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The Constitution of Expert-Novice in Scientific Discourse¹

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This paper argues that an examination of expert-novice relationships in unfolding interaction should not proceed from the static and unidirectional view that knowledge and status are distributed as functions of a priori categories such as age, gender, and hierarchical rank. Although analysis of interactional sequences from the group meetings of a university physics team reveals the co-occurrence of professional status and expertise in some segments of the data, we show, through a conversation analytic approach, that the constitution of expert-novice in dynamic interaction is a much more complicated, shifting, moment-by-moment reconstruction of Self and Other, whether within a speaker's talk or between speakers. We demonstrate that the constitution of a participant as expert at any moment in ongoing interaction can also be a simultaneous constitution of some other participant (or participants) as less expert, and that these interactionally achieved identities are only candidate constitutions of Self and Other until some next interactional move either ratifies or rejects them in some way. This way of viewing expert-novice relations can help account not only for the bidirectionality postulated in those models of apprenticeship, socialization, and learning which are based on activity theory but also for change and innovation in communities of practice. The implication for research raised by this study is that the analysis of language use ought to go beyond the extrinsic social, cultural, and biological identities of speakers and recipients; it should include an analysis of how utterances constitute these identities and how utterances are organized despite these identities.

INTRODUCTION

Many models of socialization, of occupational or professional apprenticeship, and of learning in formal and informal contexts have assumed a unidirectional transference of norms, skills, and knowledge from one group or individual to another.

While these groups or individuals may be differentiated by categorical asymmetries such as age, gender, and status, it is the relative asymmetry in competence which has been central to such models of social, cultural, and cognitive reproduction. Perhaps to avoid the evaluative implications of the competent-incompetent dichotomy, certain streams within the social sciences have preferred to view the processes of socialization and learning as metaphorically akin to occupational and professional apprenticeship, in which "experts" initiate "novices" into particular worlds of cultural and social competence. Yet, such a change in imagery has not always brought about a concomitant change in viewing socialization as an essentially unidirectional process.²

In contrast, other research, grounded in activity theory (Vygotsky, 1978; Leont'ev, 1981; Engeström, 1987; Smith, 1990), has stressed that learning is not simply a passive transference of knowledge from the more competent to the less competent. Instead, it is seen as an active and interactive process in which learners or novices increasingly participate in a community of social practice and in which the thinking and identity of competent experts as well as novices are transformed (e.g., Engeström, 1989; Lave & Wenger, 1989; Rogoff et al., 1989; Rogoff, 1990; C. Goodwin, 1991). Such a viewpoint posits learning not as a mental event internal to an individual but as a social achievement within a complex framework of community, goals, tools, and activities. These studies also go beyond activity theory by concretizing apprenticeship in various actual cultural and professional contexts. Moreover, in addition to acknowledging that experts can "expertize" the novices, this research is also better able to account for innovation and change in any community of practice because it has recognized that novices can sometimes affect the experts as well as the community of practice.

Lave & Wenger (1989), for instance, view this interactive dimension in any community of practice as an underlying tension between the reproduction of the community and the displacement of the experts, a tension which is necessarily worked out locally between individual novices and individual experts. For novices not only must learn

to engage in the existing practice, which has developed over time: to understand it, to participate in it, and to become full members of the community in which it exists . . . they have a stake in its development as they begin to establish their own identity in its future. (Lave & Wenger, 1989, pp. 33-34)

This is not to say that all experts view novices as threats, but that some experts may recognize the benefits which can accrue from a naive and inexperienced perspective.³ Such interaction between experts and novices can increase "reflection on ongoing activity" (Lave & Wenger, p. 35) and allow the expression of multiple perspectives. When this view of the "peripheral participation"⁴ of novices in communities of practice is endorsed, even an expert, with a recognized historical status of competence, "can to some degree be considered a 'newcomer' to the future of a changing community" (Lave & Wenger, 1989, p. 35), especially in particular moments of micro-interaction. And thus, the identities of expert and novice are not entirely static; they can also be understood as complex and dynamic constitutions and reconstitutions of Self and Other brought about by and through interaction over time. Nevertheless, the literature on apprenticeship and expert-novice relations has not, in our view, shown in sufficient detail how expertise and novicehood are interactionally achieved.

A similar notion of the gradual development of competence in cultural practice also informs situated studies of child language socialization (e.g., Ochs & Schieffelin, 1984; Schieffelin & Ochs, 1986; Crago, 1988; Ochs, 1988; Cook, 1990; M. Goodwin, 1990; Miller et al., 1990; Schieffelin, 1990; Heath & Chin, forthcoming; Ochs et al., forthcoming). In these studies, language acquisition is seen as the socially achieved outcome of particular and recurring interactional moments between caregivers and children in particular societies. Based as they are on recorded and transcribed interactions, these studies suggest that to learn a language is also to learn a culture, because culture and interaction are the only contexts in which language has meaning. In this view, linguistic knowledge is more than knowledge of the language as a self-contained system; it is knowledge both of how language constitutes and is constituted by culture and of how language constitutes and is constituted by interaction within a culture. Nevertheless, even in these studies, the identified "expert" or "novice" is apparently an ethnographic given due to the obvious differences in cognitive and social development between caretakers and children.⁵ And thus, although many of these caretaker-child studies are based on models of socialization derived from activity theory, they rarely illustrate the bidirectionality of learning which these models assume.

Defining "Expert" and "Novice"

We would argue that viewing expert-novice as a bipolar dichotomy or as some set of relative statuses to which individuals may be assigned fails to capture both the complexity of what it means to "know things" and the dynamic fluidity of expert-novice relations as they are constituted in unfolding interaction. On the one hand, any individual is a particular complex combination of knowledges, perspectives, experiences, and expertises in the general sense of knowing things and knowing how to do things. This complexity may, to some extent, derive from categorical social identities, such as gender, age, education, and rank, but it also comes from an individual's own history of experiences (or lack of them) in previous particular interactions. Any relationship or interaction of individuals thus necessarily involves multiple asymmetries of knowing, which may be invoked in or relevant to a particular situated context.

On the other hand, it is through interaction itself that participants display, whether verbally or non-verbally, the relevance of the differing amounts or kinds of their knowing as well as their assumptions concerning the knowledge of other participants, and these displays (or lack of them) are also what constitute the nature and structure of particular interactions. Indeed, since all talk-in-interaction is oriented to some particular recipient(s) at some particular point in the talk, the distribution of expertise in ongoing talk has to be seen as a jointly constructed achievement between participants (Schegloff, 1989). And thus, while knowledge and social identity for an individual may cognitively derive from the processes of socialization and training as well as experience, their status relative to other participants' knowledge and social identity must be collaboratively achieved as interaction unfolds. For, like all intersubjective meaning, social identities, including "expert" or "novice," in some sense do not exist outside the mind of an individual without an Other to recognize them and ratify their meaning. Thus, even when objective differences in competence among participants obtain, these differences can be seen to be relevant to participants when they are constituted in interaction, and in some moments of interaction an expert may be merely one who is momentarily constituted as "more-knowing" (rather than "all-knowing"), while a novice may be one who is momentarily constituted as "less-knowing" (rather than "not-knowing"). The identification of participants as experts or novices, for our purposes,

is thus a metaphorical labeling of their interactionally achieved asymmetries of knowing; it is not directly or necessarily a function of participants' professional certification or licensure.

To illustrate hypothetically at this point, if a speaker evaluates something a recipient has done, offers advice, or delivers a directive to the recipient, this act is a candidate constitution of the speaker as the one who, at that interactional moment, is knowledgeable enough to evaluate, give advice, or command, and, simultaneously, it is also a candidate constitution of the recipient as the one who, at that interactional moment, is in need of evaluation, advice, or direction.⁶ However, in the very next interactional moment, certain utterances could be produced by either the speaker or the recipient which may or may not ratify the candidate expertise and candidate novicehood presupposed in the speaker's original utterance. The recipient, for instance, may design his or her uptake to reject the speaker's evaluation or to refuse to fulfill the directive. Moreover, the original speaker may modify his or her own utterance as it is being produced (C. Goodwin, 1979; Schegloff, 1979) or as it comes to completion. Similarly, if a speaker asks for information or advice, this act, in that interactional moment, can be a simultaneous candidate constitution of the speaker as less knowing or less competent and the recipient as more knowing or more competent. Whatever occurs in the next moment of interaction will ratify or call into question those candidate identities. In other words, a candidate constitution of an "expert" can simultaneously be a candidate constitution of a "novice" (and vice versa), which requires some next interactional moment in order to be ratified or otherwise challenged.

This is not to say, however, that *every* candidate constitution of an "expert" is *always* a simultaneous candidate constitution of a "novice" in an apprenticeship sense. For instance, a specialist physician participating in a case conference with physicians from other specializations may have her opinion oriented to by the other participating physicians as one of a set of complementary expertises and not as a novice with respect to the other specializations. Although it is true that each specialist knows less about each of the other colleagues' specializations, for purposes of conducting a case conference it is the distributed expertise, and not the gap between expertise and lack of expertise, which is likely to be the most relevant differentiation for the participants in this kind of interaction. In contrast, when this same specialist physician oversees a case conference involving medical students, it is likely that her opinion

will be oriented to by the students as more expert relative to the views of the less competent trainees. Whether an utterance is understood to momentarily constitute a recipient as a novice or as a complementary expert may thus depend on the relevance of particular interactional contexts and particular combinations of participants. But whichever expert/novice or expert/other-expert statuses may be relevant to the participants, the course of talk in any context can always be flexible, contingent, and fluid from moment to moment.⁷

This way of viewing the distribution of expertise is particularly crucial when analyzing peer interactions--interactions among colleagues or team members--who cannot simply be divided into those who know and those who do not know, since they are all people with different specializations and different levels of experience. The constitution of "expert" or "novice" in such contexts is thus potentially an ever-changing distribution of relative knowing which can be reconstituted anew in the moment-by-moment unfolding of interaction.

DATA

To illustrate how the conceptualization of "expert" and "novice" as dynamic and mutual socially constituted interactional achievements differs from traditional unidirectional and status-derived notions of distributed expertise, we shall examine several segments of two different meetings of a university physics research group. Such a group is an interesting focus for the study of expert-novice interactions not only because it is comprised of adults who, whether native or nonnative speakers of English, have sufficient linguistic, cognitive, and professional competence to engage in a physics research team, but also because the members can be ethnographically categorized as falling along an actual professional hierarchy, from principal senior investigator to third-year graduate student.⁸

Our segments are taken from a large database of 26 video-recordings representing approximately 60 hours of face-to-face interaction between members of a physics research team collected over a six-month period.⁹ Three of the sessions are of members performing experiments, but the remaining recordings are of group meetings, normally scheduled once a week, in which the members

come together to report on the progress of their individual and/or collaborative endeavors, to rehearse for upcoming conferences, to discuss professional matters (e.g., job and grant applications, networking, conference news), and to devote a limited amount of time to collaboration and feedback on written documents, such as abstracts, CVs, and co-authored manuscripts. The general format of these meetings is that of an informal roundtable discussion, moderated by the principal investigator, in which participants may make use of a blackboard, overhead projector, and various types of written and graphic documents, whether the meetings take place in a classroom, a conference room, an office, or a laboratory.

The Participants

The members of the group¹⁰ at the time these videotapes were made, included:

- Ron: principal investigator, tenured professor of physics, American male.
- Isabel: post-doctoral fellow, faculty member in the physics department of a European university, Portuguese female.
- Gary: post-doctoral fellow, temporary instructor of physics, Canadian male.
- Jeremy: post-doctoral fellow, temporary instructor of physics, American male.
- Miguel: advanced doctoral candidate, Colombian male.
- Marsha: advanced doctoral candidate, American female.
- Daniel: doctoral student, Hong Kong male

In background interviews the participants emphasized the somewhat extraordinary makeup of this particular research group. They reported that most physics groups are either experimental or theoretical in research orientation, whereas their group is composed of both experimentalists and theorists (Ron, Jeremy, and Isabel are the theorists). They also reported that although it is especially

unusual for a principal investigator who is a theorist to direct experimentalist graduate students, as is the case in this group, having opportunities to interact with theorist/experimentalist counterparts can be stimulating and beneficial to their work. They also remarked that such interaction is congruent with this particular principal investigator's advocacy of greater collaboration between theorists and experimentalists.¹¹

Another aspect of the context worth mentioning is that the group does not work during the week as a single unit of seven collaborators. Rather, members work in isolation and in occasional small collaborative groups of two or three. Although members may schedule additional meetings with the principal investigator, the weekly group meeting functions as the main forum for each individual member to talk to the principal investigator who, during the week, is often occupied with administrative and professional duties on and off campus.

DISCUSSION

A conversation analysis of these meetings reveals that the constitution of expert-novice relations is interactionally achieved in the course of unfolding talk. We shall show that at times the constitution of "expert" and "novice" is consistent with the institutional hierarchical ranking of the participants, while at other times it is not. That is, in certain segments of the talk, the display and constitution of "knowing more" coincides with the distribution of institutional status within the group, while during other parts of the talk, a lower status member is constituted as "more knowing." In addition, we shall show that within the talk of one person and within the talk between interlocutors, the constitution of expert-novice can shift on a moment-by-moment basis as interaction proceeds.

Co-Occurrence of Higher Status and Achieved Expertise

Not surprisingly, in the institutional context of a university scientific research group, many stretches of talk in our transcripts attest to the socialization of junior members by more experienced senior members. In much the same way as in contexts involving caretakers and children, the more senior physicists employ the many

resources of interaction to constitute themselves as experts (and the junior members as novices) by, among other things, issuing directives, asking and answering particular kinds of questions, disagreeing, and evaluating the assertions and performance of others.

In Segment [1], for instance, Ron, the principal investigator, is critiquing a graduate student's (Miguel's) rehearsal of a conference talk, which took place several minutes prior to this segment. The conference talk rehearsal involved the use of overhead transparencies ("viewgraphs"), and several aspects of the rehearsal have already been dealt with by this point in the discussion (see Appendix for transcription conventions):

Segment 1 - RO Lab 10-24-90

- 01 Ron: [Okay. Another thing i:s that when you
02 [((looking and gesturing with glasses at
03 screen; Miguel writing notes))
04 say Fishman an' Aharony and
05 Ca:rdy, [(1.0)
06 [((looks at Miguel))
07 on (the)/(your) viewgraph?
08 Miguel: [Yeah.=
09 [((looks up from writing to transparency
10 on OHP))
11 Ron: =[You've go:t to give (em) a reference.
12 =[((looks at screen))
13 You ca:n't just do: that. ((looks at
14 Miguel))
15 (0.6)
16 Ron: Just [gi:ve a reference to the paper.
17 [((Miguel looks at Ron))

...¹²

18 Ron: [Uh:(.) would you just put down Phys-
19 [((looks at Miguel))
20 Re- uh:: that was uh:: Journal of
21 Physics "C" or whatever and Cardy (I
22 think it's Phys Rev "L"). Okay. Just
23 (.) wr:ite it in.
24 Miguel: [Yeah. °Okay.°
25 [((looks up at screen))

Speaking from his notes scribbled during the rehearsal runthrough, Ron starts off with "Okay. Another thing"--first constituting himself as the one who controls transitions from one discussion to another, then orienting himself to the list of matters he presumably wanted to cover in this feedback session. A second observation is that this new matter is begun while Miguel is still attending to his own writing of notes from the previous comments (line 03). When Ron pauses and finds that Miguel is not gazing at him (line 06) after Ron has moved on to his next point, he works to get Miguel's attention by adding "on (the)/(your) viewgraph?" (line 07) with rising intonation.¹³ This move elicits both a verbal and non-verbal response (lines 08-10) from Miguel through which Miguel displays that he is attending to the new discussion.

Once Miguel's attention is focused on Ron's point, Ron produces a series of directives before and after a short side sequence (see Footnote 12), which explicitly formulate what Ron thinks Miguel ought to do and which implicitly point to what the problem in the talk was that now requires remedy. Ron is constituted as the expert not only by his issuing of fairly blunt directives, but also by his conveying of the professional lesson that oral references to predecessors must be accompanied on a viewgraph by complete written citations visible to an audience. Moreover, that Ron attempts to recall the precise citation sources from memory is also a display of his professional knowledge. Finally, the simultaneous constitution of Ron as "expert" and Miguel as "novice" is supported not only by Ron being the critic of the moment, but also by Miguel not objecting to or countering in any way the criticisms and remedy formulated, which, in effect, ratifies Ron's display of expertise. When Miguel finally does respond, it is an unequivocal display of compliance with the directives ("Yeah. °Okay.°"). And indeed, by the following week's meeting he had added the complete references to his viewgraph.¹⁴

Segment [2] is a more complex example of interactionally constituted expert-novice identities co-occurring with institutional status. Unlike Segment [1], in the following segment, the graduate student (Marsha) interacting with Ron is actively participating in the ongoing talk. Yet, all of her contributions are, in one way or another, rejected as candidate claims to expertise by the principal investigator. Just prior to this segment, Miguel had presented a problem he was having with his experimental data: the procedure he was following was possibly producing an experimental artifact which could render his calculations meaningless in the eyes of other

researchers. The problem led to a great deal of discussion among Miguel, Gary, and Ron, but by this point in the session, Ron and Miguel have, for some time, been the only interlocutors trying to sort out the experimental predicament. What follows is an extended sequence in which, in response to a suggestion made by Marsha, Ron launches into a lengthy explanation of why the problem is inherent in the experimental procedure rather than mere error:

Segment 2 - RO Lab 10-17-90

01 Ron: °I see:..°
 02 (0.2)
 03 Ron: What you're saying is that b over a:
 04 (0.2) oh: dear. That's horrible.
 05 {(0.2)
 06 {(Gary vert[ical headshakes))
 07 {4.0} { [(Isabel looks at Ron))
 08 { [(Marsha's gaze to table))
 09 Marsha: ((to Miguel)) Wu- [you ca- you can't
 10 [(Isabel looks at
 11 Marsha))
 12 find a systematic way to subtract it
 13 out?
 14 (.)
 15 Marsha: And say well: this is an
 16 experimental error what if
 17 [I subtract ((to Ron)) this out?
 18 Ron: [No:.. No [it it's worse
 19 [(horizontal headshake))
 20 than that.
 21 (.)
 22 Ron: Uhm: what he's saying is
 23 now I'm beginning to understand
 24 [(1.7)
 25 [(turns body to Marsha)) Sorry (.)
 26 Miguel. () What he's
 27 sa(h)y(h)ing is that (0.2) this delta
 28 nought, this twenty-six,
 29 Marsha: [Uh huh
 30 [(vertical headshake))
 31 Ron: where does it come from. (0.4)
 32 [It comes from the fact that
 33 [(Marsha vertical headshake))
 34 it takes you (0.2) half a second to heat
 35 up.

36 Marsha: [That's what [establishes your barrier]=
 37 [((vertical headshake))]
 38 Ron: [(That's) [(bu)
 39 Marsha: =It's establishing your b-
 40 Ron: It it gives you an effective barrier
 41 height.
 42 [It has no meaning whatsoever. It's
 43 [((Marsha vertical headshake))
 44 simply [a (0.5) (and) the darn
 45 [((raises hand; points to
 46 board))
 47 thing is going logarithmic in that
 48 ((hand falls to table)) time as well.
 49 (.)
 50 Ron: And so: uh: (0.2) you're alw- it's
 51 always gonna look as though there's a
 52 delta nought present.
 53 (0.2)
 54 Ron: ((to Miguel)) Just because of the way
 55 you do the experiment.
 56 (.)
 57 Ron: And there's no (0.2) experimental way to
 58 do any better.
 59 (0.2)
 60 Ron: And so you're really stuck.
 61 [and you can't get down
 62 Marsha: [and you can't just say: [this is a
 63 [((does
 64 "removal" motion with hand))
 65 certain amount of aging
 66 [in my spin glass I'm going to subtract
 67 [((Ron looks at Marsha))
 68 this out somehow.
 69 Ron: Well: if you (heh) (heh) that takes a lot
 70 of faith.

As Segment [2] is rather lengthy, for the convenience of the reader, we shall proceed with our analysis by redisplaying particular portions of the interaction as we go along. We begin here with lines 01-21 for which the reader is requested to refer to the display above.

Ron's claim to understanding (line 01) is followed by a brief pause (line 02) during which no one else joins in the talk, which suggests that the other members are still oriented to being present overhearers rather than active participants in the ongoing discussion. However, when Ron abandons his candidate reformulation of

Miguel's problem for a negative assessment of the predicament (lines 03-04), Gary, Isabel, and Marsha display different reactions to the long silence which ensues (4.0 seconds). Gary, the earliest to react, aligns himself with Ron's assessment through repeated vertical headshakes (line 06); Isabel, after a slight delay, looks at Ron (line 07); Marsha shifts her gaze from Ron to the table (line 08) and self-selects in order to propose a solution directly to Miguel (lines 09-13). Unlike Gary and Isabel, Marsha orients to this pause as an opportunity space for her to become an active co-participant in what was previously a discussion between Ron and Miguel, by posing a question which suggests a possible solution to the problem that a moment ago both the principal investigator and the graduate student in charge of the experiment found insurmountable.

When no response is forthcoming from Miguel (line 14), Marsha appears to orient to his micropause as a signal that more elaboration is necessary, although she might have also chosen to understand his hesitation as a signal of negative stance toward her solution (Pomerantz, 1984b). But as Marsha is appending her elaboration (lines 15-17), Ron interrupts with a rejection ("No:. No") which draws Marsha's gaze (lines 17-18) followed by an assessment ("it it's worse than that."), which implies that while her suggestion is, in principle, the right sort of solution, it is insufficient for the magnitude of Miguel's problem (lines 18-20). Ron's move embodies a stance as an expert capable of evaluating the extent to which a graduate student (Marsha) not directly involved with Miguel's line of inquiry has understood the crux of Miguel's experimental problem.

Segment [2 - Excerpt] - RO Lab 10-17-90

22 Ron: Uhm: what he's saying is
 23 now I'm beginning to understand
 24 [(1.7)
 25 [((turns body to Marsha)) Sorry (.)
 26 Miguel. () What he's
 27 sa(h)y(h)ing is that (0.2) this delta
 28 nought,¹⁵ this twenty-six,
 29 Marsha: [Uh huh
 30 [((vertical headshake))
 31 Ron: where does it come from. (0.4)
 32 [It comes from the fact that
 33 [((Marsha vertical headshake))

34 it takes you (0.2) half a second to heat
 35 up.
 36 Marsha: [That's what [establishes your barrier]=
 37 [((vertical headshake))]
 38 Ron: [(That's) [(bu)
 39 Marsha: =It's establishing your b-
 40 Ron: It it gives you an effective barrier
 41 height.¹⁶

As a way of leading Marsha through a detailed talking through of Miguel's problem, Ron reformulates Miguel's problem (line 22, but previously begun and abandoned at line 03), though now he directs it to Marsha as a correction of her misunderstanding rather than as a confirmation check of his own understanding. Although Ron's reformulation at line 22 is given up momentarily in mid-production to express his own delayed understanding (line 23), Ron repositions his body away from the direction of Miguel and the blackboard to directly face Marsha (lines 24-26).

Restarting his reformulation of Miguel's point (lines 26-28), Ron substitutes the theoretical assigned formula term ("delta nought"¹⁶) with the precise experimental measurement in Miguel's data that is causing the trouble ("twenty-six"), a replacement which manages to elicit from Marsha a display that she has followed Ron's talk thus far (lines 29-30). But instead of continuing the pseudo-cleft construction which he resumed at line 26, Ron poses a question ("where does it come from.") whose answer (lines 32-35) had already been given by Miguel in the discussion prior to this segment. At the hearable completion (both syntactic and intonational) of this question-answer sequence (line 35), Ron and Marsha engage in a competition to gain the floor (lines 36-41), which Ron eventually wins by slightly reformulating Marsha's candidate understanding of the upshot of his point.

Segment [2 - Excerpt] - RO Lab 10-17-90

42 Ron: [It has no meaning whatsoever. It's
 43 [*((Marsha vertical headshake))*
 44 simply [a (0.5) (and) the darn
 45 [*((raises hand; points to*
 46 *board))*
 47 thing is going logarithmic in that
 48 [*((hand falls to table))* time as well.
 49 (.)
 50 Ron: And so: uh: (0.2) you're alw- it's

51 always gonna look as though there's a
52 delta nought present.
53 (0.2)
54 Ron: ((to Miguel)) Just because of the way
55 you do the experiment.
56 (.)
57 Ron: And there's no (0.2) experimental way to
58 do any better.
59 (0.2)
60 Ron: And so you're really stuck.
61 [and you can't get down

quantity as "a certain amount of aging in my spin glass."¹⁷ This rewording of her suggestion appears to be oriented to an understanding that Ron objected to calling Miguel's problem an experimental "error." And thus, Marsha's modified suggestion displays that Ron's more expert objection, elaboration, and clarification have affected the formulation of her candidate remedy to the problem, although she has not given up the fundamental solution of subtracting out the problematic quantity. Ron's initial response (lines 69-70) to Marsha's modified suggestion is not as bluntly rejective as his response was in lines 18-20, but it does display his uneasiness with the leap of "faith" required to support such a solution. Not only does he begin his response with a slightly stretched "Well:"--a typical preface to a dispreferred response (Pomerantz, 1984a; Sacks, 1987)--he aborts a hypothetical utterance ("if you") and accompanies the indirectly negative assessment of Marsha's suggestion with laughter.

In this sequence, Marsha has not succeeded in getting her claims to candidate expertise ratified by either Miguel or Ron. Ron's assessments, disagreements, and extended explanations have constituted Marsha's candidate suggestions and understandings as less expert proposals, while constituting Ron, the principal investigator in this interaction, as more expert.

Segments [1] and [2], then, essentially illustrate how Ron's publicly known and historically recognized status as principal investigator and professor of physics is maintained through the interactional displays and orientations of the various participants. Whether more junior members of the group listen in silence and acquiesce (as in Segment [1]) or attempt to display their candidate expertise (as in Segment [2]), Ron's directives, assessments, rejections, and frequent self-selections at points of turn completion, as well as the participants' orientation to these interactional moves, in these two segments at least, all help to ratify his higher-status roles of group leader and professional expert.

Achieved Expertise Despite Lower Status

The previous two segments illustrated the co-occurrence of expertise and professional/institutional hierarchy in adult peer interaction; specifically, they showed the principal investigator being constituted as more knowing, when, for instance, critiquing conference talk rehearsals or the problem-solving suggestions of graduate students. But as was argued earlier, given the individual

expertises represented by the members of this group, the co-occurrence of expertise and rank in the previous examples may be less a factor of pre-assigned hierarchy and more a factor of Ron's particular expertise lying in certain knowledge domains--how to give a paper, for example, how to ascertain what is problematic, or how to evaluate a proposed solution to a particular experimental problem. Indded, the next two segments illustrate instances in which the lower ranking members of the group are constituted as "experts" because of their particular expertise in certain knowledge domains. This is not surprising if we consider that each member of the group is a specialist in his or her own work regardless of professional seniority. Indeed, as Lave & Wenger (1989) have pointed out, for a community of practice to reproduce itself, it is imperative that "newcomers" develop sufficient original expertise to eventually overtake and replace the "oldtimers."

Segment [3] comes from a subsequent part of the same rehearsal critique from which Segment [1] was taken. Between these segments, Ron, the principal investigator, faulted Miguel (a graduate student) for failing to reference important previous work in his talk. He pointed out in that intervening sequence that this lack of referencing makes it impossible to distinguish between what other particular predecessors (e.g., Birgeneau) have done and what Miguel is reporting to have done.¹⁸ Following a brief pause in which no response is forthcoming from Miguel, the following sequence occurs:

Segment 3 - RO Lab 10-24-90

- 01 Ron: For example, did Birgeneau see this
02 effect?
03 (.)
04 Ron: The [d M d Tee:? ((i.e., $\partial M/\partial T^{19}$)
05 [((Ron points to screen))
06 [((Miguel looks at screen))
07 ((Daniel raises body up from table))
08 (0.8)
09 Miguel: No. Nobody has seen d M d T.
10 People have see:n birefringence,²⁰

Perhaps to elicit some sort of response from Miguel at this point, Ron formulates a yes-no question (lines 01-04) aimed at clarifying what one of the previously named predecessors may or may not have seen. It appears that this is a genuine question since

Birgeneau is an experimentalist who heads an experimentalist research group and Ron, being a theorist, may be less familiar with the literature on experimentation than Miguel. Moreover, following Miguel's answer (line 09), there is no teacher-like uptake²¹ such as 'right' or 'no' on Ron's part; instead Miguel carries on detailing what other experimental groups have seen besides the "d M d T" effect (line 10).²² Although Ron had previously been constituted as an expert in the public presentation of research findings (see Segment [1]), by asking this particular question of Miguel ("did Birgeneau see this effect?") he is now, in this interactional moment, constituted as a "novice" and Miguel as an "expert" in the knowledge domain of the history of previous experimentation.

When Miguel finally answers Ron (line 09), after having looked at the screen on which the d M d T effect is projected (line 06), his answer is composed of two parts: a response to the question about Birgeneau ("No.") and an assertion oriented to Ron's earlier criticism that Miguel had not clearly delineated his new findings from the work of predecessors ("Nobody has seen d M d T"). By saying that "Nobody has seen d M d T," Miguel, in one utterance, has constituted his findings as unique in the field. And thus, despite his graduate student status and his advisor's ongoing critique of the presentation, Miguel is constituted as an expert in this interaction by answering Ron's question with absolute certainty, by characterizing his findings as unique, and by not being challenged any further on this particular point.

A similar sequence occurs soon after the same discussion from which Segment [2] comes. In this segment (Segment [4]), Ron is again voicing his assessment of Miguel's experimental predicament, that due to the artifact produced by the experimental procedure, his findings have no real physical meaning and cannot be reputably reported. However, he formulates this assessment as a candidate understanding of the problem, which Miguel eventually confirms:

Segment 4 - RO Lab 10-17-90

01 Ron: So we're out of business. So (.) what
 02 you're telling me then is [if=
 03 [((looks at
 04 Gary))
 05 =[I ask [Gary and Daniel to=
 06 [((gestures to Gary))
 07 Marsha: [(s:)]

08 Ron: =measure at point nine nine [T g,²³
09 [((looks back
10 to Miguel))
11 (0.5)
12 Miguel: >I don't think you will< get [teh::
13 Ron: [you won't get
14 anything.
15 (0.5)
16 Miguel: No- nothing particular(lar)ly interesting.

Ron's first turn in this segment consists of two parts (lines 01-08). The first part is a display of what he understands to be the upshot of Miguel's problem ("So we're out of business."), which is similar to the conclusion he came to in Segment [2] ("and so you're really stuck.") except that now Ron expresses the problem as a team problem ("we") rather than as an individual problem for Miguel ("you"). The second part begins with the same upshot marker ("So") as the first part, but differs in that Ron now formulates his talk as a candidate understanding of what Miguel was previously implying ("what you're telling me then is"). The candidate understanding is formulated as an if/then construction, with Ron producing only the "if" clause before pausing after a continuing intonation (line 11). This designed incompleteness, momentary hesitation, and gaze toward Miguel invite Miguel to collaborate in the completion of the thought, which he does (line 12).²⁴ Although Ron is obviously in mid-thought and displays a candidate constitution of himself as the one who would "ask Gary and Daniel" to perform the experiment, Miguel at this point collaborates in the prediction of what the results of the experiment would be, a move which seemingly brings Miguel's expertise on a par with Ron's.

The completion of the if/then structure (lines 12-14) is achieved, however, in a somewhat complex interactional manner. Miguel begins to deliver his experimental prediction (the "then" part of the if/then structure), but just prior to possible completion of his utterance, Ron intervenes in Miguel's attempted collaboration (lines 13-14) by overlapping and slightly reformulating Miguel's by then projectable answer, adding the upshot "anything." After a slight pause (line 15), Miguel agrees ("No-") with Ron's syntactically negative assertion ("you won't get anything.") but then corrects Ron's candidate understanding of the predicted results by envisaging them as not "particular(lar)ly interesting." In this sequence Miguel has been constituted as someone in a position to project the results of particular experimental methods for the team's

research enterprise, despite their having been proposed by the principal investigator. And Ron, on his part, has been constituted as someone whose understanding has been guided and confirmed by Miguel, his experimentalist graduate student.

Segments [3] and [4] have illustrated how displays of expertise can be constituted in ongoing interaction regardless of pre-assigned institutional or professional hierarchical rank. It is not just that experts display expertise, but that this candidate expertise must be ratified in some way by other participants who are interactionally constituted as less knowing in some sense, an asymmetry which is likely to obtain, given the distributed knowledges, perspectives, experiences, and expertises within the group. Moreover, the analysis of Segments [1] through [4] not only supports the notion that being constituted as more knowing or less knowing is a potentially shifting interactional achievement to which participants are oriented as interaction unfolds, it also suggests that the relevance and procedural consequentiality of this or that expertise may change from moment to moment (Schegloff, 1991, forthcoming [a], forthcoming [b]).

Shifting Expertise

That "expert" or "novice" is a candidate constitution of Self and Other which may be ratified or challenged in ensuing talk can be explained theoretically by the varying configurations of at least three interacting dimensions: the individual, the recipient, and the domain (or domains) of knowledge. That is, as we discussed above, the same individual can be constituted as an expert in one knowledge domain, but constituted as a novice when traversing to some other knowledge domain. Secondly, within a single knowledge domain, the same individual can be constituted now as more knowing, now as less knowing. Finally, in either of these two situations, the valence of expertise may shift with a change of recipients.²⁵ In Segments [1] through [4], we were able to illustrate temporary constitutions of less knowing and more knowing by isolating relatively short segments of interaction. We would argue, however, that any isolation of turns and short sequences to illustrate the status of a particular party as *the* expert or *the* novice in a fragment of interaction may be something of an artificial procedure, at least as far as transcripts of adult interaction are concerned, for any next turn can shift the until-then interactionally achieved distribution of expertise.

Let us take, for instance, Segment [4] and the turn which follows (we shall refer to this sequence as Segment [4A]):

Segment [4A] - RO Lab 10-17-90

01 Ron: So we're out of business. So (.) what
 02 you're telling me then is [if=
 03 [((looks at
 04 Gary))
 05 =[I ask [Gary and Daniel to=
 06 [((gestures to Gary))
 07 Marsha: [(s:)
 08 Ron: =measure at point nine nine [T g,
 09 [((looks back
 10 to Miguel))
 11 (0.5)
 12 Miguel: >I don't think you will< get[teh::
 13 Ron: [you won't get
 14 anything.
 15 (0.5)
 16 Miguel: No- nothing particular(lar)ly interesting.
 17 (4.2) ((Isabel looks at Ron after 1.0
 18 second and keeps her gaze on him as he
 19 moves to look at the graph))
 20 Ron: Do I agree with you? ((puts on glasses
 21 and leans forward to look at graph))

In our discussion of Segment [4] above, we noted that the fragment ends with Miguel being constituted as an expert as he confirms Ron's candidate understanding of the predictable experimental outcome (line 16). However, as Segment [4A] reveals, a long silence of 4.2 seconds follows (line 17), which itself may indicate some trouble for the current primary addressee (Ron). During this silence, Isabel's gaze turns to Ron (lines 17-19) who is pondering Miguel's graphs on the table. Her shift in gaze indicates that she considers Ron to be the relevant next speaker given Miguel's assertion at line 16. Ron's response finally comes as a spoken thought (line 20) which in that interactional moment undermines, rather than ratifies, Miguel's previously achieved identity as expert. This move recasts Ron's earlier understanding check as simply a check on what Miguel was literally saying rather than as a display of his acceptance that what Miguel said was correct. Indeed, the effect of Ron's utterance (line 20) suggests that the entire segment (starting

from lines 01-02) may have been a somewhat extended setting up (by Ron) of Miguel's position for critique.

Such a shifting constitution of knowing more and knowing less permeates the group's weekly meetings, some of which go on for more than two hours. Indeed, we sense that it is this interactional dynamism which drives the talk forward as participants disagree, raise questions, criticize, suggest, argue, co-construct utterances, and even remain silent. Were our unit of analysis the laboratory meeting in its entirety, our first four segments would be seen to be part of larger dynamically shifting configurations of expert-novice distribution, rather than snapshots of some temporarily static asymmetrical distribution of status and knowledge.

That the constitution of expertise can shift within the same speaker's talk as well as from one speaker to another is especially revealed in Segment [5]. This sequence comes from the continuation of the discussion concerning Miguel's experimental problem which was talked about in Segments [2] and [4]. This particular segment, however, occurs approximately 22 minutes after Segment [4]. During those 22 minutes (not shown) Ron reintroduced Marsha's suggestion from Segment [2] several times, and, after a brief discussion in which Marsha also participated, Miguel acknowledged that the issue raised by her suggestion was "very important." In terms of the larger context, it is worth mentioning that before the talk in Segment [5] occurs, the status of Marsha's suggestion had been transformed in the course of the discussion from being constituted as a novice suggestion (see Segment [2]) to being acknowledged as a more expert raising of an issue worthy of consideration, even if the suggestion has the status of not being actually implementable. Segment [5] comes in the midst of a detailed discussion between Miguel and Ron concerning the quantitative problems in Miguel's calculations, which have prevented him from accepting Marsha's suggestion on the spot.

In this segment, Miguel takes Ron step by step through the precise alternative (and conflicting) quantities which could be understood to be represented by the symbolic terms of his formula ("b over a"):

Segment 5 - RO Lab 10-17-90

01 Miguel: But I'm saying. (0.5) this over this (.)
02 can be either thirty-two over thirty,

03 (0.2) or it can be: thirty-two minus
04 [twenty-six (.)
05 [((Ron mild vertical headshake))
06 over thirty-two minus [(0.5)
07 [((Ron mild vertical
08 headshake))
09 >thirty-two minus twenty-six over thirty
10 [minus twenty-six.< And those
11 [((Ron mild vertical headshake))
12 are different numbers.
13 [(2.0)
14 [((Ron vertical headshake))
15 [((Miguel vertical headshake))
16 Miguel: >They are close to one< but
17 when you subtract one (0.5)
18 [(and that's) (0.2) that's what I'm
19 [((Isabel looks up at Miguel))
20 interested in.
21 [(5.0)
22 [((Miguel shakes head vertically
23 throughout pause))
24 [((Isabel looks at Ron after 4.0 secs. and
25 then looks at Miguel))
26 Miguel: So that's why this b over a ((i.e., b/a))
27 is bothering me and I (0.2) I have no idea
28 what to do with (it).
29 Ron: But (.) [M a r s h a [has just
30 [((points to Marsha)) [((Marsha
31 looks at Ron))
32 made a suggestion [that by shifting your
33 [((Isabel glances at
34 Ron))
35 time scale [you might be able to
36 [((Marsha looks at table))
37 (make it) go away.
38 [(0.6)
39 [((Marsha looks at Miguel))
40 Miguel: (But) I cannot shift the time scale (.)
41 li- linear(ly).
42 (.)
43 Miguel: By half a second
44 [(0.5) (it doesn't make any) al-
45 [((Isabel glances at Ron))
46 if if I start again (0.2) all the

47 analysis [(.) from
 48 [((Ron looks away from Miguel to
 49 blackboard))
 50 Ron: [No no. That's
 51 [((horizontal headshake))
 52 [((Isabel looks at Ron))
 53 ab- [t h a t ' s: [correct
 54 [((vertical headshakes)) [((Isabel
 55 glances at Miguel))
 56 and I: [I d o n ' t k n- [have a
 57 [((vertical headshake)) [((Isabel
 58 looks at Ron))
 59 suggestion for you. I don't know how to
 60 do that shifting.

Miguel packages his review of the quantitative problem he faces into several extended turns which are punctuated by frequent vertical headshakes on the part of Ron, indicating that Ron is following the explanation and inviting Miguel to continue. After what could be interpreted as a first attempt on Miguel's part to bring the description of the problem to closure (lines 18-20), Ron does not react as before despite Miguel's own vertical headshaking. That it was appropriate for Ron to react in some way at this point can be seen in Isabel's looking to Ron after a 4-second pause (line 24). Miguel's response to this lack of uptake on Ron's part is to offer a sequence-closing-implicative summary of the quantitative problem ("So that's why this b over a is bothering me") and immediately to follow with an admission that he doesn't know how to solve it ("and I (0.2) I have no idea what to do with (it)."), thus indicating the limits of his own expertise. Miguel has displayed that he is capable of defining the problem but not of finding an appropriate solution.

As we saw in Segment [2], in this group meeting when a participant seems to come to a dead end, someone (Marsha, in that segment) fairly soon offers a candidate solution, perhaps in a sympathetic attempt to help a colleague rescue his/her research efforts. In Segment [5], it is Ron who responds to Miguel's throwing up of his hands with another invocation of Marsha's suggestion as a way out of the problem (lines 29-37), a move which now constitutes Ron and Marsha (via Ron) as the momentary candidate experts. Yet, after a pause (line 38), Miguel rejects Ron's (and Marsha's) suggestion (lines 40-44), an interactional move which displays that although Miguel does not know what to do to get out of his predicament, he knows enough to be able to evaluate

Ron's (i.e., Marsha's) suggestion as impossible, thus refusing to ratify the candidate expertise to which Ron's turn made claim.

Miguel's rejection of the reinvoked solution is then followed by an incomplete formulation of what the consequences of taking up the suggestion would be for his work (lines 46-47). Perhaps Miguel has understood Ron's repeated invocations of Marsha's suggestion as an implied directive to begin a major reanalysis of his measurements. Ron dispels Miguel's inferred conclusion ("No no.") and aligns himself with Miguel's critique of Marsha's suggestion ("That's ab- that's: correct"). Ron backs down from his candidate solution and defers to Miguel's expertise as an experimentalist by not insisting that the measurements be reexamined. Nevertheless, though Ron finally admits that he lacks the expertise to suggest a way out of the dilemma (lines 56-60), his utterance presupposes that *some* sort of shifting would give meaning to the data, which is what Marsha had been suggesting all along. What these interlocutors ultimately achieve in this sequence is an interesting equalization of expertise among Ron, Miguel, and Marsha.

Segment [5] illustrates how the constitution of knowing more and knowing less, of "expertise" and "novicehood," can shift from participant to participant and from turn to turn within the talk of the same participant despite historical roles and hierarchical ranking. It was also shown in Segment [4A] that the apparently stable interactionally achieved distribution of expert-novice in a continuous stretch of talk can shift depending on the uptake of a particular participant at a particular point in the talk. Indeed, a closer look at the first four segments discussed in this paper would reveal many similar kinds of shifting of constituted expertise. And, as was suggested above, any isolated segment of interaction may appear to distribute expert-novice roles differently when the larger sequential context is taken into account.

CONCLUSION

This study demonstrates that expert-novice relationships in unfolding interaction are not necessarily functions of a priori macro-level social categories such as hierarchical status. Although some interactional sequences can reveal the co-occurrence of professional status and expertise, we have tried to show through a conversation

analysis of several segments of interaction that the constitution of expert-novice in dynamic interaction is a more complicated, shifting, moment-by-moment reconstruction of Self and Other, whether within a speaker's turn at talk or between speakers, and that the talk can be seen to be intricately organized by participants in ways other than those which derive directly from extrinsic social identities. We have also stressed that the constitution of a participant as expert at any moment in ongoing interaction can be a simultaneous constitution of some other participant (or participants) as less expert, and that these interactionally achieved identities are only candidate constitutions of Self and Other until some next interactional move either ratifies or rejects them in some way.

The interactionally dynamic constitution of expert-novice relations is especially worthy of study in contexts of adult teamwork, such as in a university physics research group, in which individual members bring their particular knowledges, perspectives, experiences, and expertises to the collaborative effort of the team as a whole. For it is through the complex array of questions and answers, of evaluations and agreement, of explication and problem-solving--in short, through the collaborative process itself--that participants negotiate who is more or less knowing at particular interactional moments.²⁶

Thus, rather than viewing interactional behavior as the direct, unproblematic outcome of participants' particular hierarchical social identities, we view interaction as the locus wherein social identities are co-constructed, maintained, and modified with consequences for future interactions, even if participants come to the interaction with professionally ranked social identities and a history of past encounters with one another. Indeed, one of our physicist informants, in a conversation about an earlier draft of this paper, quite spontaneously remarked that it is as if expertise and novicehood can each be understood to have a macro- and a micro-level of realization in that each participant has a macro-level and a micro-level expert-novice identity; that Ron, for instance, as principal investigator and as a leading figure in the scientific community, is unquestionably the "macro-expert" of the group, while in unfolding interaction he may be at one moment a "micro-expert" and at another, a "micro-novice."

It is just such a conceptualization of expert-novice relations, we have argued, that can help account not only for the bidirectionality postulated in activity theory-based models of apprenticeship, socialization, and learning, but also for change and

innovation in communities of practice. This view of the link between the micro-phenomena of interaction and the macro-structures of society and culture has been a philosophical and methodological tenet of ethnomethodology (e.g., Garfinkel, 1984) and conversation analysis (e.g., Heritage, 1984; Schegloff, 1987, 1991, forthcoming [a], forthcoming [b]; Hilbert, 1990), and it has also played an important role in anthropological studies of language use (e.g., Duranti, 1981; Ochs, 1988; Schieffelin, 1990; M. Goodwin, 1990). The implication for research in situated discourse is that in order to capture what any stretch of interaction may mean for the participants, the analysis of utterances ought to include an analysis of how social identities are realized in actual contexts of interaction as well as of how utterances and the surrounding interaction work together to constitute social identities.

NOTES

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² Welker (1991), for instance, eschews the expert-novice metaphor for classroom teaching because it "has been used to buttress professional privilege and to widen the distance between those who know and those who do not" (p. 19).

³ Indeed, because less expert novices have not yet been fully socialized into "insider" knowledge and ways of thinking, they may enjoy a certain advantage in approaching expert tasks. Engeström (1989), for instance, reports that in a task-comparison study (Engeström & Engeström, 1986) novice cleaning workers outperformed expert cleaning workers "in tasks requiring reasoning about the goals and structure of the entire activity system and organization," while experts excelled in "discrete routine tasks" (p. 16).

⁴ Lave & Wenger's (1989) concept of "peripheral participation" refers to the gradual incorporation of a newcomer or apprentice into a community of professionals, beginning with small, non-central tasks and gradually being encouraged by designated master practitioners to work towards a fully integrated professional competency.

⁵ But see Ochs (1990) for a discussion of how so-called novice children socialize their parents into parenting.

⁶ Heritage & Sefi (forthcoming) observe how the giving and requesting of advice in interactions involving health visitors and first-time mothers can constitute the participants as more or less knowledgeable and competent. Likewise, M. Goodwin (1990, pp. 75-108) discusses how requests and directives can constitute the leadership and competence hierarchy in the play activities of urban Black male children. She also sees these constitutions of asymmetrical relationships as

proposed identities which are dependent for their ratification on the response of others.

⁷ We are grateful to Manny Schegloff for pointing out that the absence of expertise in a particular setting may not necessarily be the constitution of novicehood in that domain but may instead be the constitution of another more relevant, complementary kind of expertise. Cicourel (1989) also makes reference to the complex distributions of expertise and novicehood throughout the phases of physician training and in continuing professional medical courses for practicing physicians.

⁸ We cannot say, at this stage of our analysis, whether national origin, linguistic competence, or gender directly play any role in the interactional phenomena we describe. Although we have described the participants using particular categorical terms (see "Participants"), the issue for any analysis, as raised by Schegloff (1989), is whether it can be demonstrated that such categorical or scalar factors are relevant to the participants and have consequences for their interaction as it unfolds.

⁹ We do not mean for this one physics group necessarily to be taken as representative of all physics groups. What is generalizable to other groups, we would claim, is our overall approach: to explore social categories, such as "expert" and "novice," through a close analysis of socially distributed and co-constructed interactional and linguistic phenomena.

¹⁰ Pseudonyms are used to protect the privacy of the participants.

¹¹ To our knowledge, there is no explicit code of interactional conduct established by or for this group to accommodate different types and levels of expertise. In interviews, some of the post-doctoral fellows mentioned that they feel the graduate students deserve priority attention from the principal investigator at the group meetings. However, many of these meetings include interactions primarily involving the senior members, while at other meetings there is much high-spirited disagreement and criticism involving both senior and junior members.

¹² We have deleted the following clarification sequence between lines 17 and 18 in Segment [1] since it is parenthetical to the interaction between Ron and Miguel which resumes immediately afterward:

```
Marsha:  = [Was that the sa:me paper you quoted befo:re?,
           = [((high voice; points [to screen))
                [((Ron turns head to
Marsha))
                [((Miguel turns head to
                screen))
Ron:      Well [we: would have no way
           [((Miguel turns head to Marsha))
           of [knowing. ((horizontal headshakes))
           [((Miguel turns head to Ron))
Marsha:  [You- you quoted one (.) a little (.) at the
           [((looks at Miguel))
           [((Ron looks at Marsha))
           [((Miguel looks at Marsha))
           beginning. (.) [of the talk.
Miguel:  [Well thi:s [one
           [((head and hand to screen))
```

Ron: [This is the beginning=
 [((to screen then Marsha))
 Marsha: =>This's the begi-< Oh. [Sorry.
 [((drops hand))
 (.)
 Marsha: Okay.=

13 Relationships between recipient eye gaze, emerging syntax, and the attention-getting device of pausing are discussed in C. Goodwin (1979, 1980).

14 Our data include photocopies of viewgraphs used in the meetings we recorded. In the case of successive rehearsals of upcoming conference talks, participants kindly provided us with all versions of viewgraph displays.

15 "Delta nought," which is equal to "b over a," is a formula notation corresponding to a barrier height. Space does not permit us to give a more detailed explanation for this and the other concepts briefly defined in this paper. While some of our readers requested glosses for the physics terminology used by the participants, it is doubtful, in the case of the segments analyzed in this paper, whether the simple content glosses which we provide add further understanding to the interactional import of the sequences. See Footnote 16 for an explanation of "barrier height."

16 A "barrier height" is the energy necessary to go from one physical state to another.

17 "Aging" refers to time decay in the measurement; a "spin glass" is a disordered magnet.

18 The entire intervening sequence is as follows:

Ron: ((looks at screen)) (0.4) It's:: you're getting it
 fu:ll I understand that.[But uh::
 [((glasses on; looks at
 notes))
 [Thee uh::
 Marsha: [(I think there's enough room up there.).
 [((high voice, gesturing to screen, opening &
 closing hand))
 Ron: (U- u-) one of-
 [I: have a [pro:b|lem
 [((removes glasses)) [((Miguel looks at Ron))
 [((Marsha raises & lowers
 left hand))
 ((Ron lays glasses on table: 'DUNK DUNK')) (0.2)
 [with your ta:lk, [(0.4) uh::
 [((Ron's hand to forehead)) [((Miguel looks down))
 not with the: (.) the physics in it, but with the
 >la:ck of references to anybody else's work.<
 [(0.4)
 [((Miguel keeps head down))
 Ron: Um:: (.) It's [no:t clear to me what Jaccari:no
 [((Ron points hand to screen))
 [((Miguel looks at Ron))

has done, [(0.4) or what Bir:geneau has
 [((Ron looks at Miguel))
 done, (0.3) an' what [you've done.
 [((Miguel moves viewgraph up))
 ((Ron looks at screen, keeps fingers pointing))
 (.)

19 In Segment [3], we have decided to transcribe spoken versions of scientific notation in as close a representation to their written form as possible so as to preserve their identity as formulaic concepts. Upper case letters in these phrases are therefore not meant to indicate loudness as in conventional conversation analysis transcription (e.g., Atkinson & Heritage, 1984, pp. ix-xvi).

20 "Birefringence" is the optical index of a material.

21 The evaluative teacher comment following teacher-initiated question-answer sequences in classroom settings has been discussed in research representing different discourse analysis traditions (e.g., Sinclair & Coulthard, 1975; McHoul, 1978; Mehan, 1985).

22 The term "d M d T" refers to a quantitative relationship between magnetism (M) and temperature (T).

23 "T g" stands for temperature of the glass.

24 The notion of "collaborative completion" was first introduced by Sacks (e.g., Fall 1965, Lecture 1; Fall 1968, Lecture 5; Fall 1971, Lecture 4). The collaborative potential of if/then utterances has been discussed in Lerner (1987, 1991).

25 C. Goodwin (1981, pp. 149-166) analyzes how, when engaged in a cooperative activity (e.g., playing bridge), speakers modify their emerging utterances as their gaze moves among recipients with differing amounts of relevant procedural knowledge.

26 On the construction of asymmetry in children's peer relationships, see the chapter on directives among Black male children in M. Goodwin (1990).

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APPENDIX

Transcription Conventions

Transcriptions conventions generally follow those developed by Gail Jefferson and other conversation analysts as cited in Atkinson & Heritage (1984, pp. ix-xvi). However, the following modifications to the notation conventions have been used in this study:

- | | |
|-------------|--|
| (xxx)/(yyy) | Alternative doubtful hearings are transcribed on the same line and separated by a slash rather than one above the other. |
| . . . | An inter-linear ellipsis indicate that intervening lines of transcript are not shown. |
| ((xxx yyy)) | Non-verbal behavior as well as explanations of mathematical expressions appear in double parentheses and in italicized font. |
| ?, | A question-mark followed by a comma is equivalent to the intonation notation ?. |