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ARTICLES

Embodied Practices of Engineering Work

Lucy Suchman
Department of Sociology
Lancaster University

This article explores relationships between activity theoretic and ethnomethodological studies of work and its objects, with specific reference to the case of design practices in civil engineering. My starting point is the shared interest of activity theory and ethnomethodology in the place of artifacts in everyday working practice. I review briefly some basic premises of first ethnomethodological, then activity theoretic studies of artifacts-in-use. I then offer a preliminary account of computer-aided and paper-based design work in civil engineering, informed by both perspectives. My account emphasizes the multiplicity of media and associated objects involved in the work of engineering on the one hand, and their integration in practice into a coherent field of action on the other. The article concludes by returning to the question of relationships between ethnomethodology and activity theory, focusing on differences in their respective stances toward theory itself.

Interest within the social sciences in the relationship between working practices and their associated objects has given rise to a collection of alternate research programs in the area of work and technology studies. This journal has been founded on one of those programs, that of activity theory, which offers a generative framework for the analysis of mind, culture, and activity as dialectically developing, sociomaterial relationships.[1] My own work has been deeply informed by the program outlined by Harold Garfinkel and his colleagues under the rubric of ethnomethodological studies of work.[2] Here I take this special issue of *Mind, Culture, and Activity* as the occasion to reflect on relationships between ethnomethodological and activity-theoretic projects for the study of work and its objects. In doing so I am interested in points of affinity and the difference between an anthropologically informed, ethnomethodological stance and certain aspects of activity theory's central tenets and preoccupations. My aim is not to compare these two programs in general, but to consider their respective orientations to work and its objects with reference to a particular case of

Requests for reprints should be sent to Lucy Suchman, 55 Bordon Street, Toronto, ON, M5S 2M8 Canada.

[1]My understanding of activity theory, although cursory, relies most directly on the writings of Bødker, 1991; Cole & Engeström, 1993; Engeström, 1990; and the articles collected in Nardi, 1996b.

[2]See, for example, Garfinkel, 1986, 1996; Livingston, 1987; Lynch, 1993. For a useful overview see Heritage, 1984.

working practice. More specifically, my reflections draw from a project concerned with the object-centered work of civil engineering.[3]

The work of civil engineering comprises activities done always in a particular place and time, but with meanings inflected by collectively remembered histories and imagined futures. While in progress, moreover, engineering projects are positioned within multiple spatial and temporal networks that must be simultaneously elaborated, managed, and contained. Coordination within and across these networks implies the accomplishment of alignment across multiple shop floors and social worlds, each with their own identities, contingencies, and concerns.[4] Given the extent and complexity of civil engineering as a practice, a few words of clarification on the limits of the discussion offered here are in order. I am concerned in particular that the boundaries that I draw around the field for my purposes might be taken as principled limits on the extent of what I take to be relevant and important to the study of civil engineering work overall. To be clear, then, I assume that a fuller treatment of the work of civil engineering would include, inter alia,

- A cultural-historical account of civil engineering and its tools.
- Location of the site studied here with respect to its particular histories, including relevant details of the political and economic circumstances of the project at hand.
- An account of the extended actor networks that make up the project, including members' own orientation to demands of engagement in time and across space.
- An account of the project's work organization and divisions of labor.
- An account of my own circumstances, as a researcher, in engaging with the project.

With that said, the limited focus of this article is on that aspect of engineering work that comprises the production of exhibits and plans and the place of computer-aided design tools and paper-based drawings as mediators of that form of engineering practice.[5] A common orientation to material artifacts as mediators of human activity is, to my reading, the strongest element that aligns ethnomethodology with activity theory. In the remainder of this article I review briefly some basic premises of, first, ethnomethodological then activity theoretic studies of artifacts-in-use. I then offer an account of engineering design work informed by both perspectives. Finally, I turn back to the question of relationships between ethnomethodology and activity theory, focusing on differences in their respective stances toward theory itself.

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[3] My colleagues on this project were Jeanette Blomberg, Randy Trigg, and David Levy. Our study of the working practices of civil engineers went hand in hand with the design of a prototype technology for online document filing and access in collaboration with members of the study site. For a discussion of our approach to work-oriented, cooperative design, which is not the focus of this article, see Blomberg, Suchman, & Trigg, 1996; Suchman, Trigg, & Blomberg, 1998; and Trigg, Blomberg, & Suchman, 1999.

[4] See Suchman, in press.

[5] Alder (1998) provided a compelling history of the rise of projective engineering drawings in mid-18th century France. For an insightful account of relations of paper and digital media in contemporary practices of mechanical engineering, see Henderson, 1999; for another view onto the work of civil engineering discussed here and its associated disciplines of testing see Sims, 1999.

PHENOMENAL FIELD PROPERTIES

Ethnomethodological studies of work are concerned with what Garfinkel (1996), following Gurwitsch (1964), has named the "phenomenal field properties" of particular work sites and their practices.[6] Emphasis is on the irreducible relations of mutually constitutive details, through which isolable actions, objects, artifacts, and the like take on their specific, practical significance. Meanings on this view inhere neither in individual elements or properties, nor in some underlying structure that stands behind appearances, but only in relations of "mutual reference" across a field of observable phenomena (Lynch, 1993, p. 127). Ethnomethodology adds to this field the necessary presence of the embodied subject, through whose history and present engagement phenomenal relations are enlivened and made relevant to some ongoing activity. Moreover, the phenomenal field of action does not simply preexist and take its meaning from activity, but is reflexively generated through the same activity that it organizes, as found objects are appropriated and mobilized and new objects created (see also Ueno, this issue).

The mutually constitutive relation of actions and their environments includes the fact that accounts of activity are themselves crafted from the juxtaposition of observable features of embodied actions with phenomena selected from the scene in progress (Goodwin, in press). This applies equally to accounts that are internal to a given activity, as to those created about it in advance or afterwards. For ethnomethodology, then, the relationship between social practices and accounts of those practices is deeply and unavoidably a reflexive one, for participants and observers alike (Button & Sharrock, 1998; Lynch, 1993, p. 1; Ueno, this issue). And like material artifacts, formulations of action—whether done as part of an activity or as accounts of it by participants or others—are specifically situated in the occasions of their production and use. Together talk and other culturally formulated, socially and materially constituted artifacts comprise the phenomenal field of embodied practice.

MEDIATIONS

Activity theory has a rich history and many interpreters, to which I cannot begin to do justice here. Recognizing the multiplicity of researches that go on under activity theory's rubric, a central premise, as articulated by Cole and Engeström (1993), is that to grasp an activity fully one needs to understand how cultural-historically constituted artifacts both mediate activity and are in turn enlivened, given their functionality and significance, in and through it. At the same time that tools and symbol systems mediate between individual and purpose, or subject and object, artifacts are continually shaped in and through their use.[7] Most important for the analysis that follows, artifacts shift from being themselves the objects of our activity to working as transparent media through which we act with and on other objects. As Bødker (1996) put it,

> Artifacts are there for us when we are introduced to a certain activity, but they are also a product of our activity and as such are constantly changed through the activity. Artifacts thus have a double character:

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[6]See also Lynch, 1993; Goodwin, in press.

[7]A similar perspective is developed in social studies of technology, specifically actor-network theory; see, for example, Akrich, 1992.

> they are objects in the world around us that we can reflect on, and they mediate our interaction with the world, in which case they are not themselves objects of our activity in use. (p. 149)

With particular reference to computational artifacts, Bødker proposes an analysis of the use of computer applications in terms of the relation of an application to its object, "object" here having the double sense of the material thing to which our activity is oriented and its purpose or aim. She identifies three possible relations:

1. The object of activity is present only in the application.
2. The object exists as a physical object but is only present in the use activity as the rendition provided by the computer application.
3. The object is physically co-present outside the application.

My analysis of engineering design work builds on Bødker's analysis, showing the dynamic interrelation of these logical distinctions in actual practice. The dominant relations in the case of civil engineering design work are a hybrid of Relations 1 and 2, as new roads and bridges are imaged in and imagined through the conventional graphics and symbol systems of engineering and in relation to a distant physical landscape and infrastructure, located some 30 miles from the district headquarters in which the design work is done. I am interested both in how we as analysts can see engineers shift among these objects in the course of their work and also in the ways in which the objects for them are effectively joined, in and through their practice, into a unified phenomenal field.

DESIGNING A BRIDGE

Historian of engineering Henry Petroski (1995) wrote that for a civil engineer, the design of a bridge is the stuff that dreams are made of. He emphasized as well the significance of the codevelopment of modern engineering practice and the artifacts of inscription and persuasion that have become as much its stock in trade as concrete and steel:

> In the association [in the mid-19th century] of bridge building with drawing and calculation and written argument before any construction was started, a new era was begun. From then on, the grandest dreams could be articulated and tested on paper, and thereby communicated to those who would have to approve, support, finance, and assist in designing a project that could eventually take years, if not decades, of planning and construction. (p. 12)

The building of bridges is rare compared with the building of roadways and other surface structures, insofar as bridges are costly projects that last on the order of thirty to in some cases hundreds of years. In the area where our study is located, six toll bridges have already been built and no additional bridges are planned. At the same time, the area is threatened with earthquakes. In response to the critical problems experienced in the last major earthquake, the state government has set aside substantial funds for "seismic retrofitting" of the existing toll bridges.[8] One of the area's toll

[8]For additional background on these initiatives see Sims, 1999.

bridges is actually a pair of old trestle bridges that connect the north and south shores of a relatively narrow strait. Charged with ensuring the safety of these bridges, engineers at the state Department of Transportation (DOT) have argued that whereas one of the bridges can indeed be retrofitted, the other is sufficiently old—dating from 1927—and that it is both unsafe and uneconomical to try to reinforce it. Instead, they have proposed "replacement as a retrofit strategy." In this way they are able to direct funds for retrofitting to a new bridge building project.

At the same time, it is a bit misleading to say that the engineers are engaged in designing a bridge if what we imagine by that is the design of the structure itself. In this case, in fact, the bridge design is outsourced to a specialist design firm, with DOT engineers responsible for oversight. But it also turns out that the bridge itself represents a small fraction of the entire project relative to the highway approaches and interchanges that tie the bridge into the landmasses that it connects. So although the design of the bridge is contracted out, DOT engineers maintain responsibility for the bridge alignments and all connecting roadways. These make up the focus of their design work.

WORKING IN COMPUTER-AIDED DESIGN (CAD)

My analysis of engineering design work is based on a set of tutorials provided by Andrea, a lead engineer on the bridge replacement project team.[9] The first of these took place in front of her CAD workstation, where she took us on a tour of some of her recent work. The object of her activity on this occasion was the earth—in Bodker's (1996) terms an object physically existing, but present to Andrea only as the rendering of it provided by the computer system. More specifically, Andrea was engaged in figuring the volumes of dirt that would need to be displaced to construct the highway interchange on the bridge's south side. Andrea's purpose at hand was to calculate, as she put it, "how much dirt we're going to dig up—literally, not just as a figure of speech!"

The interface that mediates Andrea's access to her work's objects is actually composed of two software applications running together. An engineering application is layered on top of, or nested within, the functionality of a second, graphics application. The engineering application, in Andrea's words "uses the [graphics application] to let you see the results of actual engineering calculations." The layered space[10] of the CAD environment includes as well a collection of menus arranged as a kind of frame around the periphery of the CAD workspace. Some of these menus serve as views onto the directory structure of Andrea's hard disk and provide the means by which files are located and opened; others provide "tool boxes" of available actions to be taken on graphical objects within those files, whereas a third controls the layered space of the CAD display itself. When focus shifts to these menus as objects, they become a top layer, superimposed on the objects they are used to manipulate (see Figure 1).

Latour (1990) pointed out that representational conventions in engineering are aimed at maintaining an "optical consistency" between three-dimensional objects and the flattened renditions

[9]The tutorial was provided to me and my colleague Jeanette Blomberg, who interviewed Andrea as I recorded the session on video.

[10]Star's (1989) notion of *layered representations* applies here as well, insofar as the working up of drawings is almost always a matter not of beginning from scratch, but of reusing and adapting available renditions. Regarding multilayered inscriptions, see also Ueno, this issue.

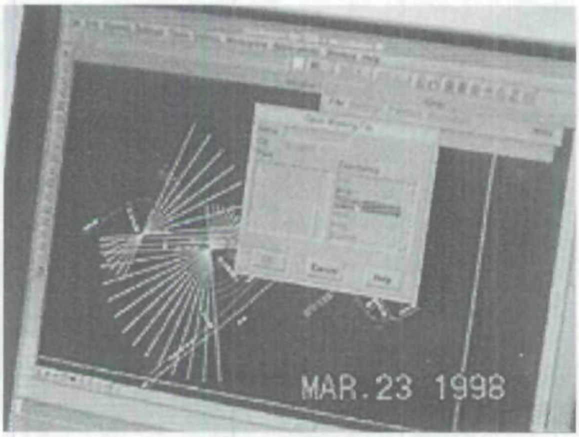

FIGURE 1 CAD interface with toolbars menus.

that comprise sketches, plans, and the like (pp. 52–54).[11] These conventions include highly elaborated lexicons of line types, perspectives, geometries, and symbols. In the case of mechanical engineering, Henderson (1991) observed that "[t]he lexicon allows the schematic drawings to remain flexible enough that engineers can read the coded functions in the layout and understand the interrelations of the various functional components of the whole project" (p. 459). Fundamental to civil engineering in this regard is the *plan view* or *horizontal alignment,* which flattens engineering objects into something akin to a bird's-eye perspective.[12] In roadway work, the plan view relies on a geometric object called the point of intersection (PI). The PI in turn references a virtual grid laid over the mapped physical environment, establishing a series of points in space that mark the place where, as Andrea describes it, "a straight line meets a straight line." A second focal object is the *control point,* which she describes as a place of maximum constraint that consequently controls much of the design (see Figure 2).

Andrea explains it this way:

> And then, you always have some control points. We have a major control point on Vista [an existing surface street], which is right here [pointing to indicate curving street to left of ramp] where it goes underneath that ramp, that controls really so much of the entire design on the new road ... We have to have clearance for trucks to go under it, and while they're building this new ramp they have something called false work-up. Which has its own depth, it might be three feet it might be six feet deep. And then there's the depth of the structure. So we know what the elevation is on the ramp, right at this point [leaning in to

[11] See also Alder, 1998; Henderson, 1991.

[12] Alder (1998) discussed the distinction between perspectival drawings, developed in the Renaissance to convey a sense of realism, and projective drawings, designed in the mid-18th century in the engineering schools of Enlightenment France to correct for the distortions of scale on which the realism of perspectival drawings relies. Such correction was seen to require shifting the viewer's stance from one positioned in relation to the scene or objects depicted to the bird's-eye view or "view from nowhere" (pp. 513–514).

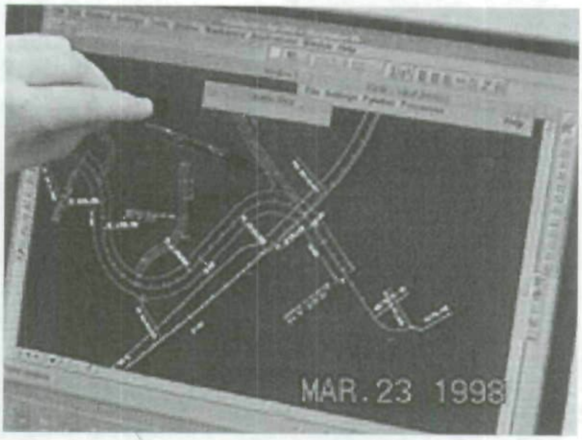

FIGURE 2 Andrea indicates control point.

show] actually its control point turns out to be right here. But we have to then add that there's a depth to that structure, then there's gonna be some false work, so we have to go way under it.

Andrea's account of the problem makes clear that highways and bridges are not self-standing objects but structural elements that are laid over and must be effectively incorporated into existing landscapes. In the case of civil engineering, moreover, the spatial field of objects is complicated by the element of time. Andrea's calculations must take into account not only the plans for the new ramp, but also the temporary structures, or false work, required for its construction. All of this in turn must be placed in relation to existing landscapes, made up not only of natural features such as geological formations, waterways, and the like, but of strata of built environments laid down over a period that may comprise hundreds of years. The pace of this latter building is accelerating, moreover, in such a way that each new project confronts an increasingly dense infrastructural archeology, including prior structures, utilities, waste disposal sites, and even areas protected for recovery from previous interventions.

All of these features must be accurately mapped for the soundness of a design to be ensured. The graphical renderings of the plan view can be interrelated with a Digital Terrain Map, which renders the 3-D contours of the physical environment in which the objects of design will actually be built and into which they need to fit. Maps are created from survey points, assembled together through the use of conventional symbols that render the topography of the original ground. Like the ground, the Digital Terrain Map appears as a kind of bottom layer that sits beneath the design objects themselves. As with the engineering and graphics applications, however, the layers are not simply superimposed but dynamically cross-referential. Specifically, once the horizontal alignment or plan view has been created, engineers need to generate a *profile,* a rendering that makes visible the relationhip between the proposed new roadways and the existing terrain. By drawing *cuts* through a particular section of the plan view of the site, Andrea is able effectively to instruct the engineering application to create a series of cross-sections for each of those cuts showing where the existing surface is, using the map as a reference (see Figure 3).

Andrea's workspace, in sum, is made up of an assemblage of computational, metrological, geometric, cartographic, and graphical tools. Together these comprise the interface through which she sees and manipulates the physical objects of her work. With reference to Bødker's (1991) framework, Andrea works *with* the elements of the layered interface that the CAD system provides and *through* the interface to the objects that those various renderings mediate: in this case, the earth, the existing and projected roadways, and her team's interests in them. Ethnomethodologically, our interest is in how these multiple elements and objects together comprise the phenomenal field properties of Andrea's embodied practice. Having enumerated the distinctions among heterogeneous elements, in other words, the question becomes how in practice does Andrea bring them together?

In our tutorial Andrea took us through her previous day's work in a way that made not only the heterogeneity but the integrity of her workspace clear. For example, she pointed out to us one of what she called the "major control points" for her design, a physical location on an existing roadway named Vista del Rio. As she explained it, a defining constraint of the design problem at hand is that one of the on-ramps to the highway must be built to run over Vista del Rio, an existing surface street. To provide enough clearance for the ramp, Vista must be effectively lowered below the current surface level by removing earth at the point where the street crosses under the ramp. As Andrea guided us through a profile of the site, she explained further:

> And you can see that at the top of Vista we're pretty much following the existing ground. And as we go down, we get *way* below it, this is about 10 meters of dirt that we're taking out. And then I think the point that we're crossing under is right on this [pointing with pencil] little flat here.

Andrea's demonstration takes the profile as a locus of what Goodwin (1994, 1995) has named "professional vision," a site from which we can "see" the contours of a roadway far removed from the place where we sit in front of her workstation and assess its relevance for the imagined future

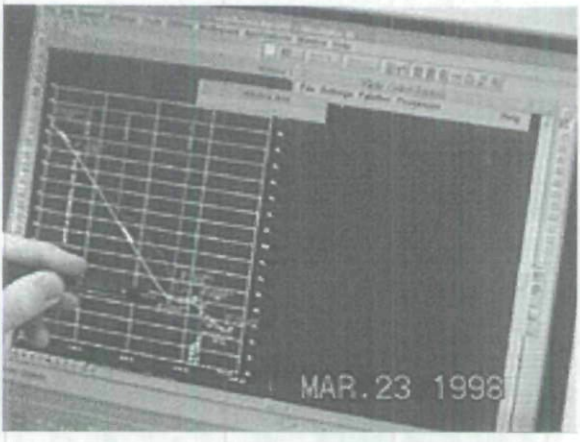

FIGURE 3 Profile view.

activity of constructing a new road.[13] In this way, the display acts as a surrogate for the physical place of engineering interest. Andrea's narrative positioned us figuratively on the physical site "at the top of Vista," from which we could "follow the existing ground." But "as we go down" this virtual roadway we enjoy the ability to continue our travels below the existing surface, removing 10 m of virtual dirt to reach the projected future crossing below. The latter is indicated by a geometric point in space, positioned figuratively under the new ramp and more literally on the flat line of the CAD display. Bringing together narrative form and imagination, metrology and geometry, Andrea is able to "see" under the existing ground, to project a newly excavated roadway that does not yet exist. In doing this work she moves fluidly between pictures and things and across time, as the artifacts and objects of her work are read through each other to achieve a rendition that aligns what is there now with its desired transformation. At the same time Andrea's small gesture, the point of her pencil, reminded us that it is with the engineer's body that this work of virtual travel and assembly gets done.

THE MEDIATING BODY

That engineering objects mediate embodied practices of engineering is clear. By looking more closely, we can see as well how bodies mediate engineering objects. So in the course of her tutorial Andrea made continuous use of various forms of what Goodwin (1994) has named *highlighting for perception,* instructing us on where and how to look with the gestures of her pencil. At other times, the performative aspects of her reading served to animate the static CAD image that we saw. So, for example, once she had used the system to create a series of cross-sections of a roadway, say every 5 or 20 m, she could then effectively "travel" along the roadway by scrolling through the sections displayed on her screen. At still other times her body itself became a reference, adding a kind of third dimension to the CAD screen as when, for example, she used the angle from her hand to her elbow to demonstrate the slope of a road.[14]

As CAD has become an increasingly central aspect of engineering practice, a perspicuous site for seeing these bodily mediations is in the relations and differences between working at the CAD station and on paper. Another way of understanding these differences is in terms of the relatively greater scale and expanse of paper. Another engineer described this to us vividly, as she enacted with gesture the difference between sitting in front of the CAD station, elbows close in to the sides of her body, hands constrained within the narrow terrain of the keyboard, eyes glued to the screen on which she zoomed in and out and traveled across the virtual space with mouse clicks, and sitting or standing over a large sheet of paper, arms outstretched or hands and arms engaged in a variety of actions of drawing, measuring, turning the paper to get another angle, moving it slightly on the table, and so on.

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[13]Although we are concerned here with how it is that engineering artifacts mediate imagined future activities, Goodwin's (1994, 1995) analyses take up the question as well of how the mediating artifacts of professional vision can reconstitute past events, ranging from archaeologically available traces of human habitation and police actions in Los Angeles, 1994, to flows of the Amazon into the world's oceans, 1995.

[14]For an extensive discussion of the place of gestures, specifically pointing, in constituting a relevant phenomenal field see Goodwin (1994). For a discussion of the scientists' body as defined by the materials on which it depends, see Mialet, 1999.

At the same time, it is also the case that Andrea identified a great benefit of CAD as the effectively unbounded (other than by the size of files) virtual space that CAD's zooming and scrolling functions provide. Andrea is able to create an extended workspace, a kind of spatially arrayed library or storehouse of her work, made up of shrunken images that she can browse, select from, and expand. In this way all of Andrea's cumulative productions—what would comprise a bulky collection of plan drawings each at the scale of 24 in. by 36 in.—can be surveyed on a single screen simply by saying "show me everything that's in this file at once."

Another difference between paper- and CAD-based work practices could be that older engineers choose the former, whereas younger engineers more familiar with digital media choose the latter. Indeed, Andrea explained to us that in the previous week she had prepared a set of paper plans to bring a problem for consultation to one of her more senior colleagues who works only on paper. At the same time, she herself also frequently turns to paper in the course of her work. A week after our tutorial I noticed her working at her drawing table with an array of paper documents spread out around her and asked her to tell me about them. She explained that she and two of her colleagues had sat down several days before to, as she put it, "nail down" the design of the highway interchange on the bridge's south side. The primary documents were a set of three plan views taped together (see Figure 4).[15]

In this case, Andrea explained that whereas she could have done her design work with a smaller image, she wanted as she put it a "meaty" scale: "So I could really have a good picture of what's going on. When you're doing the design a tiny postcard of it is not that helpful. This is the whole interchange area."

The assembled plan view, although still a minute fraction of the size of the physical area that it renders, extends what would be available within the limits of the CAD screen to something that becomes a space for joint work. Through it the object of Andrea's work is both viewable as a whole and still within arms' reach. Andrea described the annotations evident on the paper plans as the residue of engineers' "thinking with a pencil in their hand."[16] In addition to the annotated plans, I asked Andrea about a pad of graph paper sitting on top of the other sheets. She explained that she uses the pad for her calculations:

> What I'm trying to do on the pad is something that seems like an extra step, but personally I think that it's pretty important. I'm just trying to record the calculations that I'm doing, to determine clearances and to determine actual elevations. [explains specific problem] So I could just do the whole thing with my calculator, and that's what a lot of people do. I'd come up with the number and then I would write down the number and start working. But we're at the point where we need to check it. That's why I'm

[15] Kathryn Henderson (1991, 1999) described the use of sketches in mechanical engineering work, comparing the flexibility of paper media with CAD. The uses of paper that she observed included (a) conscription (i.e., the enrollment of others in joint work, consultations and the like); (b) "thinking with eyes and hands" (borrowing a phrase from Latour, 1990); and (c) making things visible and intelligible to others (e.g., through exhibits that make use of color highlighting). She summed up these observations with the statement that engineering is a "visual culture," characterized by Latour as "how a culture sees the world and makes it visible," by defining both "what it is to see" and "what there is to see" (1991, p. 469, Footnote 1; see also Goodwin, 1995).

[16] Alder (1998) described free hand sketches as "a quasi-private language, used as an extension of the creative process, or as a kind of private notation to oneself or one's immediate colleagues" (p. 512). It was against the idiosyncrasies of such sketches that the principles of descriptive geometry were developed by Bachelier and his colleagues in the mid-18th century. At the same time, it becomes clear from studies of contemporary engineering practice that freehand and projective drawing comprises less a developmental sequence than a repertoire of complementary and dialogic elements.

FIGURE 4 Paper plan views.

> trying to be a bit more meticulous.... The way that I see it is that the big advantage of working it out on paper is that you're leaving a bit of a trail as to how you got to the thing that's the final answer. We also save previous iterations electronically, but they're not well documented. There's not an easy way to go back and say, did anyone ever try putting a 2 percent grade on this? I think it's nice to see on paper: Oh, look, she tried 2, 2.1, 2.2, 2.3 and 2.5, look, it goes right through the point that she needed to hit, and it works.

The object of Andrea's activity in this respect was not only to find the requisite grade for the roadway, but to produce a residual trace of her actions as a visible rendering of the calculative work that she had done. Another particularity of paper, then, is that work "black-boxed" by the machinery of the electronic calculator can be made visible, and in relation to the objects that it references. The engineers' pad serves not only as a space for calculation but as a technology of accountability that makes the course of her work retrospectively visible to her colleagues (see Ueno, this issue).

In elaborating the benefits of paper as a medium, Andrea explained that 6 months ago she tried to do more with CAD, but now has realized that paper is just better for some things. Andrea's tutorial instructed us that rather than a simple progression from paper to CAD, the maturing of electronically based engineering practice may emerge as the informed, selective use of both paper and digital media, based on a deepening understanding of their particularities and of their effective interrelation. CAD might be seen, moreover, as the logical extension, the embedding into a computational instrument, of what the early progenitors of the rules of engineering drawing took to be the benefits of descriptive geometry and other conventions, that is, their force as a corrective to the artisans "ignorant and prejudiced" imagination (Bachelier, 1768, quoted in Alder, 1998, p. 512). It becomes clear from our observations of the actual use of CAD as an aspect of Andrea's practice that the calculative powers of the machinery to "make things the same" (Alder, 1998) are effective only insofar as they are enlivened by her readings of the objects rendered, in and through the interface of her workstation, as the highly differentiated, more and less obdurate materials of a fully embodied, natural–artifactual world.

CONCLUSION: SOME REFLECTIONS ON THEORY

In this account of Andrea's tutorials, I have tried to convey a sense for the close interrelations of working practices and associated artifacts as together constituting the embodied practices of engineering work. My interest is to respecify the work of engineering from general formulations to specific occasions of professional practice at the screen and on paper. In focusing on the work's objects, I have emphasized some potential lines of connection between activity theoretic concerns with mediation and an ethnomethodological interest in phenomenal field properties of distinctive forms of professionalized practice. My discussion so far would seem to suggest little difference between these two programs. In this closing section, however, I wish to turn to at least one, potentially fundamental, difference between ethnomethodology and activity theory. This difference turns on their relations to the project of theorizing itself.

Speaking on behalf of activity theory, particularly with respect to its relevance for understanding work at the screen, Nardi (1996b) proposed that "[t]here is a fundamental need for a theory of practice in human-computer interaction studies" (p. xi), including a generic lexicon or common vocabulary. She continued:

> The development of a common vocabulary is crucial for HCI. As we move toward ethnographic and participatory design methods to discover and describe real everyday activity, we run into the problem that has bedeviled anthropology for so long: every account is an ad hoc description cast in situationally specific terms. Abstraction, generalization and comparison become problematic. An ethnographic description … remains a narrative account structured according to the author's own personal vocabulary, largely unconstrained and arbitrary. (pp. 10–11)

Setting aside for the moment the question of whether this characterization does justice to the comparative research tradition that comprises anthropology,[17] what I am interested in are the basic premises that (a) the ad hoc, specifically situated character of accounts is a special problem for the social sciences that renders comparison impossible in the absence of a unifying theory and that (b) left to themselves, individuals construct accounts according to a "personal" vocabulary that is "unconstrained and arbitrary." This premise at once obscures what I think is in fact some of the common ground between activity theory and ethnomethodology and points to what are some important differences. The common ground that seems obscured here turns on the extent to which practitioners of activity theory and ethnomethodology alike view the terms of any account as culturally and historically constituted. Rather than rendering transcendent, eternal descriptions of generic human behavior, both produce narrative accounts that are themselves embodied and embedded in particular cultural and historical circumstances. Whatever their generality, lexicons, classification schemes, models, and the like are reflexively constituted as descriptive of particular occasions of

[17] For a recent discussion within anthropology of the status of ethnography as a comparative program, see, for example, Clifford and Marcus (1986), Marcus and Fischer (1986), and Gupta and Ferguson (1997).

everyday activity through, and only through, the cultural–historical practices of their production and use.

Taken as a theory-building project in the sense that Nardi (1996b) proposed, however, activity theory stands in profound tension with ethnomethodology. This tension is not, as Nardi suggested, a matter of systematic versus ad hoc analyses, but rather a matter of how we understand the relationship between the two and the project of theory-building more generally. In an article titled "Silence in Context: Ethnomethodology at the Margin of Social Theory," Michael Lynch (1997) took up the question of ethnomethodology's somewhat puzzling failure to engage in traditional practices of theory-building. Lynch recasted this "failure" as a studied action and offered to fill the silence with an account of "ethnomethodology's distinctive stance toward theorising" (p. 2). As those with an orientation to the cultural–historical grounds of human activity should appreciate, ethnomethodology's stance toward theorizing does not arise out of nowhere, but rather is embedded within and responsive to the particular histories of traditional sociology. As Lynch put it,

> ethnomethodology depends upon classic sociology for its research motives and themes; and thus, one needs to be thoroughly acquainted with established research traditions in sociology to appreciate why and how ethnomethodology disturbs them. (p. 6)

It is in this sense that ethnomethodology's silence is contextual, a meaningful one and not simply an absence. Lynch's argument is that ethnomethodology is not so much atheoretical as deliberately marginal, in a way that makes the margins of social theory instructive. The margins that ethnomethodology inhabits are not, he pointed out, about some kind of empiricist alternative to theorizing that posits a purely inductive process of "just seeing" what's "really" going on. Although acknowledging the use by ethnomethodologists of phrases like "naturally occurring," "actual," and the like, Lynch argued that these are specifically contextual injunctions not for empiricism but against the perpetuation of sociology as a literary, rather than an empirical, endeavor. Empiricism and empirical study are two quite different matters. Moreover, as Lynch put it: "Ethnomethodology does not simply offer an alternative theory or method … it provides an alternative sociological *practice*" (p. 6).

That practice, among other things, resists taking up the rules of sociological method, in particular the various procedures that turn lived experience and embodied practice into general lexicons and associated models. Rendered as a literary enterprise in this sense, social theory-building becomes a conversation that provides its own materials, self-referentially. Empirical studies then, not empiricism, are lost.

Some in activity theory have drawn attention as well to the problematic aspects of a view of activity theory as a theory of activity-in-general. As Kuutti (1996) put it,

> both parts of the term activity theory … are slightly misleading, because the tradition is neither interested in activities in general, nor is it a theory, that is, a fixed body of accurately defined statements. (p. 25)

It must be the case, moreover, that practitioners of activity theory themselves actually develop the meanings and extensions of the terms of the theory, in any actual instance, in a way that is necessarily contingent and even, forgive the expression, ad hoc. Any instance of the use of activity theory's canonical triangle, for example, involves a mapping of its generic terms to some aspects of the activity in question, selected to characterize it for the practical purposes of mapping it. That such mappings are—must be—ad hoc makes them no less purposeful and systematic. Rather it is falsely dichotomous to oppose the two.

Theory-building and theories-in-use are themselves specifically situated activities. The terms of the activity theoretic triangle—subjects, objects, rules, divisions of labor—are what Garfinkel (1996) called "Durkheimian things," that is, aspects of the ordinary society continually reproduced in and only in the details of lived experience and everyday activity. Like its objects, the work of the theory is accomplished not by the general lexicon but always in situ and specifically by those engaged in activities of theorizing. In Kuutti's (1996) words,

> it is impossible to make a general classification of what an activity is, what an action is, and so forth because the definition is totally dependent on what the subject or object in a particular real situation is. (p. 32)

Garfinkel (1996) argued that however much procedures of formal analysis replace the specific details of practical action with general constructs, they nonetheless thoroughly rely on those specifics both for their own activities of theory-building and for the intelligibility of their products. Nor, in Garfinkel's view, should the goal of social studies be to find a remedy to this fact, taken as a "problem." It is in this sense that ethnomethodology refuses the call to engage in theory-building, not because of some claim to be without presuppositions but out of "an uneasiness about the summons" (Lynch, 1997, p. 19). The summons to theory that is rejected is the demand that we treat the specific concreteness of practical activity, like the practices of engineering work considered here, as a problem to be solved. Instead, the proposal is that we take practical activity—including its unruliness, its "ad hocery" and its endless detail—as just the fundamental phenomenon that we as students of human activity are out to recover.

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