Representations that Depend on the Environment:
Interpretative, Predictive, and Praxis Perspectives on Learning


Commentary by
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Suchman’s book has stirred debates over the past fifteen years that have produced both interesting work and questionable polemics. As one colleague stated, “Discussing Suchman has become something of an indoor sport around here.” Rather than revisit the various arguments, we will export Suchman’s idea that plans, and more generally representations, arise in and depend upon situated activity. We will lift this idea from its methodological roots and apply it three times, each time according to a different criterion of social-scientific knowledge. Ideally, this exercise will help us use Suchman’s idea to inform diverse characterizations of learning and instruction.

To promote her idea that plans arise in and depend upon situated activity, Suchman argues that plans are insufficient to specify situated action, and therefore, they are not the sole mechanism for producing or regulating that action. Like the legal system, there is no number of laws or plans that can possibly anticipate all the contingencies (which is why we have judges to interpret new contingencies and congres to make new laws). Suchman also raises the attendant question of how people revise their understanding when their knowledge or plans prove inadequate. To continue the analogy, when the laws of a legal system fail because of unanticipated (and therefore unrepresented) contingencies, the laws cannot easily self-correct (hence judges and congres). Suchman’s research challenge is to understand how people work with circumstances to build new plans and representations. This is one reason why Suchman’s work is relevant to education, it addresses how new understanding emerges when old understanding is insufficient.

In Suchman’s effort to explain meaningful activity, she does not reject plans all together. Instead, she advocates investigating how representations and situations co-constitute one another in activity.
To get at action in situ requires accounts not only of efficient symbolic representations but of their productive interaction with the unique, unrepresented circumstances in which action in every instance and invariably occurs. (Suchman, 1987, p. 189)

One approach to this investigation is to make “an account of the relation between planning-as-activity, the artifacts of that activity, and the subsequent activities to which those artifacts (conceptual, linguistic, or otherwise) are meaningfully related” (Suchman, 1993, p. 75). The approach of starting with activity is Suchman’s preferred method. Another approach is to examine how plans and representations are structured so they can develop in and depend upon new situations. For example, how is the legal system designed so it can respond to situations that its current laws do not cover? Or, more relevant to education, what is the structure of perception and its relationship to activity such that we can come to see what we could not previously perceive? It is possible that activity-first and representation-first approaches must be pursued by separate disciplines, or perhaps by an interdisciplinary field like cognitive science. Regardless, both methods are useful for developing accounts of “practical reasoning and action” (Suchman, 1993, p. 75), and we will pursue the latter approach here as a way to export some aspects of Suchman’s work.

Suchman set us the task of looking for the interaction between representations and “unrepresented circumstances.” Because of our emphasis on the representational side of the equation, we label this interaction “representations that depend on the environment” or RDEs for short (as opposed to something like SAGRs, “situated activities that generate representations”). We suggest the broad value of considering RDEs (while hopefully undermining some of the polemic) by showing that they hold educational significance, regardless of one’s social science preference. We do this by looking for empirical evidence of RDEs using three distinct
social-scientific orientations. The orientations we consider are interpretation, prediction, and praxis. These three crisscross the social sciences broadly (e.g., economics, sociology, geography, psychology, political science, etc.). They set different goals and criteria for social-scientific knowledge and draw our attention to different facets of education and the relevance of RDEs for learning.

THE SOCIAL CONSTRUCTION OF REALITY
AND THREE CRITERIA OF SOCIAL-SCIENTIFIC KNOWLEDGE

We recall a debate in which scholars were arguing against the funding of nuclear accelerators. Their argument was that the machines create atomic particles that only exist in the machine, and therefore the scientists were studying an artificial reality of their own creation, not nature. Whether or not this argument is valid for the physical sciences, it clearly does not apply to the social sciences. It would be strange, for example, to propose that we should not study democracy because people have created it. As scholars from Rousseau to Searle have argued, social reality is constructed.

--- Figure 1. Types of social scientific knowledge---

As a consequence of the social construction of reality, the social sciences have multiple, and sometimes competing, criteria and aims for knowledge. Terrence Cook (1994), a political scientist, offers a helpful scheme for organizing one’s thoughts about social-scientific knowledge. We present this scheme in the guise of Figure 1 which shows three primary vectors of social knowledge: interpretation, prediction, and praxis. We will explain these in turn to show the educational value of Suchman’s idea across multiple theoretical agendas.

INTERPRETATION

We begin with the interpretive tradition, because this is the umbrella under which we locate Suchman’s ethnomethodological and symbolic interactionist
approach. The noted anthropologist, Clifford Geertz (1973), provides an elegant account of the interpretive tradition in general:

Believing, with Max Weber, that man is an animal suspended in webs of significance he himself has spun, I take culture to be those webs, and the analysis of it to be therefore not an experimental science in search of law but an interpretive one in search of meaning (p. 5).

By this view, the task of the social scientist is to gain insight on the interpretations that orchestrate people's lives. Interpretation here is not pejorative. It does not mean a specific type of weak inference, perhaps in distinction to deduction. Instead, the term interpretation embraces concepts like intent, significance, belief, role, identity, goal, practice, and value -- things that constitute the "text" of meaningful human experience and that social scientists may attempt to understand. Cook states that the "basic idea is to attain that level where the observer's account of the words and deeds of the person observed could be eventually accepted by the subject, even if initially resistant to that account" (p. 15, 1994).

Though the interpretive tradition is concerned with meanings and the signs which convey those meanings (hence the typically heavy emphasis on language), it is hardly subjective in a solipsistic sense. There are a variety of methods to support good interpretative science ranging from hermeneutics to psychoanalysis to ethnomethodology to semiotics to phenomenology. And, although the interpretive tradition is primarily concerned with human experience, it is not inherently mentalistic. For example, one can study practices (as opposed to, say, behaviors) without making hypotheses about mental contents.
Analyzing videotapes and discourse patterns to understand how teachers and students create their classroom practices is a frequent instance of an interpretive endeavor. Notice that in its purest form, it is not necessary to predict the distal consequences of classroom interpretations or to show that these interpretations hold elsewhere (though this is a desirable outcome). Replication, while a criterion of evidence in predictive science, is not a prerequisite of good interpretation. The generality or replicability of a particular meaning is an empirical question rather than a standard for being admitted into the scientific collective as a "fact".

Suchman fits within the interpretive tradition. Her work does not analyze tacit, uninterpreted plans that lead to action (e.g., habits, motor plans, etc.) but instead, it points to how interpretations of planning emerge during activity. Moreover, she believes that interpretation is rarely general. She does not advocate "looking for structure that is invariant across situations" (p. 67), because all situations have "uniquely constituted circumstances" (p. 67). This is one reason Suchman proposes that neither researchers nor participants can anticipate the meanings that people construct in collaborative activity.

...mutual intelligibility is achieved on each occasion of interaction with reference to situation particulars, rather than being discharged once and for all by a stable body of shared meanings. (p. 50).

As evidence, she showed that the best-laid plans of an intelligent copier did not anticipate the meanings constructed by novel users. In particular, the machine “believed” it had finished the task of making five copies of a one-page book, whereas the individuals believed the copier had completed the sub-goal of making five copies of the book’s first page. Because the copier only had abstract plans that attempted
to predict the possible meanings it could encounter, it had no resources for detecting miscommunication or for building a new understanding with the participants.

From here it is not too difficult to see why Suchman proposed that representations of planning depend on situated activity. After a breakdown, people engage in post-hoc interpretations and negotiations. They try to develop a suitable representation of what happened and to recover shared meaning. These interpretations necessarily depend on situation particulars. They cannot be applied in advance and independently of the specific situation (unless people can anticipate unanticipated breakdowns). The copier failed, in part, because it had no representational capacity for constructing shared meanings; it could not depend on the unanticipated social realities of its situation.

Suchman’s evidence is primarily found in examples of communication breakdown that occurred because the copier could not support emergent representations of the situation. There are also examples that involve successful emergent representations. For example, we asked 7th-graders to read descriptions of fictitious fish and their habitat requirements: the Frolling lives in lakes with weeds; the Halluck needs weeds and a sandy bottom; etc. Their task was to create a visualization of the relationships. Students worked alone or in pairs. Figure 2 provides a representative sample of their visualizations. Only 6% of the individuals created visualizations that were abstract in the sense that they did not actually look like fish and lakes. In contrast, 67% of the pairs constructed abstract representations like a matrix or chart (Schwartz, 1995). This percentage is well above the probability that a pair would have included at least one member who would have constructed an abstract representation working alone. The meanings students constructed in collaboration cannot be reduced to the meanings of individuals, and therefore this meaning emerged and depended on the environment of collaboration.
The idea that representations arise in situations of social activity leads to several interpretations of good educational practice. Suchman specifically suggests that we should attend to the resources with which people recover from miscommunication. Although Suchman is discussing how to build machines with social intelligence, the observation is a good one for education. It is important to provide students with methods for detecting and overcoming a lack of shared understanding (for example with teachers), and more generally, for constructing meaning in a social context. Greeno and MMAP (1997), operating within the interpretative tradition, state that their educational research “is concerned with how students can acquire practices of discourse and inquiry in which meaning is constructed and shared” (p. 117). Thus, the primary goal is not helping students develop adequate “stand alone” representations or concepts of a situation. Rather, the goal is to help students learn to rely on and participate in social situations to construct meaning.

**PREDICTION**

The predictive tradition presupposes that there are regularities (and perhaps causes) that hold across social, spatial, and temporal contexts. For example, ecological psychologists attempt to identify the invariant information that people use to perceive a stable world in the face of changing sensory information (e.g., a table continues to look rectangular as we walk about it; Gibson & Gibson, 1957). In research like this, the goal of science is to discover the consistencies that regulate human activity, perhaps regardless of the meaning people attach to those activities. The criterion of knowledge is whether we can forecast the conditions under which a
specific outcome will be replicated, and the method of work involves testing predictions both prospectively and retrospectively.

The interpretive and predictive orientations are not necessarily incompatible. Cognitive science, for example, is often both: we predict people’s interpretations and interpret people’s predictions. And though Suchman’s insights come from the interpretive tradition, and she challenges the predictive tradition with her argument that we can never sufficiently forecast (plan) the future, the idea of RDEs is still productive in the predictive tradition. Distributed cognition is one example (e.g., Hutchins, 1995; Pea, 1997). In this work, researchers uncover the ways that humans depend upon (and engineer) their physical and social environment to create a reliable cognitive system. Other examples come from education and the problem of transfer.

Our predictive example of RDEs comes from students learning to add fractions by using the manipulative materials shown in Figure 3 (Martin, 2000). We wanted to observe children learning to distribute their cognition (in distinction to studies that examine already distributed systems). Our leading question was whether some physical materials helped students learn fractions more easily than others, and whether this had an effect on their ability to distribute their cognition to new situations. Fifth-grade students who did not know how to add fractions were asked to learn to solve problems like, "What is one-half plus one-fourth?" Half the students worked with tiles, small square plastic chips, and half the students worked with pies, plastic circles divided into fraction parts: halves, fourths, etc. During a guided discovery period, the students learned to solve the problems with the help of structured feedback. After learning, students tried to solve similar problems in their heads and with the alternate materials -- the pie students worked with tiles, and the tile students worked with pies.
The results provide a nice example of RDEs. No students could solve the problems in their heads, yet they all solved problems using the opposite materials. Evidently, their understanding depended on the environment, even if the environment was not identical to the one in which they originally learned.

Interestingly, the learning across the two conditions was not symmetrical. The students who learned with tiles adapted to the pies quickly and could solve complex problems (e.g., numerators greater than one). The pie students, on the other hand, took more trials and were confined to simpler problems. One explanation for this fact is that the tile students learned to perceive and depend upon a more general feature of the environment than the pie students did; namely the countability of the tiles. The tile students developed an arithmetic strategy with which they counted, added, and multiplied pieces. When they confronted the pies, they saw they could count them just as they had done with the tiles. In fact, they disregarded the shapes of the pies so that a 1/3, 1/2, and 1/4 wedge could equal three when combined. In contrast, the pie students had learned a strategy that depended on geometry rather than countability. For example, they would fit a 1/3 and 1/6 piece on top of a 1/2 piece. When these students confronted the tiles, they could not use their spatial strategy easily, and they had more trouble adapting to the new materials.

Overall, the results complement Suchman’s claim that “the function of an abstract representation... is to orient or position us in a way that will allow us, through local interactions, to exploit some contingencies of our environment, and to avoid others” (p. 188).” Although we hesitate at the term “abstract,” it seems clear that the students who learned with tiles were orientated to the more general “contingency” of countability, and therefore they could find a way to make a new situation scaffold their thinking.
We can entertain prescriptions for effective instruction that come from a predictive analysis of RDEs. One suggestion is to help students learn to perceive and work with underlying regularities (physical and social) that apply across many situations. This will help them adapt their strategies and understandings to situations with different surface features. A second goal might be to help students learn to adapt their situation to support their cognitive needs. So, rather than thinking of learning as reducing people’s dependence on scaffolds, one might think of learning as developing people’s ability to find and create scaffolds to support their activity. For example, students might eventually learn to cut rectangular tiles into pie wedges to support a spatial strategy for adding fractions. From the predictive perspective, the goal of education is to help students predict and control the environment to their advantage.

PRAXIS

In society, we are the forces that are being investigated, and if we advance beyond the mere description of the phenomena of the social world to the attempt at reform, we seem to involve the possibility of changing what at the same time we assume to be necessarily fixed (George Herbert Mead, 1899, p. 370).

In addition to interpreting and predicting social reality, we can fundamentally change it. Praxis is predicated on change and may prove useful to interventions like design experiments that try to improve learning but have trouble experimentally isolating causal variables (e.g., Engestrom, 1987). Frequently credited to Marx via Aristotle, praxis involves trying to change reality for the better. Whereas predictive and interpretive scientists may hope their findings can subsequently inform efforts at change, the scientific method of praxis begins with change directly. Praxis determines if a particular social configuration or outcome is necessary, for example,
capitalism and the alienation of labor. Praxis tries to change current reality, for example, to communism. If a given situation can be changed, then it was not a necessary fact, and the theory has created a new one “in its own image.”

When we disregard its explicitly moral constitution, praxis research can seem like predictive research, but it is not. One difference is that knowledge changes reality, not just our knowledge about reality. Showing that a state of affairs is not necessary through praxis is different from falsifying a hypothesis. Praxis can change reality so that which was once a true hypothesis, becomes false. Moreover, creating a new reality is not simply reconstruction from old building blocks or reinterpretation from old ideas. Praxis tries to synthesize a new reality so that contradictory needs are no longer in contradiction (and no longer exactly what they were before). A self-contradictory empirical reality is not a construct normally found in predictive or interpretive research.

The praxis tradition seems the most removed from Suchman’s considerations and from standard contrasts between situative and cognitive perspectives. As such, it offers a nice opportunity to see that there are other theoretical options available, while at the same time showing that the idea of RDEs extends beyond its original theoretical contexts. Our praxis example comes from an attempt to change two realities: one is that lectures do not help students learn satisfactorily; the other is students’ view of statistics as a set of inviolable and unalterable rules. Our examples of RDEs in this case are representations that do not work in the abstract, but instead, resonate to instances. Like the Platonic analogy between knowledge and the sun, these representations do not copy the world (like an imprint on a ball of wax or a linguistic proposition in a semantic network). Instead, like the sun, the representations illuminate the world, and hence they depend on situations to manifest their knowledge.
Figure 4 shows the shots produced by four rifles aimed at the center of their respective grids. We asked 8th-graders to invent procedures that could compute a consumer index (a single value) to indicate the reliability of each rifle. Some students measured the perimeter of each pattern; others counted the frequency of hits in different grid quadrants; and still others measured distances between shots. Though they were on the right track to measures of variability, no students generated conventional solutions, and they were unable to discuss or reason with their representations independently of the specific instances. Moreover, on standard tests, students like these performed more poorly than students who received standard textbook treatments.

----- Figure 4 Rifle grids-----

Even so, activities like these generate the RDEs that can prepare students to learn conventional solutions subsequently. By discerning contrasts between the shot distributions, students come to perceive the features that expert solutions have been designed to handle, including different central tendencies, sample sizes, densities, ranges, and so forth. This discernment prepares them for future learning. For example, after a similar activity in a class on memory, students listened to a theoretical lecture. The discernment plus lecture enabled students to better predict outcomes of new situations compared to students who first studied a relevant text and then heard the identical lecture (Schwartz & Bransford, 1998). The discernment activities helped students develop the RDEs that illuminated the meaning of the lecture and the elegance and significance of the expert solutions. And befitting the praxis methodology, cultivating these RDEs also made it so that the negative outcomes of lectures are not a necessary reality.
Allowing students the agency to invent their own mathematical characterizations also helped students change the reality of formulas. We asked students to evaluate some non-conventional procedures for computing variance (Moore & Schwartz, 2000). Traditional students rejected these procedures with the common sentiment that they “are not how you are supposed to do it. You have to follow the rules.” For these students, statistical reality was a set of fixed and seemingly arbitrary rules one had to follow, which is not an unreasonable characterization of what they had been taught. In contrast, the students who had a chance to develop RDEs noticed the value in the novel procedures (e.g., handles outliers well), and they offered suggestions for how to improve them. As one 8th-grader spontaneously proclaimed during a subsequent lecture explaining the standard deviation, “Hey, I’m not so stupid! I can make math too.” For at least a moment, the reality of mathematics and her ability to act in that world had changed.

The praxis approach offers ways to change learning. As researchers we should de-emphasize the surface appearance of student knowledge when it is tested in the abstract, sequestered from an environment of resources for producing learning. Instead, we should examine whether students have developed the RDEs that can help illuminate and realize new learning opportunities (Bransford & Schwartz, 1999). A second change is to allow students the productive agency to determine reality – “determine” in the tandem senses of checking and producing the social reality in which they live (Schwartz & Lin, in press). Without the means of production, students are alienated from the means of their own development. Suchman states the “complex world of objects, artifacts, and other actors... [should be] seen as the essential resource that makes knowledge possible and gives action its sense” (p. 179). Of course, for this to be possible, students must be granted the agency to take action.

CONCLUSION
In our commentary, we have selected among Suchman’s many proposals, so that we can examine some of her ideas without recapitulating well-worn controversies (e.g., Vera & Simon, 1993). In some ways we have done damage to her overall intent by disregarding the broader claims of ethnomethodology. At the same time, we hope that our attempt has illuminated some of the productivity of her ideas by examining them across different learning settings and different vectors of social-scientific research. Like Suchman, we have neither challenged nor justified the assumption of mental representation. We have moved loosely between terms like representation, knowledge, understanding, and planning. Our goal has not been to develop definitions, boundaries, or mechanisms of representation. Instead our goal has been to provide instances within an empirical agenda set forth by Suchman’s question, "How it is that we are able to bring efficient descriptions (such as plans) and particular circumstances into productive interaction" (p. 188). Regardless of how one views representational thought, in a social reality that we not only navigate, but we also construct through our “productive interactions,” the relationship between the creation of understanding and novel circumstances serves as one of the fundamental questions of the learning sciences. It should be addressed by as many methods as possible.
REFERENCES


ACKNOWLEDGMENTS

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FIGURE CAPTIONS

Figure 1. The three vectors social-scientific knowledge (adapted from Cook, 1994).

Figure 2. The unique meanings that arise in situations of collaboration. Pairs are more likely to generate abstract representations than individuals, as shown in these representative visualizations. (Adapted from Schwartz, 1995).

Figure 3. Students learned to add fractions with pies or tiles. Afterwards, they tried to solve problems with the alternate materials. Students who learned with tiles treated pies like tiles, and students who learned with pies tried to treat tiles like pies, but had trouble.

Figure 4. Four distributions of shots made by four different guns aiming at the center of their respective grids. As part of a lesson on the standard deviation, students had to develop a consumer index (a single numeric value) to indicate the reliability of guns.
**Predictive Knowledge**

**Goal**: Ascertain the regularities of social reality.

**Criterion**: Identification of conditions that replicate a given outcome.

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**Interpretive Knowledge**

: Insight on the meanings and signs that organize social reality.

ion: An account of words and deeds that eventually be accepted by the subject.

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**Praxis Knowledge**

**Goal**: Determine which aspects of social reality are fixed and which are mutable.

**Criterion**: Evidence of precipitating a new social reality.

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Figure 1.
Figure 2.
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<th>Pie Group</th>
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<td>= 3/4</td>
<td><img src="image9" alt="Tile Group" /></td>
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Figure 3.
Figure 4.

Gun 1.

Gun 2.

Gun 3.

Gun 4.