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Sociocultural Approaches to Analyzing Cognitive Development in Interdisciplinary Teams

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Abstract

This paper considers whether a sociocultural theory of cognition can supply a suitable perspective for analyzing the nature of interdisciplinary collaboration within groups in the National Institute for Science Education (NISE). We discuss the metaphors of apprenticeship and voice in conversation to identify relevant elements of analysis in group discourse. The NISE group shows evidence of cognitive apprenticeship and of multiple voicedness, but the theories do not fully explain the impact of interdisciplinary interaction on group cognitive development. Although both the apprenticeship metaphor and the voice metaphor provide useful tools for analysis, it would be useful to have a metaphor that deals more directly with interaction among members of equal status from mature communities of practice.

Introduction

One activity within the National Institute for Science Education (NISE) is the Cognitive Studies of Interdisciplinary Communications project. The goal of this project is to understand factors affecting interdisciplinary collaboration so as to facilitate more productive communication and better designs for team-based organizations and conferences. This issue is of importance not only to the NISE, but to the scientific and business community at large, as many significant problems and products require contributions from specialists with various backgrounds.

The purpose of this paper is to consider whether a sociocultural theory of cognition can supply a suitable perspective for analyzing the nature and productivity of interdisciplinary conversation that occurs within the NISE. According to Wertsch (1991), sociocultural studies provide an account of human mental processes "that recognizes the essential relationship between these processes and their cultural, historical, and institutional settings" (Wertsch, 1991, p. 6). From a sociocultural perspective, interdisciplinary interaction is viewed as communication across cultural boundaries, and attending to how such boundaries are revealed and bridged in conversation should lead to important insights about team functioning and growth of team knowledge.

Alternatives to adopting a sociocultural viewpoint include (a) avoiding perspective-based bias altogether, (b) adopting an alternative theory, or (c) using an inductive research method that admits many different theoretical perspectives into the analysis. Based on philosophical arguments that all observations are theory-laden (e.g., Kuhn, 1979; Lakatos, 1978; Popper, 1959), we reject the idea that theoretical bias can be avoided. Concerning option b, we accept the likelihood that alternative suitable analytical perspectives may exist; however, consideration of other theories is outside the boundary of this paper, which seeks only to assess the applicability of sociocultural theories. Regarding option c, we are attracted to the idea of an inductive, interdisciplinary methodology such as Interaction Analysis (IA) (Jordan & Henderson, 1995) that does not privilege one particular theoretical perspective. We are employing IA approaches in some of our work, but the availability of multiple perspectives is limited and we cannot not rely on it entirely. In addition, even for interaction analysis, we need a theory to insure systematicity in our own observations.

Sociocultural Theories of Cognition

The perspective from which we will examine data borrows from several sociocultural theories: Lave and Wenger's situated social cognition theory (e.g., Lave, 1991; Lave & Wenger, 1991; Wenger, 1990), Vygotskian developmental psychology (e.g., Vygotsky, 1978), and Bakhtin's semiotic activity theory (as cited in Wertsch, 1991). These viewpoints are highly compatible and even borrow from one another, though each contributes unique concepts that are useful for our analyses. All lead to the insight that team productivity and growth of team discourse will be highly intertwined.

Knowledge Building

If the purpose of an NISE team is to integrate and create knowledge that can be brought to bear on difficult and important issues, then a team's productivity is largely determined by how well it carries out processes that drive knowledge construction. Sociocultural theories assume that knowledge construction is essentially social in nature. Lave's viewpoint is that knowledge 'lives" within communities of practice where it develops and thrives through social discourse. Individual participation in this discourse requires knowledge of language and other

conceptual tools of thought that are shared by other members of the community. Shared community knowledge can change and grow when new language and concepts are assimilated or constructed by the discourse.

The insight that conceptual tools (such as language) and physical tools (such as white boards or flip charts) both shape and comprise the evolving community knowledge base is attributed to Vygotsky (1978). However, physical tools have not yet been a significant factor for the group under observation, which to this point has conducted meetings without the aid of physical props.

Cognitive Apprenticeship

Central to Lave's view is the notion that team survival and growth depend upon a continuing process of apprenticing new members. Intellectual work involves cognitive apprenticeship (e.g., Collins, Brown, and Newman, 1991), whereby experienced community members share problem solving and other conversation with less experienced "novices," supporting their acquisition of community tools, especially language. Lave's view also indicates that team survival and growth depend on a continuing process of apprenticing new members. New members participate in team activities peripherally at first but, through gradually increasing participation can eventually become fully participating members of the discourse.

Multiple Voices

In order to build knowledge as a group, team members need to be able to communicate effectively. This activity may be particularly difficult in new interdisciplinary groups, since members represent different professional communities of practice that vary in terms of value systems, professional languages, and cultural histories. From Wenger's perspective (1990), communication across cultures can be initiated by seeking and using boundary concepts--language subsets that are shared across cultures. An excellent example of a cross-disciplinary boundary language is basic statistics. As new boundary concepts are located and developed through interdisciplinary discourse, a common team language begins to emerge and grow.

Communication can also be initiated by finding common "voice." The Bakhtinian (as cited in Wertsch, 1991) notion of voice refers to the personal perspective that is adopted by a speaker. For example, a chemistry professor may speak as a scientist on one occasion, as a teacher on another occasion, and as a parent on yet another. Use of less technical languages, which are more widely understood, may facilitate interdisciplinary communication. Voices can also be combined in discourse. For example, the chemist can talk to a nonscientist by filtering the voice of the chemist through the voice of a layperson. From the perspective of Lave and Wenger, individuals are capable of multiple voices because they belong to multiple communities of discourse. Shared voices can provide common ground for group cohesion and the beginning of technical exchange.

Group Composition

In this study we consider a sample of conversations from early meetings of one NISE team, asking whether the kinds of analyses suggested by a sociocultural approach provide a useful conceptual fit to the data. The group under observation meets every other month for several hours to examine the issue of how to evaluate systemic educational reform (SER) programs funded by the National Science Foundation. While we plan to continue researching this group throughout its development, our current findings are based on audio recordings and field notes collected during the second and third semimonthly team meetings.

The regularly participating members of the team include four male full professors representing the disciplines of political science, astronomy, chemistry, and mathematics education; two female professors of engineering; one female Ph.D.-level anthropologist who holds a nonteaching academic staff position; and a female representative of the National Center for Improving Science Education with a Ph.D.-level background in chemistry and science education. A male professor of mathematics has participated occasionally. Invitations to join this group were issued by the team's leader and manager, a nonteaching senior scientist. His disciplinary background is primarily mathematics and mathematics education, with a specialty in educational assessment. Approximately 35% of the team leader's full-time research position is devoted to work related to this team's mission.

Applying the Apprenticeship Metaphor

Initially this metaphor seemed inappropriate for the SER team, primarily because this team is a newly formed community, making it impossible for senior mentors to induct novices into team membership. In addition, even new members are full participants from the start, so Lave's concept of peripheral participation does not apply. However, the metaphor can be insightful if we view the team's practice as an extension of an established practicing community of educational researchers and practitioners interested in systemic reform. The rhetoric of SER is indeed present in initial explanatory materials given to members of the newly formed team, as well as in the initial charge presented verbally to the team by its leader. This community-specific rhetoric results in some differentiation between relative newcomers and old-timers; for example, the term "systemic reform" itself was mysterious to some and highly familiar to others.

The apprenticeship metaphor also seems appropriate given that interviews and group discussions reveal evidence of novice-level confusion and deliberate self-apprenticeships of some members not versed in the rhetoric of educational reform. For example, one scientist acknowledged feeling like a relative newcomer:

> I feel like a student in the freshman chemistry course. . You sense that you don't really have an appreciation for the significance [of principles being presented] and . you don't have the

perspective to allow you to ask the questions that really need to be asked.

Another scientist new to the rhetoric of SER admitted some confusion.

> I haven't the foggiest notion of what you're talking about. This systemic reform is repeated over and over again like a mantra, and I don't know what you think is wrong!

Mentorship on the part of more experienced members was evidenced by the fact that team members involved in the SER community explained terms and concepts that were unfamiliar to other members. At times these explanations were in response to direct questions from relative novices (e.g., "What does system alignment mean?"), while at other times they responded to the overall direction of another team member. For instance, when one scientist indicated that effective SER research should involve isolating variables by looking for reforms changing a single part of the system, a colleague replied with the perspective of someone experienced with SER:

> Let me give you one qualification on that: . historically, when people have tried to do one thing, quite often because of other things in the system they just haven't been able to do that [one thing] very well.

We observed that the team leader also monitored the process of educating all members in the rhetoric of systemic reform. In an interview, he described how he tried to ensure that everyone understood the concepts being discussed:

> I'm sure not everybody understands "Chapter One," so let's ask that question, free that up. I really appreciated it when [another member] said, "I don't know what summative/formative evaluation is." I knew that that was a trade term, and that he probably didn't understand that, that it needed to be qualified.

As the above data illustrate, there is evidence that during early development of the SER team, a type of cognitive apprenticeship is occurring as team members unfamiliar with systemic reform are introduced to the community of SER practice. Members experienced in reform serve as mentors in the group, and newcomers recognize that in some ways they are being inducted into a new field, in which they need to acquire knowledge as they contribute their own points of view.

Interaction of Multiple Voices

The Bakhtinian perspective focuses not only on the predominant voice of the community of SER but also on voices from other communities. The NISE group discussions show evidence that multiple voices are shaping the conversation, and that people seem to be aware of the

need to create a common voice in the discourse to facilitate group discussion and team building.

As we discuss use of common or discipline-specific voices, we recognize the difficulty in categorizing individual statements as originating from or belonging to a particular voice. Occasionally, participants explicitly distinguished between voices by associating themselves and their statements with particular disciplines, thus helping to identify the speaking voice. For instance, a comment prefaced by the statement "as a physical scientist" could probably be attributed to the voice of the natural scientists.

The most clearly identified voices in the conversation were those of the natural/applied sciences and the social sciences. Although this classification is useful for analyzing the voices that contribute to the group understanding and group products, it is possible that other classifications may also be appropriate.

Discussion Among Different Voices

As stated above, the group conversation at times seemed to be a dialogue between voices from two disciplines, the natural sciences and the social sciences. A subset of the natural scientists repeatedly called for "calibration control" and separation of influences, suggesting that the group follow a process similar to that used in the natural sciences:

> [The group should identify reforms] that are trying different approaches to the same particular problem and then devise measures for the evaluation, trying to separate it from all myriad other influences. That seems like a natural to me; that's what we would do with a population of twenty-four galaxies.

The voice of the social scientists, however, indicated that social systems differ fundamentally from physical systems, so different types of analyses might be required. One social scientist pointed out a distinction between the natural sciences and education as

> that which you want to know [in physical systems] in order to measure doesn't change in the process of being measured . . . but it changes hugely in social systems.

Later, another social scientist compared control groups in school reform to political changes:

> [In certain cases] the scientific approach is fine. [But] if you pass a law like a gun control law, you don't say this half of the people have to deal with it and these don't, and we'll compare the results. . . . That's not the way a lot of things in politics work, and in school systems [too], . [In those systems] they all want to be a part of the change.

Another team member who was experienced in educational policy agreed with the difficulty of isolating variables in educational systems, saying,

You can list systemwide indicators, . but the *causality* links there, [questions such as], 'Is it a curriculum?", 'Is it a new assessment process?"
. "Which component of [the system changes] produces these results?" Those are the things that I find to be very, very difficult to measure. And that's where the strategies really have to be, and that's where the science comes in.

The discourse between these two voices is just beginning. It will be interesting to see how the conversation among conflicting voices will change as the group develops.

Influences of Multivoicedness

There is already evidence that group products are being influenced by voices from several disciplines. Some participants--typically natural scientists--requested a rigorous and specific definition of systemic reform. As one scientist stated,

When I'm called upon to make a measurement, I have to know what I'm measuring. . . . I don't need the same thing to measure the polarization of a galaxy that I do to measure the temperature of the planetary atmosphere.

Another scientist agreed, saying that for

all of us physical scientists . . the general picture is always anchored in very specific things.

A third team member identified these requests for a systematic approach to analysis as being the voice of natural science.

As the physical scientists are saying, we have to sort of define what we mean, start out from a baseline that we all understand.

This voice was officially recognized when a social scientist experienced in SER suggested that one product for the group could be a paper summarizing current reforms. This paper topic reflected the influence of the voice of the natural sciences.

In addition to multiple voices influencing the group products, there is evidence that the voices also may contribute to how individual participants conceptualize systemic reform, supporting Vygotsky's view that social interaction influences individual cognition. At one point, the team leader mentioned the idea of 'sustainability" as being relevant to the evaluation of a reform effort. Later in the meeting, a natural scientist commented, 'I like that sustainability. That is a good point." The issue of sustainability also was mentioned by several people in subsequent interviews. As one scientist explained,

[One thing] which wasn't something I would have ever thought of on my own is this idea that systemic reform ought to be self-sustaining.

These excerpts show the beginning of the knowledge negotiation process. The interaction of voices of different disciplines has started to influence the direction of the group, define concrete group products such as paper topics, and also help shape the views that group members hold.

Evidence of Common Voices

Although differences between voices shape the group discussion, sociocultural theory predicts the development of commonality in group voices. The existence of communities or voices common to the group members was recognized explicitly by the team leader in an introduction to the second meeting:

We also view each of you as . . . taxpayers, . parents possibly, teachers also. You're also consumers of the system in that you are using products [students] that have . . come from other parts of the system.

Team members also seemed to recognize that they share a common community. During interviews, one scientist explicitly recognized a shared practice of teaching faculty, stating that group members contribute not so much their specific disciplinary expertise but also

their experience as teachers and as consumers of students, and also more specifically just familiarity or awareness with general research methods.

The discussion reveals some common voices that are being used or developed by the NISE participants. One sign of community was reflected by points in meetings where conversation using SER rhetoric was interrupted by comments in a more informal language. We believe that these comments represent an informal social language that is common to university faculty and researchers across disciplines. For instance, at one point in a discussion about funding, one team member likened the amount in question to being equivalent to 'two janitors," and a different amount was later represented as 'half a janitor." This diversion of the discussion from domain-specific rhetoric to terms that are understood immediately by everyone in the room indicates the existence of a common overlapping practice and related 'boundary language" that is used to infuse humor into conversation and serves to create a sense of cohesion and community.

In addition to the team implicitly recognizing and using areas of commonality in the discussion, there was some evidence of team members consciously striving to create links across disciplines by identifying certain ideas or approaches as new boundary concepts. For example, one natural scientist (not an astronomer) compared the problem of evaluating SER to an astronomer's task of interpreting

data from distant stars.

> It's kind of like our problem in astronomy, isn't it? Because we are studying [a reform]   and we take what few things they [reformers] send out, then look at them and try to dissect all of the information that we get from them. And what they are sending isn't very definitive.

Another scientist tried to draw a link between the natural and social sciences by noting that

> [Natural scientists and educators] can't do experiments. You can't tell them what to do in schools, astronomers can't tweak galaxies.

Sociocultural theories would indicate that, as the group coalesces, these links between communities will strengthen. As shown above, conversation data indicate that common voices are developing in three ways: (a) new members gaining expertise in the dominant rhetoric, (b) the group identifying naturally occurring concepts belonging to communities in which all participants share membership (e.g., teachers, parents, taxpayers), and (c) group members drawing explicit links between concepts that originally belonged to different communities. These processes for expanding social and technical vocabularies can be observed in action and seem important to team functioning.

Conclusions

Sociocultural theories of cognition such as those presented by Lave and Wenger (1991) and Wertsch (1991) provide useful insights on how to examine developing cognition in an interdisciplinary team. Team interaction reveals a type of apprenticeship, and different voices are emerging from the discourse.

However, theories of cognitive apprenticeship do not fully explain interaction among members of mature communities of practice. In the NISE group, established members of different disciplines were invited to the group to contribute knowledge, not merely to be assimilated by the systemic reform community. In this respect the team, lacking the peripheral participation of true novices, does not mesh with Lave's theory. Lave's metaphor does not fully explain the dynamics in a learning environment that expects the dominant community to use knowledge provided by other communities. We seek to develop a metaphor that fully describes how experts in different domains can share information and develop knowledge apart from one dominant community of practice.

Application of sociocultural theories of cognition to these first few meetings of an NISE group also raises the following questions about future team development: As the group gains cohesiveness, how does the emerging common voice incorporate ideas from several disciplines? Will the quality of discourse in the NISE group be dependent on new members continually being introduced into the group, as Lave's theory on communities of practice might suggest? If so, how might activities such as conferences or guest speakers help renew the community?

We will explore these questions in more depth as we continue to observe the group's development. The analytical units of voice, communities of practice and discourse, and boundary objects should help us to better understand the how interdisciplinary collaboration works in order to develop methods to potentially improve it.

Acknowledgments

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