and learning (Goldin-Meadow, 2004; Smith & Gasser, 2005). It is particularly valuable when students are less familiar with a topic (Radford, 2009) and in early elementary classroom contexts where a high level of physical activity is already commonplace. As a result of these findings and ongoing technical innovation that support embodied interfaces, educational technologies are increasingly incorporating embodiment as a central component of their designs (Lindgren & Johnson-Glenberg, 2013). However, it is not yet clear how we might effectively use these different modes of communication in evaluating young children's understanding of science content such as states of matter, where assessment is typically based on students' drawings and/or talk (cf., Paik, Kim, Cho & Park, 2004; Smith et al, 2006).

This paper reports on initial efforts to explore the different ways that 2nd graders expressed their understanding during semi-structured interviews both before and after an intervention, which centered on how embodied modeling with motion-capture technology supports the learning of states of matter (Danish et al, 2015). We analyzed how different multimodal opportunities may encourage or hinder students' articulations and examined the extent to which embodiment as a mode of communication can support students' early articulations of unfamiliar concepts. Given that students were embodying particles in different states of matter, we expect that students will be better able to ground their ideas or knowledge in the physical space by using their bodies (Alibali & Nathan, 2012). Moreover, given that gestures reflect a child's readiness to learn and consequently improve learning (Cook, Mitchell, & Goldin-Meadow, 2008), we expect that whole-body activity can encourage students who are less familiar with the content to better able to express their ideas and consequently increase their use of embodiment to demonstrate their understanding in the post-interviews.

Methods

Participants and data sources

Four groups of students aged seven to eight (12 males and 6 females) from a mid-western public school participated in this study. Using motion capture technology, these students worked with two teachers and learned about the particulate nature of matter and the role of energy as a causal mechanism in state changes (Danish et al, 2015). Over the course of three days, students engaged in role-play involving a narrative centered on water in various states, embodied particles and modeled how energy would impact these particles (for further details, please see Danish et al, 2015). These activities leveraged embodiment and dramatic play; encouraging students to use their positions and motions in the physical space to depict themselves as particles, which are then displayed on-screen. Pre-post interview analysis for conceptual understanding indicated that all of the students developed a more robust conception of states of matter (ibid). This paper reports on a secondary analysis of the pre-post semi-structured interview video data to understand how different modalities supported students' articulation of the particulate nature of matter and changes of state.

Assessing student understanding

To examine student understanding, we analyzed students' verbal and non-verbal responses, and developed a coding scheme structured around particle behavior and the relationship among energy, particle behavior and state changes. We began with a priori codes focusing on the underlying principles behind students' characterization of boiling and melting (both state changes) from Paik, Kim, Cho, and Park (2004). After several iterations of applying our initial codes, two sets of ordered codes were finalized and applied to all pre-post interviews (see tables 1 and 2). We targeted increasingly nuanced descriptions of matter (from observable properties to particle behavior) and types of causal mechanisms involved in change of states (from simple descriptions to articulating the relationship among energy, particles and state changes). Students' propensity to use embodiment was not assessed, although the teachers commented that students were used to physical and role play in both in class and out of class activities.

Table 1: Summary of the matter-type codes for conceptions of matter

Codes	Illustrative examples
MT1: Observable characteristics of matter	It's just stacked up, ice is hard, water can just sinks down to the bottom but ice has to stack.
MT2: Understand that matter is conserved	Really it's the same amount as this picture from that picture, cause it melts.
MT3: Initial discussion of particles (includes incorrect articulations)	The particles are frozen... on a hot day it melts the particles can't handle that much coldness.
MT4: Accurate discussion of particles (no incorrect articulations)	They [water] move a lot, medium fast, not like (makes whizzing-like noise), that would be gas.

Table 2: Summary of the change-type codes for causal mechanisms in changes of state

Codes	Illustrative examples
CT1: Superficial description of state change	Water changes into ice.
CT2: Some mechanism involved	It [The glass shaking] sorta rocks me around.
CT3: Energy or temperature as mechanism	Energy made me [particle] move faster.
CT4: Particle behavior as mechanism	Gas [particles] coming together a little bit more [to make liquid].
CT5: Relates energy to particle behavior and state change	Well, there has to be snow or something like that to get it cooler, and get the energy not flowing as much, so they [particles] move a little.

Examining student responses to different modalities

The interview protocol included a series of questions, which differed in the modality of response that they requested. This sequence of questions focused on how students explained the behavior of particles in various states of matter. Students were first asked a) what particles look like; then b) were asked to embody a particle in a liquid state, and c) directed the interviewer as the interviewer embodied a state transition. The first two questions were coded using as matter-types while the last question was coded as a change-type. Given that the content was not coded similarly, we inspected the codes to select cases where students initially responded with "I don't know", or were not codable in the verbal question, but later provided a more nuanced description when asked to embody or direct the interviewer. Selecting these cases allowed us to explore how students who do not appear to have initial ideas about the content or seem less familiar with it, respond in the subsequent questions. We also supplemented the analysis of interview data with videos of the intervention to determine how specific embodied activity might have carried over into the post-test. After examining these initial cases, we analyzed the remaining cases to explore how all the students responded to the three questions.

Findings

Using embodiment to share nascent ideas

Findings indicate that when students are less familiar with the content, embodiment allowed them to demonstrate their understanding. We present an example of a pre-interview with Jonah who initially responded that "it (water particles) would turn to ice" when asked about how particles would behave in a liquid state.

Excerpt 1: Student's embodied response to query on how particles behave in liquid state in pre-interview

	Transcript	Embodiment
1	The little specks of water	[makes specks with right hand]
2	would turn into…	[joins both hands together]
3	they would um…	[drops left hand down, and then brought it back up again]
4	they would like	[forms hands together again]
5	turn into ice	[moves hands apart from one another in a straight line]
6	and make the water still	[moves hands together and then apart]

Jonah continued to add that the sun played a role in the change from solid to liquid, all the time gesturing while articulating his thinking. When asked to embody what he meant, Jonah's response was richer and more detailed. At first, he used his right hand to represent particles (line 1), later using both hands to depict more than one particle (lines 2-4) and then further illustrating how these particles might arrange themselves in a straight line to form ice (lines 5-6). In Jonah's case, gesturing appears to allow him the time to gather his thoughts and facilitated his attempts to share his ideas. Jonah's gestures indicate some awareness that particles arrange themselves in a particular way to form ice, although he may not have the disciplinary sophistication to illuminate his idea further. In his post-interview, Jonah was able to articulate and embody an initial conceptualization of particle movement in a liquid state. He correctly moved around to embody particle movement and explained that "they (particles) move around pretty fast". Even though Jonah's characterization of particle movement in water is inaccurate (particles move around faster than in solid, but slower than in gaseous state), his gestures were not as hesitant, and more immediate and direct.

However, not all students chose to use embodiment to articulate their thinking. Seven students across both pre and post-interviews (four in pre, three in post) opted not to embody when asked to by the interviewer. Out of these, two made initial attempts but then expressed that they did not know how to embody, whereas the others declined to embody when asked by the interviewer. We contend that this could be due to students' lack of familiarity with both content as well as embodied ways of explaining their ideas prior to the intervention. Instead, some students opted to visually represent their ideas when we provided them with this opportunity in the interview (e.g., drawing a picture), demonstrating that students will default to familiar modes of expression. However, in the post-interviews, students readily used embodiment to explain themselves. 75% of the students embodied responses that were just as detailed as their verbal answers, with one student providing all details in his embodiment since his actions activated his thinking about the movement of particles. In the case of this student, the fact that the intervention supported embodiment as means of expressing one's understanding was critical in ensuring that he was able to access what he had previously learned.

The value of directing embodiment

In the seven instances where students opted to not embody, they were still willing to direct the interviewer, which then provided more insight into their thinking. Take for instance, Nigel, who initially declined to embody his explanation. He had explained that "they (particles) liquefy", paused and then added "I don't know" when asked about how particles behaved in a liquid state. Subsequently, when asked to embody, Nigel shook his head and said no. When the interviewer asked him to direct her actions, Nigel both demonstrated and verbally provided instructions to the interviewer on how to act like particles behaving in a liquid state (lines 1 and 5).

The changes in the particle movement were both demonstrated by Nigel first (e.g., lines 1, 9) and these utterances were mimicked or clarified by the interviewer. Nigel presented how he imagined particles act when they liquefy, demonstrating his assumption that particle movement mirrors the macro descriptions of matter (lines 5 and 9). Thus, his conception of particle movement is further nuanced in this sequence. In the post-interview, Nigel began to embody particles with no hesitation, moving around in a circle slowly to indicate particle movement, indicating that the implementation offered embodiment as more salient means of expressing understanding. This example also illustrates that asking students to direct embodiment could be more useful to illustrate student thinking than asking students how to embody when students are less familiar with not only this type of expression, but also the content.

Excerpt 2: Student directing interviewer as particle behaving in liquid to solid in pre-interview

	Speaker	**Transcript**	**Embodiment**
1	Nigel:	Um, you should go like this	[moves from his chair and squats on the floor facing the interviewer]
2	Interviewer:	Like this?	[mimics student and squats on the floor]
3	Nigel:	Yeah.	
4	Interviewer:	Uh huh.	
5	Nigel:	And then sorta move your arms around you because water is wavy.	[sit back down in his chair]
6	Interviewer:	Ok.	[waves arms around]
7	Nigel:	And then you'll change slowly to get less wavy	[gets up, hunches over and hangs his hands]
8	Interviewer:	Yeah, less wavy?	
9	Nigel:	Less wavy and start slowing down.	[droops over]
10	Interviewer:	Slowing down.	[mimics drooping over]

Conclusions and implications

Our findings suggest that interviews that incorporate embodiment can offer an alternative way for students to articulate their thinking, above and beyond what is originally offered in more traditional-interview formats. This is especially so when students do not include sufficient details in one mode of expression, are unfamiliar with how to express new content, and unfamiliar with using embodiment to express understanding. Furthermore, our results suggest that experience with embodiment as a form of representation leads to increased use of embodiment in post-test interviews. This suggests that there is value in teasing out when and how learning with embodied technologies supports transfer into more traditional assessment contexts.

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