This document represents a hybrid of materials created when a poster proposal for NARST 2020 was to be presented, instead, as a roundtable discussion. The document contains introductory and concluding materials, including literature cited, in prose form for context and reference as needed. There are also five PowerPoint slides that were designed to be (a) displayed on a laptop during the roundtable and (b) distributed as a handout.

Bibliography
Analyzing Science Education as a “Construction Site for Science” using Latour’s Collective of Humans and Non-Humans

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Research question:
What occurs in the examination of science classroom as a “construction site for science” where we “pack the world into words”?

Method:
Analytical narrative case study on text and image artifacts from the implementation of a science curriculum. We analyze these using Latour’s concepts to provide evidence of the agency of non-humans in the collective of the classroom.

Context / Data:
Artifacts from the classroom and professional development materials and communications (emails) within a project to implement an inquiry-based curriculum in a large urban district.

Conclusions / Implications:
Latour’s work, along with related inquiries in material feminisms, is a new basis to reconfigure the constructivist / realist divide into one where participation and agency of non-humans leads to understanding their contribution to knowledge and identity construction in science education.
Concept 1: Mobilization of the World
Latour posits that “nonhumans are progressively loaded into discourse” by the process of humans “moving toward the world, making it mobile, bringing it to the site of controversy, keeping it engaged, and making it available for arguments... instead of moving around the objects, scientists make the objects move around them” (Latour 1999). This mobilization of the world is a place where humans and non-humans both participate.

Figure 1: Email report of lab preparation
“I made up the CuO / Cu mixture by taking 100 g of Cu powder and 200 g of the CuO they have. I shook it really well for about 5 minutes and it looks evenly mixed. I checked the procedure. Things work very well with mild heating needed to convert the CuO / Cu to the deep green color we expect. There is plenty of Cu powder left over and the solution can be poured off. That solution I then reacted with some of the mossy zinc. Note that the Zn reaction took over 40 minutes, so I am writing implementation notes (see next message) that suggest the teachers have the students work to the point of decanting the CuCl2 solution, then adding 1 g of Zn before letting it stand overnight.”

Analysis
This report fits with Latour’s conception of mobilization as the task of making different solutions and mixtures involves a wide variety of specific mobilization steps, also: “shook,” “heating,”, “I then reacted,” “decanting.” These actions of the human are specifically directed at bringing non-humans into positions of activity. Once mobilized, the substances become ‘controversial,’ by, for example, their apparently surprising sluggish reaction. This prompts the human to change the plan for how to implement the experiment—a different way to make the non-humans ‘move around’ the classroom.
**Concept 2: Speech Prostheses for Non-humans**
Discourse involves a production of language that can be included within arguments, but of course non-humans generally lack speech in any recognizable way. Latour seeks to solve the problem of how we “load the world into words” by pointing to the presence of discipline-specific “complex mechanism[s] for giving worlds the capacity to write or to speak, as a general way of making mute entities literate” (Latour 2004).

**Figure 2: Student instructions for lab**
1. All partners in the lab group will be able to do this experiment, but it is important for you to do this one person at a time. All partners should obtain a small 8 ounce (250 mL) plastic bag. Do not share the bags, which should be discarded when you are done with them.
2. Breathe gently into the plastic bag for 5 seconds. This is much slower and gentler than you may be used to, so be gentle.
3. Insert the CO₂ sensor into the bag. Hold the bag so that it forms a seal along the sensor. Monitor the CO₂ concentration and record the highest value you see within 30 second.
4. Repeat step (2), except this time take a deep breath...

**Analysis**
The instructions direct students in the use of an example of a speech prosthesis to examine carbon dioxide production using a sensor and different sources. The carbon dioxide appears, is gathered, detected, and recorded through the prostheses of plastic bags, a sensor, and finally an inscription. The inscription of the data, once the start of analysis by the social constructivist, is the *third* step only. Hence, the record that results is *not* solely human speech and it is certainly not solely a human construction. It is a human record of the speech of the carbon dioxide mediated by a speech prostheses in the form of a sensor.
Concept 3: Identity in the exchange of properties
The construction of identity is closely related to ontological problems and is at the heart of many questions of science education. “What is known” is dependent on “how something comes to be known.” In Latour’s collectives, identity is formed and solidified because participants exchange properties, bestowing characteristics in a social event that depends, in part, on the agency of both the humans and the non-humans.

Figure 3: Roles for project lead
From project proposal (2005): “Wink will be the lead person for the UIC subcontract, coordinating activities at UIC and supervising the Graduate Fellows program. The bulk of the course planning, instruction and professional development for Chemistry will take place at UIC, with Wink coordinating and supervising the personnel involved...”
From email at project conclusion: “I got an email from [teacher] indicating she is going to do the titration tomorrow. Sorry for not getting that clearer earlier in the week. But, I was able to get there and set up (ain't no way I want to pass up the chance to assist actually doing the lab!). Just forgot the universal indicator, but all else is set and she knows what to do...”

Analysis
These two descriptions of a university educator document how identity shifts. Using Wortham’s category of metapragramatic identity (2001), the first description emphasizes authority, management, and supervision. The second description emphasizes classroom participation in response to a teacher request and extending to assisting in conducting the lab. These changes do not occur through interactions with humans alone: In being brought into the lab, the universal indicator also bestowed on the educator the right to participate in the classroom.
**Concept 4: Circulating Reference**

Latour points to a problem for both realist and constructivist characterizations of science in the gap between the “material extremity” of the world to the “formal extremity” of language. His answer is to engage in microanalysis that shows the reversible trail by which *matter* becomes *form* for subsequent steps. If analyzed correctly, this “circulating reference” strengthens the validity and reliability of both the world and the constructions of science.

**Figure 4: Model lesson on lab experiment**
...the steps in this activity related to several concepts. The solutions that the students obtain illustrate the principles of this division of matter. These include:

- Oil-water separation...illustrates physical separation of a heterogeneous mixture, resulting in a different heterogeneous mixture.
- Sand filtration...illustrates a different physical separation of a mixture, resulting in a homogeneous mixture (evidence given by persistence of the odor).
- Charcoal adsorption...illustrates physical separation of a homogenous mixture by absorption.

**Analysis**

This excerpt illustrates how a lab develops ontological categories. Steps in a separation scheme show specific properties of non-humans that will become important ontological categories in chemistry. During instruction, oil-water separation is the *matter* that will emerge formally as illustrating *heterogeneity*. Sand filtration is the matter that illustrates the formal notion of a *homogeneity*, and charcoal adsorption is matter to illustrate separation within homogeneity. Later on, when asked for examples of these concepts, students will be able to trace a path back to the world as manifest in these steps.