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Signs of learning in kinaesthetic science activities

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Abstract

The study addresses how students use communicative signs (e.g., speech and gesture) to shape and develop cognitive schemas during a bodily exploration of force and motion in a physics teaching-learning activity. We see 'the experiential gestalt of causation' as a cognitive element that may be used to couple an embodied experience of physics with the language of physics through dialogue. We propose that kinaesthetic learning is a way of integrating a bodily experience into a formal system of signs, in this case, force and motion in physics, but ask: to a teacher or researcher, what signs exist that students use bodily explorations to construct meaning and understanding from kinaesthetic learning that is relevant to school physics? To answer the question, we employ a semiotics perspective to analyse data from a 1-hour lesson for 8-9th graders which introduced students to kinaesthetic activities, where they used rope to pull each other in a linear and circular motion. The activity was centered on questions that guided their kinaesthetic inquiry which related to force and velocity (e.g. "do you always move in the same direction as you are pulled?") and Newton's third law (e.g. "who pulls the most?"). The analysis is conducted by searching the data to find episodes that illustrate student activity which can serve as a sign of the object that the 'experiential gestalt of causation' is employed in the construction of the intended learning outcome. In essence, we study a chaotic but authentic teaching-learning situation involving school children in order to detail situations that can reasonably be construed as evidence that students learn.

Extended summary

Relevance to science education research

The study addresses how students use communicative signs (e.g., speech and gesture) to shape and develop cognitive schemas during a bodily exploration of force and motion in a physics teaching-learning activity. We see the experiential gestalt of causation' (Andersson 1986) as a cognitive element that may be used to couple an embodied experience of physics with the language of physics through dialogue. We refer to this interplay between dialogue, cognition, and bodily exploration as kinaesthetic learning, and we analyse teaching/learning situations using Peircian semiotics (cf. Peirce 1991). We ask: to a teacher (or researcher), what signs exist that students use bodily explorations to derive meaning and understanding from kinaesthetic learning that is relevant to school physics?

A kinaesthetically grounded perspective suggests that designing activities for teaching and learning physical concepts, such as force and motion, through bodily experience is likely to bridge everyday to analytical understandings. Furthermore, since Andersson (1986) has argued that 'the gestalt structure of causation' may be at the root of most of school physics, kinaesthetic learning activities (KLAs; Wolfman and Bates 2005) that target this structure seems a promising new avenue of research.

Significance for theory and practice

We propose that kinaesthetic learning is a way of integrating a bodily experience into a formal system of signs, in this case, force and motion in physics. We analyse this integration in terms of signs that an experiential gestalt of causation (Andersson 1986) is employed by students to develop physics concepts and consider kinaesthetic experiences combined with dialogue as a way to facilitate the development of abstract/analytical concepts. The gestalt of causation, analogous to Ohm's p-prim (diSessa 1993), can be described by an agent providing energy which flows to an object: The more energy the larger the effect.

Theoretically, this study adds to the embodied perspective by applying Peirce's (1991) semiotic sign-object-interpretant relations as a tool for analysing learning situations. Peirce embraces the fact that we do not have access to the truth about what students gain from engaging in teaching and learning. What we do have access to, is what students do when they learn. Thus, our aim is to identify situations in which student action indicates student learning and make explicit the inferences needed for a teacher to provide necessary formative feedback to students (Black and Wiliam 2009).

Framework

Teachers base feedback on the signs they observe. To Peirce (1991), signs could appear when students enact kinaesthetic models. Signs are understood through an *object* (here: employing the experiential gestalt of causality), but such an object is only accessible through teachers' inference of the meaning of signs, or *interpretant* (how the observed behaviour is taken to indicate that students are employing the experiential gestalt as intended). Object, sign, and interpretant exist only by and of each other. In our context, *students' use of 'experiential gestalt of causation' to structure their experiences with pulling one another* (object) exists qua *our interpretation* (interpretant) of *their enactment* (sign).

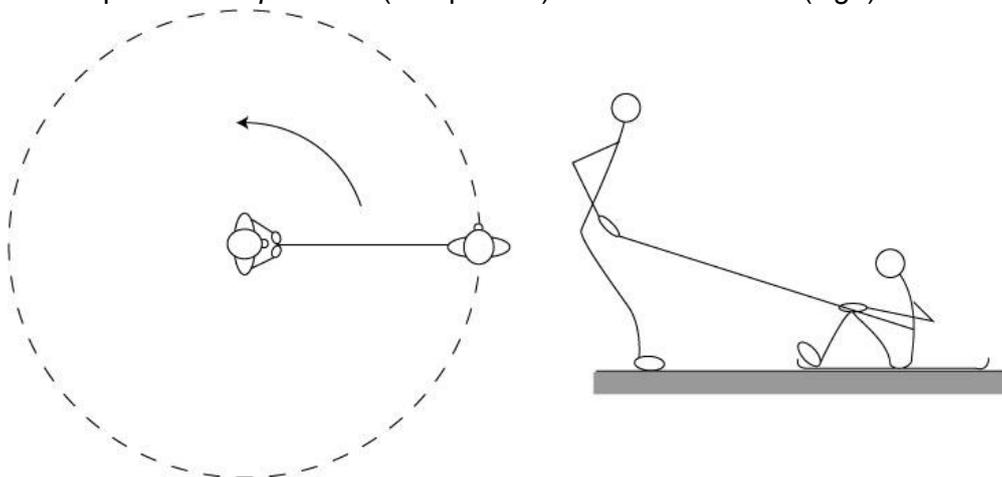


Figure 1. Schematic drawings of students enacting two different kinaesthetic activities

Furthermore, the interpretant is another sign of the object, which may lead to another interpretant. This could happen when a teacher uses his/her inference, say that a student has felt a force acting, to prompt a student to show where a force is acting in a given enactment. Then the prompt is that which gives meaning to the inference (sign), and thus is a new interpretant. The student's interpretation of the prompt (now sign) give rise to an answer (interpretant), which is then a new sign for the teacher - and so forth. Through this interaction, the teacher may continuously infer how and the degree to which the object (that students are learning kinaesthetically) exists in this situation. It is important to recognise that

the object remains a potential (Peirce 1991) that might become increasingly likely as signs of learning conform to our intentions. This interpretation is consistent with Peirce's early idea that every interpretant is itself a further sign of the signified object. In short: we take the *object* to be particular aspects of didactical knowledge that *a priori* tells us what conditions are required for learning to take place; the *sign* to be the brute, unfiltered actuality of an event; the *interpretant* to be the intention in or with any given situation. Together, these make up what we would consider evidence that students learn what we intended to teach.

Research method and design

Data was collected during a 1-hour lesson for 8-9th graders which introduced students to kinaesthetic activities, where they used rope to pull each other in linear and circular motions (see Figure 1). The activity was centered on questions that guided their kinaesthetic inquiry which related to force and velocity (e.g. "do you always move in the same direction as you are pulled?") and Newton's third law (e.g. "who pulls the most?").

The lesson was implemented at two different schools ($N \approx 60$ /implementation). In each lesson, one author acted as instructor and was assisted by 2-3 science teachers, while the other author was in charge of data collection (video and audio).

The analysis is conducted by searching the data to find episodes that illustrate student activities which could potentially serve as signs of the object that the 'experiential gestalt of causation' is employed in the construction of the intended learning outcome. We then propose an interpretant that warrants the degree to which sign and object correspond. The result is a sign-object-interpretant relation, which we use to argue the extent to which students derive meaning and understanding from these kinaesthetic learning activities.

Findings and conclusions

Here we present one instance of our construction of a sign-object-interpretant relation. We observe a student who is pulling at a rope with one hand, while using her other hand to



Figure 2: Sign of kinaesthetic learning

sense how her upper arm muscles flex as she leans into the pull.

The video shows the student discussing with her peer while performing this act. The reason this act is selected as a sign of learning is that it appears meaningful in light of our intention to relate bodily experiences with forces. Figure 2 illustrates this *sign*. Our *interpretant* is that the student is discovering how and where a force acts on her. The *object* is the potential held by the 'experiential gestalt of causation' to expand a student's understanding of Newtonian forces. To all purpose and intent, this student thus appears to be learning (an aspect of) what was intended. To gain further assurance, or to further what appears to be a dawning experience with Newtonian forces, the teacher would need to engage in conversation with this student.

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