A great deal of video has been recorded and analyzed in learning sciences research since the publication of Jordan & Henderson (1995), which remains one of the most frequently cited articles on methods (or any other topic) in Journal of the Learning Sciences. That article brought Interaction Analysis (IA) to the attention of our field, but the policies and methods proposed had been under continuous development since at least the early 1950s. Current uses of IA by learning sciences researchers draw unevenly from these earlier developments. We revisit some of that history here, particularly as a frame for studies of knowledge in use, something that is an ongoing program of research and not just a collection of methods. We then identify new opportunities and problems in developing methods for IA that have a bearing on what counts as knowledge.

The first part of our chapter focuses on assumptions about the character of knowing and learning, as these are observable in interactions shaped by what people find relevant in activity. In most research situations in our field, members’ relevancies are also related in complex ways to the deliberate and hopeful designs of learning sciences researchers. We argue that these relations should always be part of Interaction Analysis of knowledge in use, particularly those that involve design. While this creates new challenges for analysts, the effort is both productive and necessary for developing new methods and advancing our understanding of knowing and learning.

Points of Departure: From “Natural History” to an “Outdoor Psychology” of Knowledge in Use

For many readers of this volume, IA will be understood as a method, not as an approach to analysis of knowledge in use. Framing IA as an approach to
the study of knowledge in use involves, from our perspective, two orienting maneuvers.

In the first move, we recommend looking for knowledge in use in the ongoing activities of people who are engaged in those activities in ways that are adequate for their own practical purposes. This is not the same as studying “experts,” if we mean by “expertise” what highly educated people do when asked to solve typical school problems (e.g., the odd-numbered problems in a chapter on polynomial functions in an introductory algebra text). As an alternative, we recommend studying people who are engaging with conceptual practices (e.g., algebraic description and modeling) to get something done, accountable to their own satisfaction and to the organizational requirements of their work (e.g., two civil engineers modeling the amount of dirt to be “cut” or “filled” to design usable roadways for a multi-million-dollar residential development; see Hall & Stevens, 1995; Stevens & Hall, 1998). Learning to participate in knowledge in use is also something that can be studied when taking this first move, as learning is also an activity shaped by what members or participants take to be relevant for their practical activity (Stevens, 2010).

This first move has a number of rich historical precedents. One is the close study of communicative activity in a psychotherapeutic interview, undertaken by an interdisciplinary team of linguists, anthropologists, and psychiatrists — the Natural History of an Interview (NHI) Project (Bateson, 1971; Hall, Nemirovsky, Ma, & Kelton, this volume; Leeds-Hurwitz, 2005). This early effort at what would today be called multimodal Interaction Analysis (e.g., Streeck, Goodwin, & LeBaron, 2011) deeply shaped the fields of communication studies, conversation analysis, and varied approaches to discourse analysis. For NHI analysts, there was a basic commitment to discovery within the details of naturally occurring activity:

> We start from a particular interview on a particular day between two identified persons in the presence of a child, a camera and a cameraman. Our primary data are the multitudinous details of vocal and bodily action recorded on this film. We call our treatment of such data a “natural history” because a minimum of theory guided the collection of the data.

*(Bateson, 1971, p. 6)*

The “natural history” approach was not intended to be theory-free, any more than was the development of grounded theory (Glaser & Strauss, 1969; see their discussion of theoretical sensitivity and sampling in Chapters II and III). Rather, the idea was to take scenes from social life, capture the ways participants typically went about enacting those scenes, and use these records as material for making discoveries about interaction, learning, and other phenomena.

The natural history approach proposed the detailed description of whatever could be observed in an interaction. Since what was sought for was...
an understanding of the natural orderliness of interaction, observations must be made in terms of what there is to be observed, not in terms of pre-established category systems. To decide what will be measured and counted before this is done will prevent the very understanding that is sought.

(Kendon, 1990, p. 20)

The sense of “natural history” used in the NHI Project also hinged on the idea that “specimens” of human communication could be captured with enough detail to support close analysis from multiple theoretical points of view. A collection of such specimens could provide a repository (a corpus) for independent lines of analysis as well as for collaborative theory building. Then as now, new technologies for recording human interaction open up new possibilities for discovery, as we consider later in this chapter.

If we take the point of view that all aspects of observable behavior can play a role in communication … and if we recognize that how participants interpret each other’s flow of action depends upon how the various aspects of action are patterned in relation to one another, it is natural that we should require as full a description as possible of the behavior that can be observed in an interaction. This, it will be clear, can only be achieved if we have specimens of interaction available to us for study. … [T]he camera can be used to create specimens of interaction that do make possible the discovery of facts about behavioral organization which cannot be done by other means…. [A]ny photographic or cinematographic shot always contains far more information than can possibly be foreseen – at least if it is shot of the uncontrived world of daily life – and it provides, thus, a genuine “field” for exploration within which real discoveries can be made about what happened out in the world when the shutter was open.

(Kendon, 1990, pp. 29–31, italics in original)

This is important for understanding the roots of Interaction Analysis, but it is also relevant to papers in this volume in two additional ways. First, when specimens are gathered and analyzed in this way, they provide a type of “boundary object” (Star & Griesemer, 1989) that may be powerful for discovery and is common in scientific practice. Specimens in the repository (objects) are captured and indexed (one could also say, conserved or curated) in a way that maintains their identity through time and across distant uses. This is important, of course, because specimens can be used in dramatically different ways (e.g., film or video recordings can be played back, repeatedly, to recover and analyze different modalities of talk and embodied action). This requires that specimens are captured and their conservation accomplished in a way that preserves details that might make a difference for analyses framed in different theoretical ways (i.e., different local uses for a durable collection of specimens, when the repository is seen as a boundary object).
possibility for a repository of specimens, particularly used as a means of discovery, is captured nicely by Griesemer (1990):

“Remnant models,” i.e., material models made from parts of the objects of interest … are robust to some changes of theoretical perspective because they are literally embodiments of phenomena. If these embodiments are preserved, they may be studied again and again under different perspectives…. Changes of theoretical perspective about the nature of species can be taken into account by pulling the specimens back out of the drawers or off the shelves and reanalyzing the model in terms of a different set of taxonomic designations. (pp. 80–82)

This “natural history” perspective on a repository of specimens identified the NHI Project as one of the first examples of what we would now call “multiple analysis projects” (Derry et al., 2010; Grimshaw, 1994; see Koschmann, 2011, for a recent and lively effort). The core idea is that with an adequately conserved repository (e.g., indexed using standard forms, made accessible to a group of investigators with diverse theoretical commitments), it may be possible to compare different or competing theoretical treatments of social life (including activities of learning and teaching) using the “same” collection of specimens. While this may be attractive in principle, Hall (2011) notes that these kinds of projects are often fraught with difficulties – capture and conservation of specimens is selective in ways that always involve theory (Hall, 2000; Ochs, 1979), and latecoming contextual information can call seemingly stable findings into question.

Our second move in framing Interaction Analysis of knowledge in use concerns how we might go about locating and studying knowledge in the practical activities of people engaged together, accountably, in social and technical practices that make up what are usually called “disciplines” (e.g., the disciplines of academic mathematics, civil engineering, or museum curating all involve “learning to see”) (Stevens & Hall, 1998) in distinctive ways). To say that someone who proves theorems or designs roadways is a capable member of a “discipline” hides more than it reveals. But how can we go about looking behind these conveniences of classification to find knowledge in use through Interaction Analysis?

Here again, there are rich historical precedents to help theorize knowledge in use and how it is organized as an interactional achievement. A first step is to recognize knowledge in use as a social activity or practice, something that people are doing in diverse settings and with consequences (for themselves and all) that far outstrip the walls of a laboratory or a classroom:

It is a matter of conceiving of cognition, emotion, motivation, perception, imagination, memory … whatever, as themselves, and directly, social affairs. How precisely to accomplish this, how to analyze symbol use as social action and write thereby an outdoor psychology is, of course, an
exceedingly difficult business…. [It requires] regarding the community as the shop in which thoughts are constructed and deconstructed, history the terrain they seize and surrender, and to attend therefore to such muscular matters as the representation of authority, the marking of boundaries, the rhetoric of persuasion, the expression of commitment, and the registering of dissent.

(Geertz, 1983, p. 153, italics added)

The project of creating such a program of studies – an “outdoor psychology” populated with social and technical practices that are changing even as people learn to participate in them – requires that we leave our offices to go see what people are doing in settings where their disciplinary understandings involve or even produce both subjects and matter (i.e., deliberately reworking a view of disciplinary knowledge as already out there, a normatively specified subject matter). The direction in which Geertz was pointing was not lost on two monographs that, we argue, have given a great deal of shape to our field. In the first, Lave (1988) took up a critical analysis of how mathematical knowledge in use in school assessments compared with what adult alumni of schools did in a variety of everyday contexts of quantitative reasoning. Her project embarked from exactly where Geertz left off:

The problem is to invent what has recently been nicknamed “outdoor psychology” (Geertz, 1983). The book is an inquiry into conditions that would make this possible. The conclusion: that contemporary theorizing about social practice offers a means of exit from a theoretical perspective that depends upon a claustrophobic view of cognition from inside the laboratory and school. The project is a “social anthropology of cognition” rather than a “psychology” because there is reason to suspect that what we call cognition is in fact a complex social phenomenon.

(Lave, 1988, p. 1)

In the second monograph, after weeks of tedious observation in the bowels of ship boiler rooms, Hutchins (1995) was released to invent a new approach to the distributed character of way finding on the navigation bridge of a U.S. Navy ship.

I had been asked to write a book describing what is in cognitive anthropology for the rest of cognitive science. I began that project, but after I became disillusioned with my field I lost interest in it. The choice of naturally situated cognition as a topic came from my sense that it is what cognitive anthropology really should have been about but largely had not been. Clifford Geertz (1983) called for an “outdoor psychology,” but cognitive anthropology was unable or unwilling to be that. The respondents may have
been exotic, but the methods of investigation were largely borrowed from the indoor techniques of psychology and linguistics. When cognitive and symbolic anthropology split off from social anthropology, in the mid-1950s, they left society and practice behind.

(Hutchins, 1995, p. xii)

In important ways, the learning sciences we pursue today would not have been possible without the “outdoor psychologies” of Lave and Hutchins.

Interaction Analysis, Members’ Relevance, and Methods

A basic commitment of an IA perspective is to an analysis of “in use,” “in action,” or “in practice.” All of these phrasings index the idea that IA approaches to cognition and learning lean on a sense of “natural” events, as discussed in the previous section. Natural or “naturally occurring” is typically used to refer to events that the researcher has sought to capture without being a strong agent in the organization of those events. When we capture events in settings (e.g., classrooms, workplaces, museums, family homes) that are organized by and for the participants in those settings, we are working from this natural perspective.

A second basic commitment of an IA perspective is to a form of data capture that allows for close, repeated analysis and some accountability to allow for alternative interpretations of the data, either by publication to readers in the form of a transcript that accompanies an analysis or in the form of the actual recordings. Building off Sacks’ (1995) original argument for using recordings, Atkinson and Heritage (1984) argued:

[T]he use of recorded data serves as a control on the limitations and fallibilities of intuition and recollection; it exposes the observer to a wide range of interactional materials and circumstances and also provides some guarantee that analytic conclusions will not arise as artifacts of intuitive idiosyncrasy, selective attention or recollection or experimental design. The availability of a taped record enables repeated and detailed examination of particular events in interaction and hence greatly enhances the range and precision of the observations that can be made. The use of such materials has the additional advantage of providing hearers and, to a lesser extent, readers of research reports with direct access to the data about which analytic claims are being made, thereby making them available for public scrutiny in a way that further minimizes the influence of individual preconception.

(p. 4)

Once data of naturally occurring events are captured in recorded form, further commitments of an IA perspective involve how the data is analyzed. Perhaps the most basic answer to the “how” question is that data is analyzed sequentially,
unfolding in time as *interaction*: as interaction among people and interaction between people and cultural artifacts (e.g., computers, cars, cookware). Nearly always, analysts prepare a transcript of recorded events that either follows an accepted standard (Jefferson, 2004) or is more selectively constructed to display relevant events in the interactional record (Ochs, 1979). Transcripts of human interaction are generally organized into speaking turns, since the turn organization of human interaction is one of the earliest basic findings in conversation analysis (Sacks, Schegloff, & Jefferson, 1974).

The issue of what to transcribe is an important one. One perspective comes from Jefferson (2004), who wrote:

> Why put all that stuff in? Well, as they say, because it’s there. Of course there’s a whole lot of stuff “there,” i.e., in the tapes, and it doesn’t all show up in my transcripts, so it’s because it’s there, plus I think it’s interesting. Things like overlap, laughter, and “pronunciational particulars” (what others call “comic book” and/or stereotyped renderings), for example. My transcripts pay a lot of attention to those sorts of features. What good are they? I suppose that could be argued in principle, but it is also seems to me that one cannot know what one will find until one finds it.

(p. 15)

Jefferson goes on to show through analysis of transcripts, “some places where attention to such features turned out to be fruitful” (p. 15).

In practical work with recordings where transcripts are made, what typically happens is that analysts converge on recorded events of interest (relative to the research questions they are asking) and they work back and forth between evolving transcripts and the recordings (Pomerantz & Fehr, 1997). This poses the question of when to stop adding details to the transcript, and Jefferson (2004) provides an answer in two distinct registers: a *realist* answer that what is represented is “there” in the interaction, but also the *subjective* answer that she finds these details interesting. This is an honest admission, but we think there is perhaps a more principled way to address the “when to stop transcribing” question if we turn our attention to two of the core analytic commitments (i.e., interests) of IA work in conversation analysis: member relevance and procedural consequentiality (Schegloff, 1992).

Member relevance refers to the idea that an analysis of conduct must take, as its first line of work, questions like: What is going on for the different participants? To what are participants oriented? What is the working consensus in this interaction? How through their (varied multimodal) actions are participants displaying and adjusting this mutually constructed orientation to an interaction (e.g., Erickson & Schultz, 1981/1997; McDermott, Gospodinoff, & Aron, 1978; Schegloff, 1992)? In conversation analysis, member relevance typically focuses on membership categories that can be shown to be relevant to a particular interaction (e.g., that a
person is a “teenager”). The reason this is important, following an early insight by Sacks (1995), is that all people are potentially and legitimately categorized in many ways, but only some of these social categories can be shown to be relevant to events at hand. For example, I am a volunteer soccer coach but it would be hard to make that category relevant to my current activities … though I just have. Procedural consequentiality is a further constraint on analysis, building on a prior establishment of relevance. It involves showing that an identity is “consequential for the trajectory of a stretch of talk, its content, its character, or for the procedures used to organize it” (Raymond & Heritage, 2006, p. 679).

In research on learning and development, avoiding extrinsic categories (e.g., teacher/student, expert/novice, motivated/unmotivated) and instead demonstrating their procedural consequentiality during moments of interaction can be a challenge (Hall, 1999). That someone is a teacher, for example, is sometimes relevant and sometimes not. In our approach to IA, people enact membership categories (Schegloff, 2007) by engaging in actions typically bound together with those categories (e.g., interactively producing a crisp initiation-response-evaluation sequence positions speakers as “teacher” and “students”), they bring forward topics or accounts of past-time activities as being in need of revision (e.g., what was good enough before will not be, here and now), and they use these accounts to orient towards future consequences of current activity. In short, people orient to their own learning in ways that show to each other (and make available for IA) a broader kind of “developmental consequentiality” (Hall, 1999, p. 190). An example showing both relevance and consequentiality in an analysis related to the knowledge and learning-centered themes of this volume can be found in Stevens (2010). Here Stevens examines an interaction involving two girls in a classroom. Neither has an official institutional designation as teacher and thereby neither would expect to take the reciprocal role as “learner” or “student” to a classmate. Yet that is precisely what happens in this classroom, which of course is occupied by an adult teacher. Stevens shows the relevance of these reciprocal roles between the girls in interaction, as they mutually position each other in these roles, beginning with a question from one student to the other about how to do something, a question that is met not with a “go ask the teacher” but an immediate demonstration. Stevens shows how these roles are sustained, thereby showing the relevance and consequentiality of “teacher” and “learner” over the course of the analyzed segment.

An IA analysis of member relevancies and consequentiality is achieved through the methods of sequential analysis. Once a recorded event is selected and transcribed to a level of sufficient detail, analysts move through the transcript turn by turn, seeking to see what one turn sets up for a subsequent turn and what those subsequent turns do with prior turns. Said in more familiar human terms, what one person does with the prior contribution of someone with whom they are interacting matters for what comes next. Moving through a transcript (and accompanying video or audio record) is how an analysis of an event gets built up as an analysis of what is going on for the participants in the interaction. If member relevance and developmental
consequentiality provide constraints on analyzing interaction, they likewise suggest a constraint on when to stop adding detail to a transcript, i.e., when a transcript includes all the observable elements in a recorded event that can be shown to be relevant and consequential for the participants within that interaction.

**What Counts as Knowledge**

Turning directly to one of the core constructs for this volume – knowledge – the issue of relevance and consequentiality can be framed in the following way. A typical social-scientific approach to knowledge analysis (in the broad sense, not the specific sense meant by authors in this volume, though it would include their approach) is to determine beforehand what counts as knowledge and then to devise a machinery to detect and capture it in human data (e.g., pre- and post-test, coding interview, or interactional data). What counts as knowledge might be framed in terms of concepts or skills or metacognition or p-prims, but in every case it is a pre-existing, specialized theoretical language that is largely or entirely indifferent to what participants in an interaction count as knowledge and how they handle it according to their own criteria (e.g., its reliability, durability, correctness, incorrectness). One of the primary values of an IA perspective on knowledge is that it provides an ongoing check on what is persistently a danger in the analysis of “others” (especially less powerful others), namely the production of deficit accounts of their knowledge. Attributing a lack of or faulty knowledge to someone from an “outside” perspective now can be juxtaposed to a consideration of whether the status of that apparent lack or faultiness has any meaning or relevance to the participants themselves.

Conducting an analysis of knowledge in use with the criteria of relevance and consequentiality may be especially useful for interactions involving more traditional research activities (i.e., not the sorts of natural events we are mostly interested in) in which the researcher takes a strong role in organizing and guiding events – like interviews and experiments. In these situations, certain aspects of interaction are clearly relevant to the researcher (e.g., math or physics knowledge), but it remains to be shown that they are relevant to the research participants. This is an important issue, because without establishing something like a mutual sense of relevance (e.g., that solving a problem with math or physics matters), researchers’ inferences about knowledge that a participant has or does not have are equivocal. For example, if I were asked to solve a hard calculus problem, I could probably do it but my incentive for conjuring up that long distant school knowledge would be minimal. I might try for a bit, lose interest, and then stop without solving the problem. In such a situation, could an analyst say that I did not know? IA techniques furnish the means to differentiate between events in which some knowledge is demonstrably relevant to participants and those in which it is not, an issue that various chapters in this volume have explored (see Gupta, Elby, & Sawtelle, this volume).
In the first section of this chapter we presented a historical retelling of the formative “natural history of an interview,” and in the second section, we explored some of the roots of the IA approach to knowledge in use within the history and commitments of conversation analysis and ethnomethodology. Education and learning have never been core concerns for studies in these traditions; it took other scholars to pick up these ideas and bring them into contact with education- and learning-related topics. Beginning in the late 1970s, a trio of scholars – Hugh Mehan, Ray McDermott, and Fred Erickson – undertook such an endeavor. Each of these scholars drew heavily on ethnomethodological ideas and conversation analytic techniques in a collection of related studies of classroom talk and social organization. For example, Mehan studied a common interactional structure of classroom talk, the initiation-response-evaluation (IRE) sequence, and showed how IRE sequences were used to ask “known-answer” questions (Mehan, 1979). McDermott (1977a) analyzed a reading lesson in a first-grade classroom to provide an exemplar of an “ethnographically adequate” account of these “concerted” activities among students and a teacher, showing in fine detail how the group moved through a series of “positionings” that were collaboratively accomplished and as a sequence produced what was mutually understood and enacted as the reading lesson. Among Erickson’s (2004) classroom studies was one in which he analyzed a mixed-age classroom (composed of first graders and kindergartners) in which a teacher was asking known-answer questions to the cohort of children, showing how the students less familiar with the interactional organization of classroom talk routines (e.g., kindergartners) were susceptible to “turn sharks,” “who watched for damage in other speakers’ turns. When they saw blood in the water they would strike, taking the turn away from a speaker who had faltered or committed some error in appropriateness” (Erickson, 2004, p. 54–55).

Taken together, these studies established a critical point about knowledge in classrooms – that there were quite particular ways that knowledge could be displayed for it to count; as Erickson put it, contributions to classroom talk needed to be “informationally correct but socially correct as well” (Erickson 2004, p. 55). These studies also showed that when interaction is the medium for knowledge display, the available range of ways of displaying knowledge are often quite narrow and that these ways – or the opportunities to learn these ways – can be unevenly and unfairly distributed among students (Erickson, 2004; McDermott, 1977a). In sum, what these studies did was to show that appearing to “have knowledge” depended on the interactional context of its display.

Comparative Analysis of Knowledge in Use

Another suggestive aspect of these studies is the use of comparison, a use that echoes Howard Becker’s famous framing in “A School Is a Lousy Place to Learn Anything In” (1972), which argued that (a) schools might not be organized
to perform their “characteristic function” (i.e., organizing learning) and that (b) other organizations of activities in contexts other than schools might perform this function more effectively. In these interactional studies, Erickson, McDermott, and Mehan compared the interactional arrangements of classrooms, and the affordances thereof, to those in which the students were otherwise engaged, like their homes. For example, Erickson’s (2004) case of “turn sharking” revolves around a kindergartner named Angie, whose lack of familiarity with having to compete for turns in the competitive environment of a classroom lesson led her to participate in a number of what Erickson calls “inappropriate moments” (p. 66). Based on some visits to Angie’s home, Erickson reports that Angie was an only child, who, in that home interactional context, did not need to compete for a turn at talk with other children (e.g., siblings) and could hold the floor easily (i.e., her parents did not “turn shark” her). While Angie eventually did adapt to the forms and timing of knowledge display in the classroom, Erickson reported on another child named Billy, who did not, and that this had consequences for his longer-term school career. McDermott (1977b) told a similar story about Rosa, a native Spanish speaker and first grader, who was seen by her teacher as an unreachable, failing reader. McDermott shows the value of an interactionally grounded ethnographic approach by showing that both Rosa and her teacher were behaving sensibly, though without what McDermott (1977b) calls “trusting relations” (p. 199) or a “working consensus” (McDermott, Gospodinoff & Aron, 1978, p. 268). The lack of trusting relations meant that the teacher and Rosa effectively and implicitly “conspired” in Rosa “not getting a turn to read.” So Rosa “spends little time trying to read in the classroom; she will either learn to read at home or suffer school failure” (McDermott, 1977b, p. 204).

Other similar comparisons highlighted the different interactional arrangements between classroom and home cultural interactional patterns. Both Erickson & Mohatt (1982) and Philips (1972) showed how classroom interactional practices, like singling out individual students to answer known-answer questions, were at odds with more cooperative and voluntary forms of adult–child communication “preferred” (in the conversation analytic sense) in Native American cultural contexts.

While this formative work used conversation analytic techniques to understand classroom interactional practices and therefore invited attention to the narrow conditions for knowledge display that counted, this work largely did not try to characterize learning itself (Gardner, 2013). The general point these studies made, for those looking for it, was to establish that all contexts present opportunities and constraints on what knowledge will count and who gets to count it (Stevens, 2000b); whether it be a teacher, a researcher, or other participants in the scene (e.g., Erickson’s turn sharks, who knew they could interrupt faulty attempts to hold a turn in the classroom). In showing the narrowness of classroom interactional arrangements for the display of knowledge, suggestive comparisons from these foundational works in the 1970s began to invite attention to how other
contexts might be organized in alternative ways for displaying a person’s knowledge and, in fact, whether that knowledge should be properly treated as exclusively an individual’s.

A dramatic example of how different contexts can be organized for a person to appear differentially knowledgeable is the case of Adam (McDermott, 1993; cf. Cole & Traupmann, 1981). McDermott studied video recordings of Adam, an eight-year-old boy institutionally labeled as learning disabled. These analyses compare what might be called the differential organization of Adam as observably knowledgeable (or not) for others and himself; the comparison involved four contexts of “Everyday Life, Cooking Club, Classroom Lessons, and Testing Sessions” (McDermott, 1993, p. 278). What the comparative analysis argues for is a strong alternative to the default assumption that knowledge (or lack thereof) should be understood to be the sole property of an individual, in this case a learning disabled child. Across the cases, the same child, Adam, appears in some of the contexts rather completely unknowledgeable and incapable (e.g., Testing Sessions) and in other contexts (e.g., Cooking Club, and Everyday Life) he gets along. Why the difference? Because the situations organized around him are differentially flexible and arbitrary in their task demands: the more flexible the environment for getting things done and the less arbitrary the tasks, the more capable and knowledgeable did Adam appear. Though McDermott is using a strategic case to make this relational point about knowledge in use by studying a learning disabled child, it is clear that the conceptual insight can generalize (Becker, 1990) to all contexts of knowledge display.

Disciplined and Disciplining Perception

One paper did take on the question of learning directly using the techniques of Interaction Analysis (Stevens & Hall, 1998). Since we have tried to give our text so far a historical as well as a conceptual basis, we will share some history of how this paper came into existence, what it was responding to, and why Interaction Analysis techniques were valuable in helping us understand the recorded events that were selected to form the two cases in the paper. Our investigations began with a shared principle of both cognitivist- and interactionist-oriented researchers using recordings – to “make sense” of the events available in the recordings. (That same principle animates all of the analyses in the current volume). Searching for ways to make sense of the video recordings, we began exploring conversation-analytic approaches. We found ourselves increasingly attending to interactions as a primary unit, between people (i.e., the tutor and Adam), and between Adam and Bluma’s sensory modalities (i.e., looking, pointing, marking) and the various semiotic/representational materials in the environment. This represented a marked difference from the dominant focus at the time on internal cognitive processes, states, and forms.
These two key ideas about interaction animated the specific findings of the disciplined perception line of work. First, fine-grained attention to the materiality of the task and tool environment and the ways it was used by Adam brought into view what Stevens and Hall would call Adam’s “grid calculus”; the grid calculus was a non-standard but locally productive way to solve some of the problems using a grid of dots that were in the task environment. This was similar to non-standard solution strategies Hall had found in his dissertation (Hall, 1990) and treated as “workarounds” (Gasser, 1986) to the demands of formal algebra instruction. This same grid of dots was of course visible to the tutor, but there was a sense that it was also invisible for practical purposes to the tutor, because she had other routine ways of solving the problems using linear equations. This was why, in the analysis of the recorded events, there was significant confusion in the interaction between the tutor and Adam, because her “disciplined eyes” could not quite see (at least initially) that he was using the grid of dots to solve the problems. Eventually she did come to realize this, and that was the second focus on interaction as an analytic unit in this study: the interactions between Adam and the tutor in which differences in practical action and understanding are shown to develop that are at first unseen, then recognized, then attended to explicitly in interaction. As the productive possibilities of the grid calculus “dawned” (cf. Wittgenstein on “the dawning of aspects,” 1953) on the tutor Bluma, she sought, in a variety of ways, to “discipline” how Adam saw and used the semiotic resources in the environment. In the end, although this was an analysis of cognition, it was one that treated cognition as embodied and distributed, and decisively shaped through interaction, both interactions between people, and between people, tasks, and tools.

This project came to be embedded within a broader shared program of work, studying how mathematics was used “at work.” Hall had studied algebraic problem solving for his dissertation and Stevens had taught mathematics in settings ranging from a school for adults, to a private high school, to a university; in all of these contexts, a common question from students was, “when are we ever going to use this”? Hall and Stevens decided to investigate this question directly, conducting initial fieldwork in a civil engineering firm. Engineers were among the professionals most commonly identified as those in need of high-level mathematics, but there were no studies at the time that detailed how mathematics was used by engineers (or other professionals) in their daily work. Based on the fieldwork, we undertook two comparative analyses; the first compared the engineering design case to the work of middle-school students doing architectural design in their project-based classroom experiences (Hall & Stevens, 1995) and the second compared the tutoring case from Stevens’ prior work to the same engineering case (Stevens & Hall, 1998).

Disciplined perception is a concept grounded in close interaction analyses of video recordings of two pairs of people engaged in complex socio-technical practices. As our recounting of the paper’s history suggests, our interest in putting this concept into circulation was, in part, corrective, as theoretical work often is. At the time the paper was written and revised (between 1992 and 1998), prominent
accounts of cognition and learning left out too much that mattered about how people learned and used knowledge together. These accounts were richly furnished with actants of the mind – schemas, concepts, sub-goals, productions, p-prims – but were anemic when it came to actants of the observable world – voices in conversation, computer screens, drawings, pointing fingers, moving hands, and noticing eyes. This focus on interaction had a basic Deweyan resonance, as written in *Art as Experience* (Dewey, 1934/2005), “The first great consideration is that life goes on in an environment, not merely in it, but because of it, through interaction with it” (p. 12). And because, informed by science and technology studies, we saw disciplinary practices as cultural practices, we sought a better account of how other people shape each other’s practices and understandings through disciplining perception.

Borrowing techniques and principles from conversation analysis and ethnomethodology, we attended to observable actions and interactions, and, moreover, to what participants in interaction were noticing, seeing, using, and making matter to themselves and to each other. What we were studying after all were their interactions, and, however implicit, they themselves had their own understandings of it, which according to conversation analysis, they displayed to each other. As we described earlier, some of these understandings, both between Adam and Bluma and between the two engineers, were unaligned. That we refrained (for the most part) from looking past the observable actants (turns at talk, hands in motions, computer screens, drawings, gestures, pointing, etc.) into the world of mental actants that are so readily visible to many cognitive scientists was indeed our bias, but we held no epistemological or ontological stance (then, nor do we now) that rules out a parallel and integrated account, one that seeks to argue for durable interior resources we “acquire” and carry around with us that give shape to our actions. We do remain skeptical about how observable actants and actions can be seen through to provide a confident account of interior actants and processes, though many of the cases in this volume, by showing real attention to interaction, give us some of the liveliest examples in the literature.

Though we did not elaborate on how we would approach such an integrative account, it is worth exploring how we might do so. “Disciplined perception” used interaction analytic techniques and ideas from science and technologies and ethnomethodology, but it also closely aligned itself, especially in its use of the concept of coordination, with Hutchins’ ideas of distributed cognition (Hutchins, 1995). Following Hutchins’ heuristics (see below) would lead us, we believed, to discover how and when internal representations and processes do real work in contexts of knowledge in use and avoid the “overattribution” that Hutchins diagnoses in his critique of traditional cognitive science approaches (Hutchins, 1995).

When one commits to the notion that all intelligence is inside the inside/outside boundary, one is forced to cram inside everything that is required to produce the observed behaviors. Much of cognitive science is an attribution problem.

*(p. 355)*
In light of this attribution problem, Hutchins argues that we should first describe the representations that are observable in the analysis of any tasks. If the “propagation and transformation of representational state” (to use Hutchins’ technical language) is not observable but happened, then it argues for positing internal knowledge entities or processes. For example, if I am asked for the square root of 121 and verbally produce an answer of “eleven,” if “external” representational transformations are not observable – such as those involving the use of calculator, pen, or paper – this computation could be inferred as an internal process. In fact, in our disciplined perception cases, we implicitly attribute some “background knowledge” in both cases though we don’t elaborate it. For example, in the tutoring case, we highlight Adam’s “simple visual capacities” (Stevens & Hall, 1998, p. 115) as essential to his ability to deploy his grid calculus. Thus, our perspective may be like Occam’s with respect to the attribution of functional internal representations (i.e., favoring parsimony), but it is by no means a principled or ideological objection. And therefore we consider it a fruitful exercise to revisit these cases in the disciplined perception analysis from the perspective of explicitly attributed internal “knowledge” (cf. Levin & diSessa, this volume).

The disciplined perception analyses (Stevens, 1999; Stevens & Hall, 1998) and others coming from the Math at Work project (Hall & Stevens, 1995; Hall, Stevens, & Torralba, 2002; Jurow, 2004; Stevens, 2000a, 2000b) employed comparison in an explicit sense, comparing the talk and embodied action of pairs or groups of people “in different contexts.” For example, Stevens and Hall (1998) compared a tutoring interaction around recognizably school mathematics involving coordinate systems, graphs, and equations with interactions between two architects involving engineering-specific coordinate systems and conventional representational media of plans, sections, and profiles. These analyses also employed a less obvious form of comparison, in comparing and connecting non-contiguous events. The purpose of these comparisons was to provide accounts of learning that extend over time (see Hall [1999] on ways of following “developmental consequentiality”). While much of our work has involved comparative analysis, there are still serious methodological questions about how to make connections across non-contiguous events, a seemingly pervasive and largely ignored analytic issue.

Stevens (2010) identifies two distinct approaches to the analysis of learning – one endogenous and one exogenous. The exogenous approach dominates in formal contexts and in academic discourse, though arguably the endogenous approach dominates in almost all of the other contexts of human activity and learning, making it the primary learning phenomenon worth understanding. The conventional exogenous approach involves analysts or experts administering instruments or procedures (e.g., tests, surveys, interviews) at two (or more) points in time and using differences between (or among) performances by “subjects” to make claims for (or against) learning. An endogenous approach that treats “learning as a members’ phenomenon” looks within and across events to understand how participants are initiating, managing, sustaining, and bringing to a close learning as a
joint interactional achievement. Stevens’ analysis showed how the techniques and principles of conversation analysis could be used to show learning endogenously when the datum is a contiguous event, but argued that there were real tensions with “pure” conversation-analytic approaches when an analysis seeks to connect non-contiguous events. Since not all learning happens only within contiguous short-term events (cf. Lemke, 2000), an endogenous approach to learning requires ways of connecting events without falling back into an exogenous approach. This elaboration is beyond the scope of the current chapter but can be found elsewhere (Stevens, 2001a, 2001b).

While much of our prior work has involved comparisons of related activity systems involving different people (e.g., middle-school students designing and professionals designing), more recent work has sought to use IA techniques to more directly explore knowledge in use questions about what psychologists called transfer (e.g., Gick & Holyoak, 1983) and what Lave called “continuity across contexts” (Lave, 1988). These ongoing studies of knowledge in use involve following the same people across contexts (Stevens, Wineburg, Herrenkohl, & Bell, 2005). These studies build on prior comparative work, such as McDermott’s case study of Adam interacting with others in different contexts (McDermott, 1993), and other formative studies that highlight differences in what interactional arrangements are available for knowledge display. In this ongoing line of work (e.g., Keifert, 2012; Mehus, Stevens, & Grigholm, 2010, 2012), we have sought to explore both what counts as knowledge in different contexts (Stevens, 2000a; Stevens, O’Connor, Garrison, Jocuns, & Amos, 2008) and what interactional arrangements are in place for both learning and knowledge display (Stevens, Satwicz, & McCarthy, 2008). Not surprisingly, we have found stark differences in how social and material contexts afford ways of learning and opportunities for using and displaying knowledge. This may seem an obvious finding, though it has had little impact on the practical business of organizing formal or informal learning environments or on how we see people as knowledgeable (or not) across contexts.

We have so far discussed a range of ways that IA techniques have been combined with comparative analysis to explore knowledge in use. These include (a) comparisons of related activity systems involving different people learning and using knowledge, (b) comparisons of distinct, non-contiguous interactional events that can be analytically connected while still treating knowledge and learning as members’ phenomena, and (c) comparing interactional events involving the same people across time and place to explore transfer-like questions. A newer (tacitly comparative) line of work involves using IA techniques to look at intersections between physical mobility and knowledge in use to study people literally in motion. While our work from the outset has been about forms of active movement and embodied practice (e.g., the very active hands and eyes in Stevens & Hall, 1998), these studies push us further to consider a sense of mobility that has always been with us but has been ignored, but is increasingly visible due to the
pervasiveness of mobile information and communication technologies (Taylor, Stevens, & Champion, 2014; Taylor, Takeuchi, & Stevens, in press). Actually, these mobilities have perhaps been understudied because recording technologies have not been up to the task of following them, but also certainly because of a bias toward studying forms of human activity that involve relatively still and boxed-up humans (Leander, Philips, & Taylor, 2010).

Interaction Analysis, Mobility, and Studies of Knowledge in Use

For many of the things that people learn to do together, our understanding of their activity is advanced only indirectly and partially by making inferences about what an individual would need to know to participate in the activity. For some types of activity – e.g., navigating ships (Hutchins, 1995), achieving architectural designs (Stevens, 2000a), performing in team activities like a high-school marching band (Hall & Ma, 2011b), or riding bicycles as a group in an urban street grid (Taylor & Hall, 2013) – doing the activity and quite probably learning the activity would be impossible without careful attention to multiple bodies, multiple experiential modalities, and the structure of ongoing, mobile participation in ensemble performance. It is, of course, possible to see activities like mathematical modeling, engineering design, or scientific inquiry as multi-body ensemble performance and learning, but this has not been typical in our field.

A commitment to studying learning in intact activity systems recommends that we take this wider perspective on knowledge in use in efforts to integrate IA and KA. This is, of course, not entirely new. Reviewing the contribution of cultural and historical theories of mind to our understanding of how people (learners) participate in activity, Duranti (1997) notes:

[T]hinking subjects do not just think, but they also move, build, touch, feel, and, above all, interact with other beings and material objects through both physical and semiotic activity. This perspective, which is often absent in North American cognitive psychology, is close to (and in some cases supported by) recent anthropological studies that treat culture as practices rather than simply patterns of thought.

(p. 282)

Most research using IA to study knowledge in use and how it is learned focuses on talk and action (including use of technology) that is within reach of a stationary, often seated, group of interactional partners, typically within an enclosed space no larger than a classroom or laboratory. While early research in IA traditions has been described as limited by “talk bias” (Hak, 1999; Mondada, 2013), we could add to this “seat” and “container” bias (Leander, Phillips, & Taylor, 2010). Perhaps
this is a result of philosophical traditions that treat knowledge as the contents of a (typically singular) mind that is carried around (only incidentally) by a body. With some notable exceptions (e.g., Ochs, Gonzales, & Jacoby, 1996, set hands and eyes in motion in an analysis of work by university physicists), there is still relatively little work that focuses on the modal engagements of the body in knowing and learning, much less on ways of knowing that involve or appear to require moving bodies (Hall & Nemirovsky, 2012).

Learning to participate in knowledge in use is often also “learning on the move” (Taylor, 2013), in the sense that the joint activities making up these practices regularly extend across settings (e.g., modeling architectural spaces on site and at the drafting table; see Murphy, 2005; Stevens, 2000a) or involve movement as part of the activity being learned (e.g., learning a part in a high-school marching band; see Hall & Ma, 2011b). Extending IA to study knowledge in use under these circumstances, something that we think is implied by the concept of “use” we are advancing, presents challenges and new opportunities.

We Have Always Been Mobile/We Have Never Been A-modal/A-mobile

From an IA perspective on knowledge in use, mobility may be a broadly relevant but overlooked topic. In this section, we consider conceptual practices of scientific and engineering modeling, and in later sections, we describe studies of IA and mobility in a variety of quite different practices. What learning sciences researchers study as “models” rarely include people moving across sites, even though representational practices of modeling and the systems that support them (databases, graphs, tables, etc.) are predicated on (i.e., are about and enact) complex relations between activity in the world and symbols or marks on paper (Latour, 1990). Even if a modeler does not visit the world shown on paper (or a computer screen), representations in modeling are understood to be about that world. Latour (1999, pp. 68–73) describes this activity as “cycles of amplification and reduction” in a case study of soil scientists at work discovering the role that earthworms play in moving the boundary between forest and savanna ecosystems. Plants and dirt are collected, their qualities are coded by type and quantified, and these codes and numbers are arrayed in tables to show changes in soil over time and across space (i.e., soil and plants/animals are “reduced” but their qualities and quantity are “amplified” by coding for later assembly in tables and graphs). Representing or modeling required coordinated movements of people and material across settings, including: the field where samples were cut or excavated, restaurant tables over which samples were ordered and examined, university offices where papers were written, and still other offices where published papers – now in professional circulation – were read and ransacked to contest content claims and borrow methods. Though models (e.g., drawings, tables, and graphs) published in scientific
articles appeared at the end of these active traversals, they were made and read as a demonstrable, reversible, and contestable relation between the world and marks on paper. In this sense, the epistemic practices of modelers – studied as working accomplishments of knowledge in use – have always been mobile.

Lots of people make and trade models for a living, of course. While discipline-specific modeling practices vary with the scale of what is modeled and what networks of modelers value, mobility across settings may be a critical and understudied aspect of how models are made and used. For example, when we set out to study uses of mathematics in design-oriented work (Hall, 1995; Hall & Jurow, in press; Hall, Stevens, & Torralba, 2002; Stevens, 2000a; Torralba, 2006), we faced the immediate problem of figuring out where that work took place and how to follow people (and material) across settings they assembled together in their modeling practices. This was made possible (both as a practical matter and in our imagination) by newly available consumer video recorders with image stabilization features and removable batteries, which allowed us to move with people within and across settings. We also took advantage of wireless microphones that enabled forms of audio sampling that were independent of the location of a moving camera.

For example, with truly separable L/R audio input to a camera or audio recorder, a collection of wireless microphones could be attached to people and places to sample conversation from different positions – both physical and personal – within unfolding activity. Figure 3.1 shows three toon strips\(^5\) of civil engineers talking about roadways in hilly terrain. In the top panel, a senior engineer (Jake; see Levin & diSessa, this volume; Stevens & Hall, 1998) shows how to make a “profile” view of a roadway, and then, seconds later (bottom panel), he shows how to make a “section” view of the same roadway. In the center panel (recorded about an hour later), Jake finds and holds a place along an unusually steep roadway they have designed, then draws and talks through a design rationale that trades the cost of filling in dirt below the roadbed (sketch in rightmost image) against the larger cost of denuding the surrounding landscape.

By following these engineers across settings during their workday (a partial but informative sample of their activities), we learned several things about modeling in design work. First, design conversations typically waited for drawings (e.g., engineers were “rigging”\(^6\) places for comparative analysis and talk; see de la Rocha, 1985). Second, the representational infrastructure of modeling (e.g., computer-aided drawings) amplified information about surfaces in the hilly terrain for volumetric soil calculations, but it simultaneously reduced information about landscape features that were important for a successful design (e.g., trees and other upslope vegetation in the surrounding terrain). Third, what Jake restored to the model (landscape features) in his design rationale suggested that he and (in a learning opportunity for) his junior partner Evan were thinking and acting simultaneously in the office and in the field; knowledge in use while modeling roadways in hilly terrain engaged Jake and Evan simultaneously in the world and on...
paper (Hall & Stevens, 1995; Stevens & Hall, 1998). Finally, as anticipated in Jake’s justification for his junior partner, models that draw together the world on paper can travel and serve as settings for (sometimes contentious) conversations among design stakeholders (e.g., they become a repository for the history of a complex design project; see Henderson, 1998).

We found similar mundane but important aspects of interactive work across settings in the modeling practices of working architects, field entomologists, and habitat conservation planners (Goldstein & Hall, 2007; Stevens, 1999; Torralba, 2006). While there is not space in this chapter to examine the mobility of people and material in detail, an approach to IA that follows people across settings can be valuable for understanding knowledge in use as something that is important from the social actor’s point of view (e.g., Goldstein & Hall, 2007), and it can show how stakeholders in design work hold different, sometimes incommensurable perspectives on the temporal or social scale of the “same” entities. What some KA approaches treat as a normalized collection of elements that people know more/less about may instead be seen as people engaging in conceptual practices that actively bind the world of activity together with representational media in quite different ways. To the extent that practitioners understand knowledge in

**FIGURE 3.1** Showing and doing roadway design in civil engineering: (top panel) A senior engineer shows how to make a “profile” view of a roadway; (bottom panel) The engineer shows how to make a “section” view of the roadway at a particular point along its path; (middle panel) The senior engineer creates a design rationale that trades the cost of filling in dirt against ruining landscape features in the surrounding terrain.
use in these ways (as active assembly), we have an obligation to understand what they understand and do together while participating in these conceptual practices. This way of approaching knowledge in use is also consistent with organizational explanations for why scientific visualization is powerful – modeling practices “draw things together” (Latour, 1990) and support forms of calculation that span remarkable scales of time and space.

**Engaging Bodies to Make Places for Learning**

Our discussion of movement across settings in modeling took for granted that people were engaged together in concerted activity in each of these settings (this is how we found and studied them at work). But working formations in place and how they arise are themselves topics for study in IA. When knowledge in use involves (or requires) people working together, how do they arrange or form themselves in ways that support this activity? What kinds of formations are possible or typical, and how do people on the move manage to create places/formations for joint work/activity? As Goffman (1983) put it near the end of his career in a retrospective on studies of the interaction order,  

> What sorts of animals are to be found in the interactional zoo?… One can start with persons as vehicular entities, that is, with human ambulatory units. In public places we have “singles” (a party of one) and “withs” (a party of more than one), such parties being treated as self-contained units for the purposes of participation in the flow of pedestrian social life.  

*(p. 6, italics added)*

“Withs” can be understood as units of multi-party joint attention that are formed in systematic ways within the interaction order that people experience and produce on a daily basis. “Facing formations” (Ciolek & Kendon, 1980; Kendon, 1990) have been studied as systems that create proximal spaces for joint attention and action. These spaces are fitted to human perceptual capacities (e.g., creating a shared region for fine visual focus) and the center region provides a mutually visible region for physical manipulation, using tools or gesture production (e.g., each participant’s “gestural stage” [McNeill, 1992] is oriented towards the center of a facing formation like slices of a pie). Facing formations are dynamic – they open as bodies and attention are recruited to a place, body placement and posture shift with topic change, they are monitored for intrusions by non-members or unwanted overhearing, and they close when interrupted or when the purpose of joint action ends.

For IA studies of knowledge in use, facing formations are an intriguing unit of analysis, since they draw our analytic attention to what people are doing with their bodies in order to have a go at working together. But they may also be
overly generic, in the sense that use of past tense or managing turn boundaries in sequentially organized talk are structural aspects of almost any human communicative activity. These scenes of mutual engagement and monitoring of the surround for interruptions may be very common in human interaction, particularly when people gather around a focal object and tool-mediated joint action (C. Goodwin, 1994, 2013).

Our interest is in facing-formation systems that form joint attention for doing things that are specific to the conceptual practices we are studying. In this sense, Jake and Evan (the civil engineers we described earlier) are doing something specific to roadway design, in an interactive environment (setting) that has been rigged to make this possible (e.g., what Hall & Stevens [1995] called a “paper space” for roadway design). The same might be said of archeologists (C. Goodwin, 1994) who have rigged up a pit they are excavating as a 3D Cartesian space for precise spatial description (i.e., they act through a “structure of intentionality” [p. 609] specific to disciplined perception in archeology). And if we follow archeologists out of the pit (Hall & Ma, 2011a), we find them using their bodies in ways that establish a reversible “ground truth” (Pickles, 1995) relation between material of interest in the field (the physical remains of past-time dwellers) and remnant models of the field (in digital and material form) back in the lab. Learning to see (Stevens & Hall, 1998) like an archeologist or an engineer is also learning to move in the field, in the lab, and in the relation between them in ways that are specific to the discipline.

As a project for continuing development in IA concerned with knowledge in use, how can we animate Kendon’s (1990) concept of facing-formation systems as interactional achievements in spaces traversed by people for (possibly discipline-) specific purposes? Put another way, how do people move and deploy their bodies to look at, manipulate, and talk about entities in conceptual practices in which people operate specific types of representational infrastructure? If we see “persons as vehicular entities” (Goffman, 1983, p. 6), along what paths do people constitute objects of interest, learn new things about them, and thereby make up the content of discipline-specific practices and knowledge?

Ananda Marin (Marin, 2013, 2014) has developed the concept of an “ambulatory sequence” to describe shifts in pacing and body formation as parents and children walk together in a forest park. Since her research questions concern how American Indian families relate in embodied ways with the land as a conceptual practice (i.e., consistent with our concept of knowledge in use), her analysis of these sequences provides a set of findings that begin to show how paths (mobility) and sequentially organized talk assemble ways of understanding land, water, plants, and animals that make up what cultures experience (differently) as the natural world.

In a study of paths taken by visitor groups through a cultural heritage museum (Shapiro, Hall, & Heiberger, 2015), we analyzed how visitors form “engagement contours” around exhibits they select from galleries that display the diverse
history and material culture of American Roots Music. Similar to the ambulatory sequences described in Marin’s study, family or acquaintance groups (we studied 22 visitor groups) walked through the museum gallery at a pace that slowed as one or more in the group found an exhibit that engaged their interests. Engagement had rising and falling contours (by analogy to lines of equal elevation on a topographic map), and in moments of peak engagement, movement typically stopped, distal group members were called over (using voice or hand signs), and conversation started about particularly interesting aspects of an exhibit (e.g., a musical instrument, text and images describing its history, and sometimes audible music). Most members of the visitor group (2 to 5 people) wore a camera, so we could follow how engagement contours initially formed (we think of these as “arrivals”), what happened during interest-driven conversations (e.g., many visitors used smartphones to gather, annotate, and share images or film – forms of personal curation that rescale the museum into social networks and make it more persistent), and how the engagement ended (on “departure,” visitors resumed walking in the gallery space).

Since an analysis of multiple speakers, each moving along independent paths in a richly appointed cultural space (e.g., the gallery space of a museum) is a novel problem for IA and at the edge of (our view of) the field’s capacity, we describe how (Shapiro et al., 2015) have analyzed these materials in some detail. Figure 3.2 shows a map-like visual representation of a path taken by one of our visitor groups – the “Bluegrass Family” (BG; mother, daughter and two sons, and boyfriend of the daughter). All the children (and boyfriend) were active bluegrass musicians, and they produced a series of engagement contours while walking through a gallery where photographs of famous musicians were displayed beside their actual instruments. On the left in the top row of Figure 3.2, we show the gallery space in plan view (case displays for musicians are named in an arc in plan view). We superimposed paths (in gray scale) in the gallery taken by each member of the BG group over a period of eight minutes. On the right in the top row, we redraw paths for group members over time (horizontal axis), while preserving location in the gallery space with the vertical dimension and varying the line quality of visitor paths.

While we trace the path of every visitor in the gallery (a painstaking operation), the units of analysis of greatest interest are engagement contours that form when individual paths intersect and ongoing movement slows to engage with what can be seen, read, or heard in an exhibit. In this transcription system (i.e., talk through time and over space), utterances by individuals are embedded along their paths, and conversations that form in engagement contours collect people (paths) and their utterances (fragments of transcript) together to make a place for engaging with the exhibits. On the left in the second row of Figure 3.2, we show a conversation about Bill Monroe’s mandolin (excerpted out of the larger path diagram) between four of the five members of the BG visitor group. This transcript (embedded in overlapping paths) uses a reduced set of conventions for
showing prosody and turn boundaries, but by locating talk in place, we can see (at various levels of zoom) how talk by identified speakers makes up engagement with particular museum exhibits.

In the second row of Figure 3.2 (on the right), we isolate the path of two BG group members – Adhir (the boyfriend) and Blake (the youngest son) – to show...
a lively effort to get the boyfriend to shift between engagement contours. As is evident in the lighter (shaded) path of the older Adhir, he became transfixed by an exhibit showing the guitar used by Hank Williams during the late 1940s. He remains in reverent silence at the exhibit for 5 minutes (horizontal path, minutes 0.5 to 4.5), while the younger Blake moves back and forth between him and the rest of the BG group (his mother, brother, and sister), trying to collect Adhir for looking at and talking about the other exhibits. After checking in (often without talking) on Adhir five times, Blake finally (at 5 minutes along the horizontal scale) manages to lead him on a tour of the remaining instruments (their entwined paths between minutes 5 and 8).

While there is not yet a consensus on how to analyze IA and mobility in relation to learning or knowledge in use, several observations may be helpful. First, while learning often happens in places, it is also the case that learning can depend on or arise from making places for engaging with entities or phenomena that interest learners. In our study of museum visitor groups, as in Marin’s (2013) study of parent/child observations and talk during nature walks, people make places for learning as they are on the move, slowing their pace and creating forms of engagement that can produce or realize (existing) learning opportunities. Second, while it has been tempting to treat museum exhibits (or other designed environments) as stable information caches for learning, attending to mobility and interest-driven (Azevedo, 2011) engagement with these environments (e.g., engagement contours and personal curation in museum gallery spaces) reminds us that what visitors experience is always a personally edited version (Lave, Murtaugh, & de la Rocha, 1984; Ma & Munter, 2014) of what was designed. By analogy to studies of pedagogical practice, designers create an intended curriculum, but visitors produce the enacted curriculum. Developing new approaches to IA and mobility may support design practices that help to bring idealized/realized spaces for learning into more productive alignment.

Learning By/About Making Things Together

A critical reader might argue that labor-intensive IA that follows mobility to find “withs” in the activities of learners will only reveal the means through which knowledge in use is enacted or learned, but that this tells us little about that knowledge itself (the content or ends from a KA perspective). In this section, we consider cases in which mobility plays a role both as the means for and the content/ends of knowledge in use. This relates to our argument at the beginning of this section that some forms of knowledge in use (e.g., modeling practices in scientific and professional disciplines) are about and appear to require activity that moves across settings, even if we rarely study that activity. More generally, the idea that what people do together with their bodies can be the content (and a central concern) of some conceptual practices is not completely unfamiliar. Dancers, people who play team sports, and ensemble
musicians all deploy their bodies in ways that comprise what they learn and create. For example, Hall and Ma’s (2011b) analysis of ensemble learning in a competitive high-school marching band described an arduous rehearsal process during which marchers learned to create dynamic visual and aural “chunks” that would garner high scores in juried competition. What they learned about a “chunk,” how they learned it, and how they produced it in competition all involved dynamic, multi-body formations.

There may be a large variety of conceptual practices in which mobility is centrally important as means and/or ends for knowledge in use. In another example, Taylor and Hall (2013; Taylor, 2013) reported a design study in which non-driving youth living in urban neighborhoods built bicycles out of discarded or donated parts, then used these bicycles to explore their surrounding neighborhoods. These youth eventually developed “counter maps” which they presented to the city government, resulting in new bicycle lanes being marked on the city’s street grid. One part of this complex intervention involved a “safety ride” through the urban street grid by a sizable formation of youth and adult riders (17 riders). That riding formation, which included youth who did not yet know how to shift gears on their bikes when climbing hills, extended over 1.6 miles in the city and crossed over 20 intersections where the riding formation would need to negotiate street signs, traffic lights, and other vehicles (e.g., cars and buses). Several youth and adults wore GoPro™ cameras attached to their bike helmets, and the resulting video and audio record could be mapped directly onto the urban street grid for further analysis.

Figure 3.3 shows two perspectives on how the riding formation produced their safety ride as an ensemble performance. The top rows show a sequence of street intersections that was part of the safety ride, captured in Street View™ using Google Maps™. Since intersections along the route of the safety ride were a stable part of the transportation infrastructure of the city, we think of them as “semiotic aggregates” (Scollon & Scollon, 2003, p. 175) that, over historical time, bring together diverse structuring resources for human activity. Intersections present riders (also drivers and pedestrians) with signage, computer-controlled signal lights, and street markings that can be used to coordinate who passes through the intersection and in which order. In just this sense, intersections are places designed to produce the sequential order of vehicle interactions while driving in the city. The parallel with studies of sequential order in conversation analysis (Sacks, Schegloff, & Jefferson, 1974) is clear once actual drivers arrive together at the intersection – intersections are sites of interaction order that any urban bike rider (adults in the riding formation, but not yet the youth on their hand-made bikes) will describe in (often vehement) depth when asked about traversing the city on a bike. Types of intersections along the safety ride are one thing to know about (in the active sense), but any particular crossing of an intersection on a bike is also an interactional achievement for riders in the ensemble. Adult riders tried to take bounding positions in the riding formation to protect younger riders, but
FIGURE 3.3 Learning to be a riding formation in an urban street grid: (first row) Sequence of street intersections that operate a turn-allocation system; (bottom row) Toon strip showing a bus intrusion and an adult rider attempting to position his body (moving and then stationary) as repair.
the formation was dynamic, moving like a slinky through the city, and subject to unexpected intrusions from vehicular traffic.

The bottom row of Figure 3.3 shows a toon strip in which a city bus intruded on the riding formation as they were approaching the intersection shown at the top of the figure. As described in more depth in Taylor and Hall (2013), adults and youth announced the arrival of the bus as the episode began ([21:50]), hollering “BUSI!” to riders ahead. The bus, approaching a green light at the intersection, signaled a right turn and drifted into the right lane ([22:15]), even as youth riders slowed and drove up on the sidewalk to avoid being hit (it is illegal to ride bikes on city sidewalks in this city). In an effort to block a right turn by the bus and leave space for two youth riders, one of the adults (also shown in [22:15]) rode between the right side of the bus and the curb, pulling ahead of the bus to stand his bike in the middle of the intersection. Despite the adult rider’s attempt to interrupt and repair the bus’s intrusion, the bus completed a right turn ([22:23]) as youth waited to enter the intersection. Finally, the adult held his position in the middle of the intersection ([22:30]) as youth and a trailing adult rider passed through the intersection, entering against a yellow light and passing through as the traffic light turned red.

Mapped onto the usual understanding of “third turn repair” (Sacks, Schegloff, & Jefferson, 1974; Schegloff, 1991) in IA traditions that led this chapter, the first turn involves youth approaching the intersection with the intention of passing straight through, the second turn involves the bus ignoring their bid for clear passing to intrude with a right turn “out of order,” and the third turn repair involves the adult signaling (by body and bike position) his intention to pass through the intersection as well (he succeeded in holding the bus, but the youth did not follow). This sequence, while not a comprehensive analysis of knowledge in use required for bicycle riding formations in the urban street grid, does illustrate our idea that what people do together with their bodies can be the content (and a central concern) of particular conceptual practices. In this case, an IA plus mobility analysis makes aspects of knowledgeable riding visible, as well as illustrating what we might think of as a zone of proximal development on the move. What youth riders stand to learn by participating in this sort of mobile apprenticeship is how street intersections work, how to interact with vehicles and drivers who treat youth as if they were invisible (e.g., youth were forced into the gutter and onto the curb), and how to survive in an interaction order that remains risky even as it is touted as an opportunity for healthier living and going green – a recurring refrain in the Mayor’s office that eventually inscribed these youths’ desire for bike lanes into the semiotic aggregate of this and other intersections in the city (i.e., lines painted on the ground).

Discussion

We were charged in writing this chapter to provide an overview of IA that could be read alongside the chapter on KA (diSessa, Sherin, & Levin, this volume). As we
took up this task, it became quickly clear to us that IA is neither a singular tradition nor a prescribed, unitary set of methods. So, one of our goals in this paper has been to make some of that breadth and history of development accessible to readers. A good part of how we study what we have called knowledge in use is linked to different traditions for analyzing human interaction (e.g., conversation analysis and ethnomethodology) and to ethnographic studies of scientific and technical practice (e.g., Actor-Network Theory). As we have argued, our work (and many collaborative projects, hopefully more to come) has always pursued an account of knowledge in use and how it is learned, something that is not a central concern of either conversation analysis and ethnomethodology, nor of science and technology studies (Stevens, 2001b; Stevens, 2002). Since one of our early papers (Stevens & Hall, 1998) has become an object of secondary analysis in this volume (Levin & diSessa, this volume), we also included some of the social history of the line of work that produced that paper. That paper, and the ensuing conversation with proponents of KA from diSessa’s group, span over 20 years of productive exchange that are made visible and furthered considerably in this edited collection.

Our ever-evolving approach to studying knowledge in use continues to invite careful attention to interaction between people and among people and things (e.g., tools, the built environment). Our approach also argues for an analysis of learning as an accountable activity – accountable in Garfinkel’s (1967) sense of “observable-and-reportable” (pp. 1–2) – that is transacted in unfolding moments of time but that is often connected (as evident in participants’ talk and actions) by participants themselves to broader scales of time, place, and social relationships. These studies focus on learning as a member’s phenomenon (Stevens, 2010) with careful attention to developmental consequentiality (Hall, 1999).

The epistemic stance we take and the commitments we make in this approach include: (a) striving for “descriptively adequate” (McDermott et al., 1978) accounts built from recordings of human interaction during people’s concerted activities, supplemented by broader ethnographic observations (cf. M. H. Goodwin, 1990), (b) giving analytic primacy to the social actor’s point of view and to what is demonstrably relevant for those we study, (c) making inferences about knowledge in use that are grounded in the details of visible and audible traces of people’s activity before appealing to hidden mental contents or mechanisms (Hutchins, 1995; Latour, 1987), (d) following the social history of changing socio-technical practices as conditions of possibility for knowledge in use (Lave, 2011), (e) maintaining an open stance towards what can be discovered in records of ongoing human activity (diSessa & Cobb, 2004; Koschmann & Zemel, 2009), and (f) offering an open account of our own desires and interests in pursing IA approaches that we believe contribute to generous* research in the learning sciences (Hall, Nemirovsky, Ma, & Kelton, this volume) and more just social futures (Espinoza & Vossoughi, 2014; O’Connor & Allen, 2010).
Although we have sprinkled this chapter with a fair amount of history, we did not set out to write a comprehensive history of IA approaches to knowledge in use. Instead, our primary goal has been to point forward to work currently underway in this area and to what seems to lie just ahead, at the edge of what is currently possible, in this research. We have devoted considerable space to studies that engage in comparative IA of knowledge in use, either across time within a setting or across settings (and time) as people do things and learn together on the move. An IA approach to learning and knowledge in use that includes mobility is, we think, one of the leading edges of our field. As we have argued, learning as a member’s phenomenon does not always (or perhaps only rarely) remain within the container of physical settings (e.g., classrooms) that have been typical in learning sciences until just the past few years.

What technology allows us to capture and the ways it can support novel lines of analysis has been a recurring topic in this chapter. As technologies for recording, organizing and indexing, and visualizing human interaction advance, the kinds of data we can gather, analyze, and curate are rapidly expanding. Recordings of human interaction in and across the cultural landscape set up new opportunities and questions for knowledge in use and learning “on the move” (e.g., our brief descriptions of research by Kiefert, 2012; Mehus, Stevens, & Grigholm, 2010, 2012; Marin, 2013; Shapiro et al., 2015; Taylor, 2013) show various directions forward in this landscape). As recording devices become multiple and wearable (e.g., Ma, this volume; Sherin, this volume), learning sciences research is being swept along with digital consumer culture towards massive stores of “personal data” and a growing interest in personal analytics (Lee, 2015). More so than ever, capturing, analyzing, and curating “data” about one’s self and one’s consociates is itself a member’s phenomenon. This creates new opportunities for research.

There remain important issues for ongoing research regarding how different contexts shape the deployment and development of knowledge for use, with contexts understood both as places and as settings organized by people and things in interaction to deploy and develop knowledge. Another important issue, also made possible by innovative uses of recording technologies, is capture of the “same” event from different perspectives. This has been a metaphoric goal of ethnographic work from the beginning, especially with the injunction to study from the “native’s point of view.” But this metaphor is more easily realized now, with the ubiquity of wearable cameras that provide something like a first-person perspective on unfolding events. Another use of technology for multiplying perspectives appears in studies by Stevens and colleagues, in which multiple recordings of the same event, from different perspectives, are recorded simultaneously (e.g., the view of people in a room interacting and the view of dynamic video game play they are engaged in) and then synchronized to constitute new kinds of video data (Stevens, Mehus, & Kuhl, under review; Stevens, Satwicz, & McCarthy, 2008).

Our approach to studying knowledge in use should make clear that IA is more than a method. The IA perspective informs our understandings of what counts
as knowledge, where and how it is to be found, and how it is learned. It informs how we see knowledge as the same (or not) across time and place. And so, new developments in IA will continue to evolve with new theoretical ideas about how knowledge moves, changes, and settles – in bodies, places, and even minds.

Notes

1 The NHI seminar started with several video recordings of family members involved in psychotherapy, but the recording receiving the closest scrutiny was an “interview” between Gregory Bateson and the mother (Doris) of a family seeking psychotherapy. The interview concerned the mental status of Doris’s young son, who can be seen playing in and around the room during the “interview.”

2 Griesemer’s (1990) use of “model” refers to the entire collection of specimens (the repository), while his use of “material” refers to the idea that specimens are genuine samples from the world about which a theory is made. Video and audio recordings of human interaction are always selective (Hall, 2000), hence our focus on curation and conservation.

3 Two earlier versions of this paper were submitted as first- and second-year projects by Stevens in the UCB graduate program in Cognition & Development. The first was entitled “Through Disciplined Eyes: The Dawning of Aspects and the Evolution of Noticing,” and the second was entitled “Disciplined Perception: Learning to See.” diSessa was a reader for both of these papers and Hall was a reader for the second. Alan Schoenfeld was the other reader for the first paper.

4 This account was extended in Stevens dissertation “Disciplined perception: Comparing…” which compared middle-school students doing architectural design projects in their middle-school classrooms with professional architects doing their work in their firm’s offices and in the field. This study was conducted as part of Hall’s NSF-funded “Math at Work project.”

5 What we call a “toon strip” borrows the conventions of panels, sequence, and gutters (or dialogue balloons) from cartooning (McCloud, 1993) to show unfolding details of talk in interaction among people and things.

6 By “rigging” we mean forms of “personal invention” (de la Rocha, 1985) and other ways in which people layer/make places with representational infrastructure that supports what Hall (1990, p. 88) termed “continuity of activity across settings.” In our studies of design-oriented uses of mathematics at work, settings were systematically “rigged” to support the “same” ways of thinking in different places (e.g., in the lab and in the field for a group of research entomologists (Hall, Stevens, & Torralba, 2002; see Latour [1993] for a similar argument about the rise of germ theory in France).

7 Goffman’s writing about the interaction order remains a central resource for IA, but different traditions (notably conversation analysis and ethnomethodology) formed and have taken a different stance towards social order since at least the middle 1960s (see Schegloff’s introductory essays in Sacks [1995]). While beyond the scope of this chapter, the recent controversy over “epistemics in action” (Heritage, 2012) includes themes related to the purpose of this volume.

8 We attach GoPro™ HD cameras to CD jewel cases worn on lanyards around a consenting visitor’s neck. This produces quite good sound and surprisingly detailed video records of things directly in front of the visitor, including their use of smartphones or computer tablets (brought to the museum by most visitors).

9 By “personal curation” we mean activities of gathering, annotating, and sharing images, sound, or video among members of a visitor group and their (much larger) social or professional networks available through social media platforms. We think of personal curation as a form of learning that makes places for shared interest and inquiry.
The Mondrian Transcripts™ we work with use color, which makes speaker/visitor paths much easier to distinguish. For the purposes of this chapter we use gray-scale shading.

References


Stevens, R., Mehus, S., & Kuhl, P. (under review). An interaction analysis of joint attention and joint action in a laboratory experiment with infants: Results from an interdisciplinary study.


