Describing Multiple Conceptual Stabilities during Collaborative Learning Activities

THE UNIVERSITY OF MAINE
Physics Education Research Laboratory

Brian W. Frank, Physics Education Research Laboratory, University of Maine, Orono, ME 04469

Supported in part by **NSF** Grants REC-0440113 and REC-0633951

Motivation and Focus

One concern for science education researchers is to better understand the various ways that students come to participate in collaborative learning activities in science classrooms.

Researchers seek to understand how various forms of participation shape many aspects of learning, including

- The quality of students' developing scientific understandings
- The quality of students' subsequent participation in science
- The identities that students form as learners and scientists

Researchers also seek to understand the ways in which setting, past experience, and interpersonal interaction shape local forms of participation.

This poster focuses on issues of student understanding during a single Tutorial session, and the mutual influences that arise among students' understanding, their behavior, and artifacts.

Some themes you might care to talk about

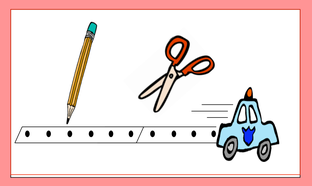
How student understanding changes over short time scales

How artifacts constrain student behavior and thinking

The complexity of collaborative activities as context(s)

A Collaborative Learning Activity about Motion

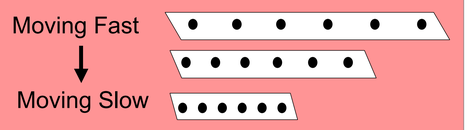
A Modified Tutorial[7] about Velocity Concepts using Tickertapes



Questions students discuss:

How do the speeds compare?

How do the times compare?



The strips of tickertape are cut into equal intervals of time (i.e., six dots)

Some Theoretical Anchoring

In contrast to conceptions-based approaches[1], knowledge-in-pieces approaches[2] have largely focused on describing the diversity and contextuality of student thinking. Students' thinking, however, often exhibits stabilities that can be local to particular times and settings.

How do we make sense of the various local stabilities of student understanding within the dynamic contexts of collaborative activity?

To answer this question, patterns of student thinking are analyzed in terms of their substantive, material, social, and behavioral aspects. This approach involves fine-grained analyses from cognitive, situated[3], embodied[4], and distributed approaches[5]. Drawing from dynamic systems approaches[6], the entire system is conceptualized as consisting of many interacting elements, which need not have causal priority in explaining system behavior.

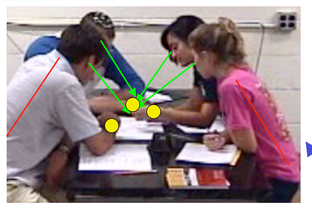
References

1. See for example, Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accomodation of a scientific conception Toward a theory of conceptual change. *Science Education, 66*, 211-227.
2. See for example, di Sessa, A. A. (1993). Toward an Epistemology of Physics. Cognition and Instruction,10(2/3), 105-225.
3. See for example, Greeno, J. G. (1989). A perspective on thinking. *American Psychologist, 44*(2), 134-141.
4. See for overview, Pfeifer, R. and Bongard, J.C. (2007). *How the body shapes the way we think: a new view of intelligence.* Cambridge, MA: MIT Press.
5. See for example, Hutchins, E. (1995a). How a cockpit remembers its speeds. *Cognitive Science: A Multidisciplinary Journal, 19*(3), 265 - 288
6. See for example, Thelen, E., & Smith, L. B. (1993). *A Dynamic Systems Approach to Development.* Cambridge, MA: MIT Press.
7. McDermott, L. C., Shaffer, P. S., & the Physics Education Group at the University of Washington (1998). *Tutorials in Introductory Physics.* Upp Saddle River, NJ: Prentice-Hall.
8. Hammer, D., Elby, A., Scherr, R. E., & Redish, E. (2004). Resources, framing, and transfer. In J. Mestre (Ed.), *Transfer of Learning: Research and Perspectives.* Greenwich, CT: Information Age Publishing.

An Initial Understanding in One Context

Students' initially think the distance is an indication of the amount of time.

The students have arranged the strips side by side, in order by length, at the center of the table.



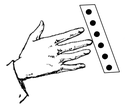
The students' gaze, bodies, and hands are oriented to the materials located at the center of the table.

S3: Obviously it takes less time to generate the more closely spaced dots.

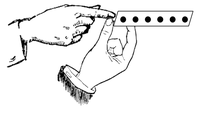
S1: So you are saying it takes less time to make the shorter segments?

S3: You can tell because it's a shorter distance
S2: It's a shorter segment.

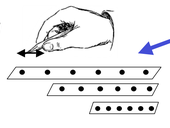
S1: There's like more little things in the same



S2: It's like the same amount of dots in a shorter piece



S2: I think they all have six dots.
S4: Is that true? 1,2,3,4,5,6, *[pointing to dots]*



S2: So it's a shorter amount of time for a shorter piece of paper

In the abbreviated transcript above, we see students attending closely to features of the strips. In discussing these features, the students draw on various ideas, including part-whole relationships (density of elements) and spatio-temporal relationships (less distance implies less time). There is evidence that each member of the group shares much of these ideas in constructing a shared understanding.

Material and Behavioral Interactions

The strips located at the center of the table establish a stable focus for sustained and repeated attention.

With the strips in hand, students move the strips both to explain ideas and get each others' attention.

Situated cognition[2] approaches emphasize ways in which objects and settings constrain and afford certain kinds of actions.

Social and Substantive Interactions

Joint attention to shared objects may promote resources for noticing, describing, and comparing patterns.

Mutual attention may promote resources involved in explaining and listening to complex ideas

Resources and Framing[8] is one approach that emphasizes how subtle social cues tell people about what kind of activity is going on.

Behavioral and Substantive Interactions

Deictic gestures may promote the use of resources for thinking about objects relationships and patterns.

Iconic gestures may promote the use of resources for thinking about motion and cause and effect.

Embodied cognition approaches emphasize ways in which knowledge is intricately woven with our bodies and physical action

Material and Substantive Interactions

The strips arranged in order by length off-load some of the cognitive task of comparing to the setting.

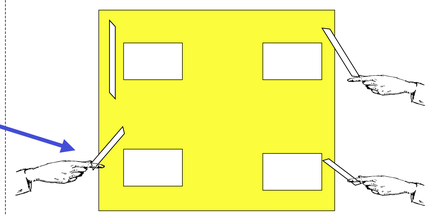
The strips and other objects used as props off-load some of the task of visualizing physical mechanisms

Distributed cognition[5] approaches emphasize how non-humans can engage in cognitive tasks that are integral to a functioning whole.

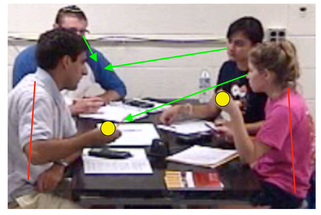
Both patterns of understanding exhibit stability, persisting on the order of minutes and resisting perturbing influences. While some aspects of their activity are largely ephemeral, other aspects leave traces within the system that continue to influence behavior and reasoning over time. It is difficult (if not impossible) to know *a priori*, which aspects of current activity are consequential to later ones without the kind of close analysis that is represented here.

Later Understanding in a Different Context

Students later think that the distance is an indicator of the speed of the strip



The students have separated the strips. Each has one in hand.



The student are upright and mutually attending to each other

S4: I think we also assumed in the that these were made by the speed at which the paper traveled through the tapper which was different for each paper….We're assuming the rate it was going through is different.

S1: Right, cause if you move it really fast then

S3: That's true! It could depend on how fast the ribbon was pulled

S3: It's like if each mark is being made a 1/40th of a second then they are all going to have the same number of marks

S4: We're assuming that umm..

S3: That the length is proportional to

S4: The speed at which the ribbon was pulled through

In the abbreviated transcript above, we see students discussing physical actions involved in making the strips. In doing so, they draw on different ideas than before, including causal relationships (between pulling and motion), and kinematical relationships (between speed and distance). Although the students' thinking is now 'correct', they continued to struggle reconciling these two different substantive understanding over much of the tutorial.