Analytical Designs: Goodwin's Substrates as a Tool for Studying Learning

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Abstract: Charles Goodwin's legacy includes a multitude of analytical tools for examining meaning making in interaction. We focus on Goodwin's *substrate*—"the local, public configuration of action and semiotic resources" available in interaction used to create shared meanings (Goodwin, 2018, p. 32), gathering early career scholars to explore how research designs adapt substrate as an analytical tool for education research in diverse settings. This structured poster session examines how substrate can be used to capture a complex web of learning phenomena and support important analytical shifts, including representing learning processes, privileging members' phenomena to address issues of equity, and understanding shifting power relations through multi-layered and multi-scaled analyses.

Session overview

Through interaction, humans create meaning with and for each other, drawing on prior experience and building new understandings and possibilities. Applied linguist Charles Goodwin's legacy includes a multitude of analytical tools for examining meaning making in interaction. His book Cooperative Action explicates how people interactively build understanding by using and transforming available resources (Goodwin, 2018). These resources are the *substrate*—"the local, public configuration of action and semiotic resources" available in interaction used to create shared meanings (Goodwin, 2018, p. 32)—and the focus of this symposium.

We gather early career scholars to explore how analytical designs adapt substrate as a tool for research on learning in a variety of settings. We present two sets of analytical designs: Poster Set 1 draws upon practices, artifacts, and interactional histories as substrates, while Poster Set 2 draws upon movement (gesture, full-body, coordinated ensemble) as substrates. Both sets of analytical designs for the use of substrate shed light on how substrate is being incorporated into analysis in the next generation of researchers by addressing a set of shared questions across all posters:

1. *How does substrate influence your analytical design (i.e. setting, scale of people/places/time, materials)?*
2. *How does substrate serve your research purpose (e.g., directions for new designs, understanding learners' sensemaking, examining movement in learning)?*

By addressing these shared questions, the posters in this session show how the lens of substrate supports analytical designs that examine how participants draw on shared history and culture to create meaning out of the infinite possible meanings that could develop in interaction. Posters take up substrate in multiple ways including different:

- Contexts of interaction (e.g., professional learning settings, formal classrooms, informal programs)
- Material substrates (e.g., land, video, talk, movement)
- Scales of analysis (e.g., within a conversation, over a few days, across years)
- Functioning forms of substrate (e.g., sedimented past substrate, in flux, influencing future action)

Preliminary findings from this collection of work illustrates that substrate as an analytical tool captures a complex web of learning phenomena in ways that support important transformations and variations in analytical designs and, in turn, research findings. Taken together, these posters suggest advances in the application of substrate to education including:

1. Matching research contexts to relevant semiotic modalities (e.g., touch in anatomy courses and dance, gesture in physics, movement in dance and science, code in programming camps, video and movement in research apprenticeship courses) supports representing learning processes in more authentic and endogenous ways; that is in the ways that participants use in their collaborative meaning-making.
2. Privileging members' phenomena (Sacks, 1967/1992) by focusing first on participants' meaning-making and *then* researchers' meaning-making in relation has implications for equity in research, including orienting researchers towards more endogenous understandings that better represent participant experience in participant's own terms rather than exclusively through the powered lenses of researchers.
3. Examining multi-layered and multi-scaled substrates supports *understanding* and *shifting* power relations (a) in settings (e.g., teachers/learners), (b) in participant/researcher relations (c) and with materials (e.g., participants/researchers/land, participants/researchers/code).

Conversation in the session will explore these implications in broader education research.

The session chair will begin with a brief overview of the session and the lens of substrate (5 min) before each team will introduce their posters (1 min each / 10 min). There will be two poster visiting sessions, each 20 minutes long (40 minutes total), during which half of the posters present. Our discussant, Rogers Hall, will share thoughts on the use of substrate across the posters (15 minutes). The remaining time (20 minutes) will be for discussion amongst all presenters and attendees, guided by the discussant and focusing on implications for further shifts in analytic designs in future learning sciences research.

Poster set 1: Artifacts, practices, and interactional histories as substrates

Temporal and geographical features of programming substrates: Navigating code structure, behavior, and function during debugging

David DeLiema, Geetanshi Sharma, Jesslyn Valerie, Alexis Cabrera, and Sophie Smith

Goodwin (2018) describes how participants in interaction position semiotic resources in *specific locations* (e.g., gestures coupled to objects) and modify resources *over time* (e.g., words added to prior phrases), creating substrates that anchor upcoming communication. In computer science, programming interfaces are substrates that encompass *location* and *time* in three ways (see Figure 1): (1) *code structure* entails locations of and changes to typed commands; (2) *code behavior* describes the temporal execution of code; (3) and *code function* describes, for example, an avatar's movement over time. This work builds on Cunningham, Guzdial, & Ericson's (under review) extension of the SBF framework to programming (cited with the authors' permission).

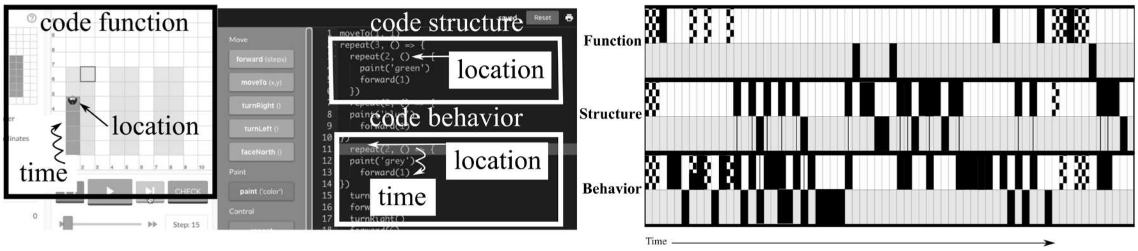

Figure 1. Coding substrate (at left). Conversation analysis of teacher (white bar) and student (grey bar) debugging, tagged for individual (black), co-occurring (connected), and polysemous (checkered) statements.

Our interaction analysis research took place in three-week summer coding classes (M-F; 75 minutes per class) in PixelBots (see Figure 1, left). We recorded classrooms with tabletop GoPros and video-and-audio screen recordings. Four researchers clipped and categorized 82 distinct debugging interactions involving first-time (late elementary/middle school) programmers (*n*=20) and experienced instructors (*n*=6). With multimodal transcripts, we documented individual, co-occurring, and polysemous (or ambiguous) references to structure, behavior, and function per turn-construction unit in conversation between dyads.

In some cases, instructors comprehensively integrated functional, structural, and behavioral features (see Figure 1, right, for an analysis of a 2m 19s conversation); in other cases, coding instruction foregrounded one over the other. Whether interactions exclusively foregrounded code structure (e.g., "I erased it" or "Do we have to add more to our function?") or wove together S, B, and F (e.g., pointing to the PixelBot movement (*code function*) while describing code: "Then (*code behavior*) I moved forward (*code structure)* ten times"), gave students markedly different windows into their broken code. Tracking how students and instructors navigate code structure, behavior, and function provides a rich window into form-function transformations (Saxe, 1991). By decomposing the categories of syntax and logic (e.g., Ripley & Druseikis, 1978) into naturally occurring practices of teachers and students during debugging, this work applies an analytical framework that can granularly track how different ways of navigating programming substrates shape student learning.

Substrate in a science classroom: Sedimentation of middle-school modeling practices

Ashlyn Pierson and Doug Clark

Scientific modeling involves the creation and revision of models—abstract relational tools that support inquiry (Gouvea & Passmore, 2017; Lehrer & Schauble, 2015; Nerssessian, 2008). Researchers have developed learning progressions to understand how K-12 students' models, practices, and beliefs shape their engagement in modeling (e.g., NGSS Lead States, 2013; Schwarz et al., 2012). Yet, these tools can background social processes of classroom learning (Pierson et al., 2017). Moreover, students' practices do not follow a linear trajectory; they are context-dependent (e.g., Ford, 2015; Manz, 2014; Rouse, 2007). We aim to understand how classroom modeling practices unfold in relation to the materials and interactions in which they are situated.

We use a *co-operative action* lens to consider how classroom practices and artifacts become part of the substrate for students' later actions (Goodwin, 2017). Goodwin (2017) and Lemke (2000, 2001) posit that such processes occur at different timescales; yet, the examples they present analyze moments of enactments of practice rather than tracing practices over time. We propose that a longitudinal analysis of modeling from a co-operative action perspective could provide insight about a social dimension of practices, serving as an indicator of health of *classrooms as scientific communities*. To test this conjecture, we partnered with an 8th grade teacher in a design-based experiment (Cobb et al., 2003). Data include students' models, reflections, and interviews and videos of each class. We analyzed data by tracing practices in relation to prior artifacts and enactments of modeling.

We find that after a practice is introduced, it can be reused and transformed in response to (1) immediate context, (2) new problems/data, and (3) other practices. Some of the students' practices sediment into the substrate as broader classroom practices, supporting and constraining learning. We propose that the extent to which practices are able to sediment into the substrate is an important indicator of the health of the classroom as a scientific community. We therefore demonstrate the importance of longitudinal analysis for understanding students' practices and illustrate how co-operative action can be used as a barometer of social dynamics.

Jokes as heteroglossic substrates in a science classroom

Sihan Xiao and Xuehui Wang

Jokes in science classrooms have long been viewed as trivial, digressing from the seriousness of science (e.g., Fisher, 1997; cf. Roth et al., 2011). Only a few recent studies explore the positive roles of jokes in learning science (e.g., Berge, 2017). Yet the moment-by-moment workings of jokes remain unclear. This study plugs a dialogic view in this scholarship and asks: what constitutes a joke, and how does it function in a science classroom?

This study relies on two ideas. The first is Bakhtin's (1981) notion of heteroglossia—the multivoiced nature of utterances. A joke is inherently dialogic, embodying various—often ridiculously entangled (Billig, 2005)—voices. Goodwin's (2018) notion of substrate further suggests that functional jokes must not only be built upon past, shared experience or understandings of the interactants, but also be "picked up" in the subsequent actions. Jokes thus are "a trove of structured materials and patterns that can be used to create something new" (p. 32). These two constructs enable us to analyze jokes at both interactional and socio-ideological levels.

Since 2017, we document a science teacher's (male, 23 years of teaching experience) argument-oriented teaching in a middle school in Shanghai, China. More than 40 lessons were videotaped, along with video-cued interviews in which the teacher and we watched and interpreted particular episodes together (Tobin, 2019). For this study, we focused on episodes of "joking around" in this classroom. Using interaction analysis (Jordan & Henderson, 1995), we looked closely at how jokes were constructed, understood, and transformed, in interactions.

We will present detailed analysis of multiple cases to illustrate three findings. First, jokes in the classroom are heteroglossic substrates: heteroglossic in that they embody a variety of resources from both local contexts and the larger social discourses; substrates in that they are simultaneously 1) the historical sedimentation of shared understandings, 2) the present transformation of previous actions, and 3) the source of subsequent actions. Second, a joke created a new power relation between the teacher and students. The teacher is challenged and students become "teasers" (Bakhtin, 1984; Gutiérrez et al.,, 1995). Third, when strategically picked up by the teacher, a joke can be transformed into a resource for teaching (i.e., a new substrate), linking the scientific with the social, and the serious with the playful. The "substrate" sheds critical light on the design of teaching in which non-academic, or even anti-academic, experience can be transformed into productive resources.

Teacher collaborative sensemaking with — and about — external conceptual resources

Nadav Ehrenfeld, Brette Garner, Samantha Marshall, and Katherine Schneeberger McGugan

Learning scientists increasingly attend to learning as distributed across environments, rather than tied to specific places (Hall & Jurow, 2015). This approach is particularly generative for research on teacher learning, which is inherently distributed across different learning environments and the classroom (Marshall & Horn, under review). In this study, we analyze teachers' collaborative sensemaking as part of a larger learning ecology. To that end, we build on Goodwin's (2018) analytical tool of substrates as a means to connect teachers' local actions to external conceptual resources. External conceptual resources — e.g., teaching frameworks, pedagogical practices, and curricular resources — travel across teachers' learning environments, including professional development sessions and collegial conversations. In this way, such resources become substrates that teachers share, modify, and repurpose, thereby creating opportunities for new practices.

For three years, we facilitated lesson-debrief conversations with secondary math teachers, aiming to support their pedagogical responsibility, pedagogical reasoning, and pedagogical action (Horn, in press). Using interaction analysis (Jordan & Henderson, 1995), we trace external conceptual resources that teachers invoke in conversation. We examine sedimented outcomes (Goodwin, 2018) of the resources, asking: How are resources introduced and taken up as substrates for new actions? What "work" do they do for individuals and the group?

We identified three external conceptual resources that frequently emerged in participating teachers' conversations: (1) the Teaching for Robust Understanding (TRU) framework (Schoenfeld, 2019); (2) the pedagogical practice of randomly grouping students; and (3) the problem-based CPM curriculum. Teachers used these resources to develop new understandings of their instructional practices. To illustrate one example: Teachers took up language from the TRU framework to articulate and negotiate their pedagogical responsibility to support students' equitable participation in class. TRU supported teachers' reflection on their teaching and subsequent re-imagining of pedagogical actions that stood to facilitate students' equitable participation. Across all three cases, we demonstrate what substrates "do" in teacher communication, how they travel across contexts, and the implications for theory and design of teachers' learning environments.

Poster set 2: Movement and touch as substrate

The embodied and relational dimensions of video as substrate

Ananda Marin, Elisa Noemí Orellana Faulstich, Clementine Bordeaux, Heather Clark, Jamie Gravell, Lindsay

Lindberg, Denise Morales, Lilia Rodriguez, and Renee White Eyes

We focus on the embodied and relational resources that shape substrates and hence transformative action in research processes (Cajete, 2005; Cruz, 2001; Goodwin, 1994, 2013; Wilson, 2008). We ask two questions: 1) How might co-designing embodied and movement-based practices for viewing video assist with generating theories that more expansively account for multiple dimensions of learning? 2) How might attending to the embodied and relational dimensions of video research shed light on researcher learning?

We draw on video recordings from a research apprenticeship course organized to support a diverse collective of graduate students interested in video research. We started with a basic premise—that how we use our bodies to view and communicate ideas about video data shapes what we can learn about the diversity of human development. In collaboration with a theatre artist, we co-designed embodied practices for analyzing video data that prioritized whole-body movement-based strategies. The source material for these sessions was video data from a research project in which Indigenous mothers and their children went on multiple forest walks.

Our co-viewing and theorizing process consisted of 5 steps. First, a facilitated warm-up prepared us to analyze video in embodied ways. Next, we viewed a short video clip of parent-child interaction. After co-viewing the video data we choreographed movement responses in small groups. We then shared our choreography to co-generate theory about the affordances of embodied practices for viewing and analyzing video data. In this context, the relationships between people and the environment, including those present in the moments of analysis, as well as those that made the research activities possible in the first place, acted as substrates for engaging in embodied co-viewing practices. Building with Goodwin's (2013) notion of co-operative action and Indigenous methodologies (Wilson, 2008) we demonstrate that action towards theorizing in this context relied on a network of substrates. Moreover, we argue that relationality is necessary for ethically engaging in theorizing from video records.

Occasioning tactile experiences for building student competence in anatomical dissection
Michael Sean Smith

Learning where to look, how to read a text document, how to manipulate a tool, or how to recognize relevant "qualia" (Chumley & Harkness, 2013) of different objects is central to the work of instruction and processes of enskillment (C. Goodwin, 1994). With the growing recognition of the embodied character of human action (Goodwin et al., 2011), comes the greater acknowledgment of the role of touch in instruction (e.g., Ingold, 2006; Råman & Haddington, in press). Acquiring manual skills involves numerous competencies, not only knowing how to use tools and work with materials, but also knowing how these should feel in one's hands. Touch, including not just fine motor movement but more so its tactile, kinesthetic, and/or proprioceptive underpinning, is thus foundational for the acquisition of any manual skill.

Building on previous work in manual skills training in dentistry (Rystedt et al, 2013) and field geology (Goodwin & Smith, in press), this study investigates the training of assistants in the dissection of cadavers in a Swedish teaching hospital. Focusing on the preparation of cadavers, i.e., the extraction of anatomical structures from surrounding viscera, I analyze the methods participants use for highlighting various tactilities of different anatomical structures. As my analysis shows, cultivating tactile understanding of different anatomical structures, is crucial to training, as the differences between different structures, e.g., nerves, veins, tendons, muscle, fat, etc., are rarely as obvious as in anatomical drawings. Manual skills training in dissection provides a unique opportunity for understanding how participants' movement, tool-use, the anatomy of the cadaver can be reconfigured into different substrates so that the learner can acquire the necessary tactile and proprioceptive skills for becoming a competent practitioner. The analytical questions pursued here include: Where does tactile experience become relevant in distinguishing various anatomical structures? What resources, embodied and otherwise, do participants use in publicly establishing that they indeed collaboratively recognize these tactile distinctions? As my analysis shows, effective instruction in this context utilizes a broader range of embodied and multimodal resources organized toward coordinating the learner's attention toward not only seeing, but feeling relevant distinctions in anatomical structure.

How physics students re-use gestures in collaborative knowledge building
Virginia J. Flood and Benedikt W. Harrer

Using ethnomethodology and conversation analysis (Garfinkel, 1967; Goodwin, 2018), we examine the different ways 12 groups of undergraduate students re-use or re-"voice" each other's gestures during collaborative knowledge building (Scardamalia & Bereiter, 1992) over three video-recorded physics laboratory sessions. We treat students' multimodal, gesture-rich contributions in small group discussions as substrates and examine how group members decompose, re-use, and transform these substrates (Goodwin, 2018) as they model physical phenomena together. Our study builds on Koschmann and LeBaron (2002) who found that medical students repeat one another's gestures to establish cohesion and agreement in collaborative knowledge building.

We found three new ways students re-use gestures, operating on the substrate provided by previous student contributions: (1) Students re-use gestures that stand in for entities or processes when groups don't have words or phrases to describe them. This allows groups to collectively reflect on aspects of physical phenomena in the absence of terminology that they have yet to develop. (2) Students re-use gestures to recast previous explanations of physical phenomena with disciplinarily specific terminology. By reproducing another student's gesture and substituting new words, students can signal that the new terminology should be seen as an alternate way of describing the same phenomenon. This helps the group achieve a central goal of the course: using physics models and concepts to describe physical scenarios. (3) Students re-use each other's gestures to articulate disagreements about physical situations. A critical part of modeling in physics is articulating assumptions and coming to agreement about what features of a scenario need to be considered. When students reproduce a previous gesture but give a different verbal description, they demonstrate that they are providing an alternative way of looking at the same situation.

To date, substrates have not been investigated in undergraduate physics. As group learning in STEM continues to gain popularity, there is a growing need to identify and characterize interactional practices learners use that make this form of instruction beneficial. This study contributes to our understanding of how learners use the substrates they make available for one another in discussion to build shared understandings together.

The push that never made sense to me: the substrate of dancers' professional intrinsic and extrinsic vision

Lauren Vogelstein and Rogers Hall

We explore *substrate* where the predominant "ingredient" is coordinated, ensemble full-body movements. We examine the professional vision (Goodwin, 1994) of two dancers as they "reset" a duet they previously performed by watching video segments and physically working on the viewed choreography. We look at verbal components of substrate (Goodwin, 2018) in relation to the felt sensations of enacting choreography to understand their conceptualizations of what movements look like from an extrinsic perspective with that they feel like intrinsically. We draw on two years of ethnographic data. Video data was analyzed using Interaction Analysis (Jordan & Henderson, 1995) to understand the multimodal parts of dancers' developing substrate.

Resetting a work of dance involves reviewing choreography to put back in one's body for a new performance. In this episode, Caroline and Faith watched a minute of choreography on video and then enacted it together until they felt prepared to return to the video and move on. They rhythmically annotated the video, commenting on movements descriptively and evaluatively. Caroline's utterances became asynchronous with the choreography as she labeled "the push that never made sense to me." Similarly, when reviewing it physically, Faith stopped in the middle marking it as a movement in need of repair (Figure 2). The dancers repaired this movement by enacting and describing how it should feel when performed together in contrast to how it should look from the outside, which led them to change how they performed the push (Figure 3).

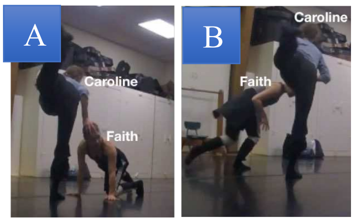

Figure 2. Faith stopped during the 1st push (A) and continued to move (B) in the 2nd.

Figure 3. Caroline's hand pushed off Faith's head (A) and then extended to give the illusion of an elongated push (B).

The substrate that supported resetting the push involved layering (1) what was viewable in the video, which was stabilized by naming parts of what was seen and felt which invited (2) remembering things that did not make sense (the push was highlighted as something to work on). This eventually lead to (3) reenactments (Vogelstein et al., 2019) in which there was a physical production of "re," "member," and "ing" through which the dancers (4) repeatedly tried out and compared sequences of co-operative action, in which each became object and process for the ensemble. In short the dancers "inhabit[ed] each others' actions" (Goodwin, 2018). In a context in which the primary components of a substrate were ensemble full-body movements, it became clear how participants jointly made sense of discrepancies between felt and visible physical experiences.

Drawing on and disrupting choreographic substrate for being scientific phenomena

Danielle Keifert, Chi Xiao, and Noel Enyedy

Classroom inquiry requires students develop shared understandings of phenomena, but what happens when students enact the very phenomenon they are inquiring about? We examine 1st/2nd graders' inquiry as they develop stabilized forms of *being phenomenon* and then draw upon them as substrate to explore scientific ideas. Students enacted being water particles to understand how the motion of individual particles determines states of matter and properties at the observable-level (e.g., standing far apart from each other and wiggling in place created solid which holds its shape and is hard, while moving slowly near each other created liquid which flows and takes the shape of its container). Because students enact the phenomenon under study, they must first successfully choreograph speed and distance to make a state before they develop ideas relating particle motion to states of matter. We ask: *how do choreographies develop, stabilize, and inform students' understanding?* We examine choreographic trajectories focusing on liquid because it proved to be the most challenging state of matter to make (because of the narrow span of relative distance and speed). We analyzed two days of video drawing on interaction analysis traditions (Jordan & Henderson, 1995).

Choreographic substrates were taken up, examined, rejected, and re-made as students made liquid. On day one, students collaboratively built choreographic substrates to make liquid. On day two, students tested these choreographies. Near the end of that day, students disrupted substrate during a call for *holding hands walking in a circle* as one student said, "No. It's working just- it's working *going slowly*." *Going slowly* was then taken up by Jesse in a call to *slow jog*, which in turn was physically transformed to *tiptoeing* by Dylan which most students joined. Disrupting *holding hands walking in a circle* and then exploring *going slowly* allowed students to engage with conceptual ideas relating particle motion to states of matter, without being confined by prior choreographies. The call to disrupt centered general ideas about speed compared with the explicit choreography of prior substrate. Both the substrates and disruptions provided key insights relating the movement of particles at the micro-level (slow, close) to successful making of macro liquid water.

This work illustrates the important role of physical, spatial, embodied aspects of the substrate created by ensembles to explore challenging disciplinary ideas (see Vogelstein et al., 2019). Once students' have established choreographies, small modifications can be productive for exploring conceptual ideas. These transformations illustrate students' thinking about key science ideas. Choreographic substrates were critical for embodiment of phenomenon and inquiry about phenomenon, and yet still disruptable for new sensemaking.

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