SECTION 2: CHAPTER 1

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BUILDING COLLABORATIVE KNOWING

ELEMENTS OF A SOCIAL THEORY OF CSCL

1. INTRODUCTION

This chapter discusses a core phenomenon for a theory of CSCL: building collaborative knowing. Rather than reviewing, one after another, various theories that are currently influential in the field of CSCL (and that are described in other chapters), a view of collaboration is outlined here that synthesizes important concepts and approaches from these other sources. It takes some of the abstract concepts proposed by these theories and attempts to unwrap what is bundled up in these concepts by illustrating them with a concrete empirical example of building collaborative knowing. It contributes to a social theory of CSCL by unpacking central concepts and by using them to understand the process by which a small group collaboratively builds new knowing. The better we can understand how the processes involved in collaborative learning actually work, the better we can design computer support for them and the better we can evaluate the effectiveness of the learning and of the support.

1.1. The need for theory in CSCL

It is often assumed that every professional discipline is founded on a well-worked-out theory that defines the objects, goals and methods of its domain. However, when one really needs to use the theory – such as to guide the design of concrete software to support collaborative learning – one discovers that at best what exists are bitter controversies and disturbing questions concerning the fundamentals. This is certainly the case with CSCL: We are still arguing over its very name.

Yet, one cannot proceed without theory. How would developers, teachers or researchers know what kind of software or curriculum to develop, how to introduce it into the classroom, or how to assess its effectiveness without a theory of CSCL?

Definitions – a starting point for theory – are always contentious. What authors mean by “computer support,” “collaborative” or “learning” are different every time someone else tries to define them (see Chapter 2 by Lipponen & Hakkarainen). If one pragmatically says, just look at the papers at a CSCL conference to see what the domain is, one finds papers that never mention computers, let alone pedagogically innovative software, or that

have nothing to do with collaboration and may be far removed from most concepts of learning. Yet, despite this, there is a field of CSCL with an active research community and much to recommend its adoption in higher education classrooms.

So this chapter will provide a consciously contentious perspective on key elements of theory for CSCL. In particular, it will be contentious by emphasizing activity and accomplishments at the **group level**. This is what we mean by a **social** theory of learning, in contrast to traditional ideas about learning as something that takes place primarily in the minds of individual people. Because the word "learning" often directs attention at psychological or mental processes at the level of the individual participant, this chapter will often use the term "building knowing" in place of "learning." Rather than saying that a group learns we will say it builds the extent of its knowing. This slightly awkward locution has the added advantage of distancing itself from the idea of accumulating things called "knowledge," as in the idea of "learning facts"; what groups learn is often practices rather than facts, ways of doing things. Pea (1993) similarly uses the term "distributed intelligence" to avoid the connotations of "learning" as involving decontextualized mental representations of individuals.

The term "building collaborative knowing," coined for this chapter, is derived from the work of Scardamalia and Bereiter (1996), who did much to found the field of CSCL. As used here, the phrase is intended to point to a core process in collaborative learning: a particular way in which a group may construct a new degree of understanding about the topic that they are investigating. This new knowing is something that the group creates that cannot be attributed to the mental processes of any one individual. As Bereiter (2002) says,

> The mark of a really successful design or problem-solving meeting is that something brilliant comes out of it that cannot be attributed to an individual or to a combination of individual contributions. It is an emergent, which means that if you look at a transcript of the meeting you can see the conceptual object taking shape but you cannot find it in the bits and pieces making up the discourse.

We will take this phenomenon as of particular interest to a theory of collaborative learning. There are many ways in which "learning" can take place: over short and long time periods, in solitude and socially, formally and informally, tacitly and explicitly, in practice and in theory. There are many ways in which people collaborate and learn: by teaching each other, viewing from different perspectives, dividing tasks, pooling results, brainstorming, critiquing, negotiating, compromising, agreeing. While all these aspects of learning and collaboration may be relevant to CSCL, we will focus on the phenomenon of building collaborative knowing, where group members invent knowledge and skill together that none of them would likely have constructed alone (Fischer & Granoo, 1995; Hatano & Inagaki, 1991; Mead, 1934/1962; Wittgenstein, 1953). We will look at a transcript of a meeting where we can see increased knowing taking shape in

the group discourse, and we will note how it is not attributable to individual understandings.

Collaboration takes place within other activities of learning and cooperation, of individual meaning-making and social enculturation. This chapter focuses on those brief, possibly rare episodes in which group discourse builds meanings, that can then be variously interpreted by the group members or sedimented in artefacts. It may well be in the mining of such gems of interaction that the potential of CSCL lies. Too often, this key stage in collaborative learning is skipped over by theories; either it is treated as a mystery or as an individual act of creativity, which is not further explained, or it is wrapped up in an abstract concept like "synergy" that names the phenomenon without analysing it. But this emphatically collaborative achievement is a key to CSCL, for this is what most dramatically sets it apart from individual learning. At least that is the hypothesis of this chapter. The analysis of such a group accomplishment requires a new way of thinking, a social theory.

1.2. A social theory for CSCL

It is not bad for theory to be subject to contending views and arguments, and to have to compete for acceptance. The purpose of proposing theory is to subject it to the discourse of the research community so that it can be refined, critiqued and negotiated to contribute to that community's collaborative knowing. This is where science gets its real power (Donald, 1991). This book's title should not be taken to imply that we know a large set of eternal truths about CSCL, but that we are engaged in a collaborative process of building shared knowing about the field and its potential. This chapter is an attempt to pull together threads from an on-going conversation and to contribute a new, tentative textual artefact into that process in the hope that it will be taken up, critiqued and modified. At the point that you read this in published form, it will already have passed through a debate involving the diverse perspectives of some of the book's authors.

The CSCL theories incorporated here are particularly contentious because theoreticians like Lave (1996) or Engeström (1999) build on a **social** theory tradition that goes back to Hegel (1807/1967), Marx (1867/1976) and Vygotsky (1930/1978). This theory is historically, culturally, linguistically and politically foreign to many people, whose intellectual instincts are shaped by an older, more ingrained tradition that focuses on **individual** minds as rational agents.

Prevalent enlightened thinking about learning owes much to Descartes' (1633/1999) theory of ideas as existing in individual minds isolated from the material and social world. Thorndikian educational theories, which still dominate schooling, go back to this philosophic position. The history of philosophy and theory since Descartes has moved toward a more dynamic, social view. Kant (1787/1999) argued that our knowledge of reality was not simply given by the material world, but was constituted by the human mind, which imposes a basic structure. Hegel (1807/1967) introduced a developmental view in which this process of constitution evolves through historical changes. Marx (1867/1976)

grounded these changes in socio-economic phenomena. Heidegger (1927/1996) then proposed a view of human being that is more firmly situated in the world than Descartes' approach. Figure 1 provides a graphical representation of how the influences mentioned here led to social versus individual theories of learning.

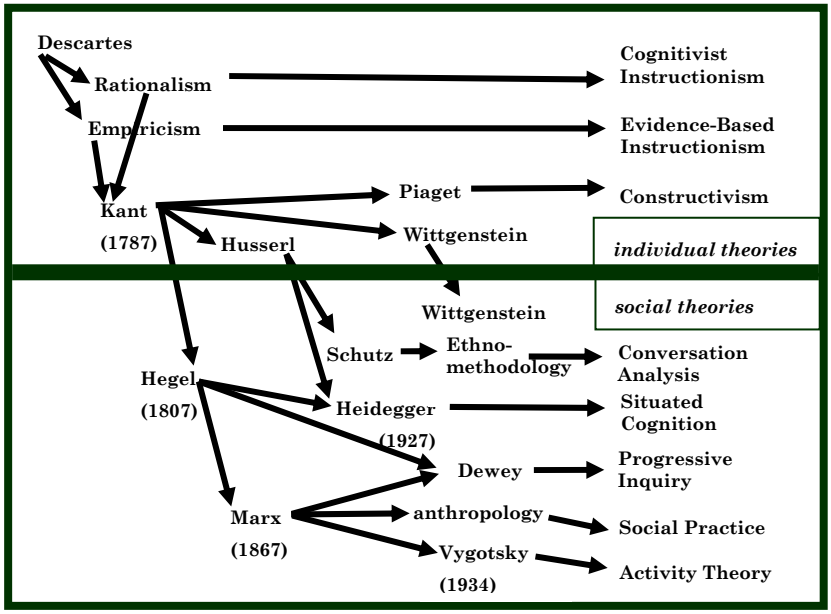

Figure 1. Influences on individual theories of learning (top of figure) and social theories of learning (below the line).

1.3. This chapter's approach to theory

It is difficult for most people to think in terms of group cognition because of the traditional focus on the individual. It is also hard to comprehend the subtle and complex interactions that pass between group and individual knowing or between meaning embedded in an artefact and its interpretation in a person's mind. But such comprehension is necessary for understanding the social approach to a theory of CSCL.

One needs, first of all, the right vocabulary for thinking about phenomena that occur on levels of analysis that we are not familiar with discussing. We need an appropriate conceptual framework and analytic perspective. This is what is meant here by a "theory." Philosophy used to provide such intellectual resources, but recently this has become a task for interdisciplinary sciences, such as anthropology, communication theory, social theory and even computer science. This chapter will draw on theoretical reflections and conceptualisations from these fields to try to understand the phenomenon of building collaborative knowing. "Theory" in this chapter is not meant in the sense of clear and distinct definitions of concepts, empirical laws, rigorous methodologies and mathematical precision. It is meant to provide a way of looking at social interactions in terms of inter-related phenomena and concepts such as: "artefact",

"situation", "meaning", "interpretation", "tacit knowing", "perspectives", "negotiation", "internalisation". These concepts are not so much defined in unambiguous sentences, as they are borrowed from other theories or philosophies and adapted into an emerging conceptualisation. The terms glean their definitions from each other, as a result of how they are configured together (Adorno, 1958). So these terms should become gradually more meaningful as you read through the chapter and try to apply its view to phenomena presented in the chapter or in your world.

The nature of the interactions involved in building collaborative knowing have scarcely been investigated in any tradition, although they are absolutely fundamental to a possible theory for CSCL. While available philosophies can provide some direction for exploring these interactions, empirical investigations are urgently required. We need to better understand how knowledge and meaning can be encapsulated in a wide variety of artefacts and then how groups of people can come to understand these embedded meanings and effectively interpret them. We need to look carefully at examples of this taking place under real-world conditions. Therefore, this chapter will begin with a fragmentary empirical analysis of a sample moment of collaboration (section 2).

The empirical example then introduces the intertwining of individual (psychological) and group (social) processes (section 3), through which collaborative knowing can be built. The sharing of knowledge among group participants as well as the building of the group's own knowing is accomplished interactively, primarily through situated discourse processes (section 4).

Discourse, which makes things explicit, relies on a background of tacit or practical knowing. The co-construction of shared knowing in discourse involves the negotiation of tacit meanings, for instance of the affordances of artefacts (section 5). The network of these meanings constitutes the social world in which we live and which we come to understand by building collaborative knowing (section 6).

This chapter attempts to suggest the core elements of a social philosophy that could provide a foundation for CSCL. Such a theory necessarily involves issues of epistemology, semiotics, hermeneutics and ontology. Epistemology asks how knowledge is possible; social epistemology shows how knowing is interactively constructed within communities (section 3). Semiotics asks how signs can have meaning; social semiotics shows how meanings of signs and other artefacts are socially constituted (section 4). Hermeneutics asks how we can interpret meaning; social hermeneutics shows how individuals interpret socially shared meaning (section 5). Ontology asks what kinds of beings exist; social ontology shows how beings are produced and reproduced within a society (section 6).

The kind of social epistemology, semiotics, hermeneutics and ontology proposed here would not provide a complete social theory. For that, we would have to build up from the social as small group to the social as institutions and multi-nationals, including cultural and historical levels of description – and then return from these abstract social formations to the

concrete activities in which people find themselves in any given moment, but this time fully mediated by categories and understandings from the larger socio-historical context (Bourdieu, 1972/1995; Giddens, 1984; Habermas, 1981/1984; Marx, 1867/1976; Sartre, 1968). The foundations and concepts for such a fuller social theory could come in part from the elements presented in this chapter.

The theory of building collaborative knowing sketched in sections 3 to 6 has implications for the field of CSCL. Section 7 touches on some of the major implications (a) for a methodology of empirical analyses of collaborative knowing, (b) for the design of CSCL software artefacts and (c) for CSCL classroom practices in higher education. These are, of course, subsequently discussed at greater length in other chapters.

2. A MOMENT OF COLLABORATION

The theory presented in this chapter emerged through an analysis of a specific example of collaborative learning. This section presents that example. The following sections use the example to illustrate the concepts of the theory.

2.1. Why we need empirical examples of collaboration

Writing about contentious matters like the nature and mechanisms of collaboration is risky. Each reader will interpret the meaning of what is said by relating it to her own experiences or to his existing understandings and to prevalent "folk theories" (established wisdom and common worldviews). Paradigmatic examples of small groups building collaborative knowing are still rare these days and the mechanisms underlying them have yet to be well analysed. So scepticism and misunderstanding are the expected outcome unless the starting point for the reader's interpretation can be appropriately grounded in shared experience. To this end, we first introduce a brief empirical example and some hints for interpreting it. We invite the reader to study our fuller analysis (Stahl, 2002) and to search for and reflect upon other examples (e.g., (Koschmann, 1999; Roschelle, 1996; Sfard & McClain, 2003) and studies from ethnography, psychology and ethnomethodology).

Clearly, our case study is not representative of all CSCL activities – it is not even typical for the focus of this book. However, it provides a particularly useful illustration of the phenomenon of building collaborative knowing that we want to analyse in this chapter. That our example represents some generality is suggested by its similarity to what Hatano and Inagaki (1991) describe as "collective comprehension activities" in Japanese classrooms: they take place among small groups of students, involve references to an artefact (or source of confirmation) and include room for comprehension.

The example we present takes place in a middle school, not in higher education. This provides a clearer view of the collaborative building of an instance of elementary science knowing: the principle of varying only

one parameter of an experimental situation at a time. In higher education, most students have some sense of this principle, but in middle school we can observe such an understanding being constructed for the first time. In addition, the computer discourse is not computer mediated; the face-to-face interaction provides richer, clearer, more intuitive evidence for what is taking place; this is helpful for analysing the detailed interactions that constitute the building of collaborative knowing – although examples will also need to be studied that are computer-mediated. The sample interaction is, however, computer-supported by a software rocket simulation, so that we can observe how the students increase their knowing about how to use a digital artefact.

Empirical examples are more than mere aids to presentation of a theory. It is necessary to show how theory is grounded in and integrated with empirical studies. Theory can be very abstract and leave the detailed mechanisms undeveloped. Often, these details are crucial for practical application of the theory – such as for guiding the design of technology to support collaboration – and are required for fleshing out the theory itself. Thus, while several recent theories stress the role of artefacts as embodiments of shared understanding (Dourish, 2001), little has been written about how new users of the artefacts learn to share these stored understandings – a question investigated in a modest way in our example.

The example used in this chapter is not an arbitrary illustration of independent ideas. The theory discussed actually grew out of the detailed analysis of this particular collaborative interaction. By presenting the theory within the context of its empirical origin, we try to situate the reader within a concrete understanding of the phenomena being analysed.

2.2. The experimental situation

Five 11-year-old boys are building model rockets for a science project at school. A computer scientist from the community volunteered to work with the students; he developed a software simulation of rockets with different design attributes (different engines, nose cones, fins and surface textures). The students can fire 8 different rockets and record their heights in a datasheet. A list of the attributes of the 8 rockets is displayed on the computer screen next to the simulation. The two sessions with the simulation totalled 3 hours and were video-recorded (see Figure 2).

Figure 2. The mentor and students discussing the list.

The first session begins with the students reading the list of rocket descriptions and discussing with the mentor how to figure out which attributes did best in the simulation and might therefore be good to design into their model rockets. Then, working in two

subgroups, they fire the different rockets multiple times and average their heights, to adjust for random fluctuations due to simulated weather conditions. After filling their data sheets, the students are guided by the mentor to figure out which attributes are optimal. Most of the discussion up to this point is teacher-centric, with the mentor posing questions, evaluating responses and controlling turn-taking, as is typical in school settings (Lemke, 1990).

A key aspect of the experiment is that the list of rocket descriptions was carefully designed to make it easy to compare pairs of rocket descriptions that differ in only one attribute. The relevant pairs are listed consecutively and the differing attribute is written in bold face (see Figure 3). However, even after having read the list aloud and having worked with the simulation for over an hour – with the list on-screen the whole time – the students are literally unable to see this property of the list.

2.3. Preliminary analysis

At a certain point, after the mentor gestures at the list, the students launch into an intense collaborative interaction, consisting of a brief utterance about once a second. Following is a transcript of that collaborative moment, beginning with the mentor's directing of the group attention to the list. We can start our analysis by dividing the interaction in the transcript excerpt into four phases:

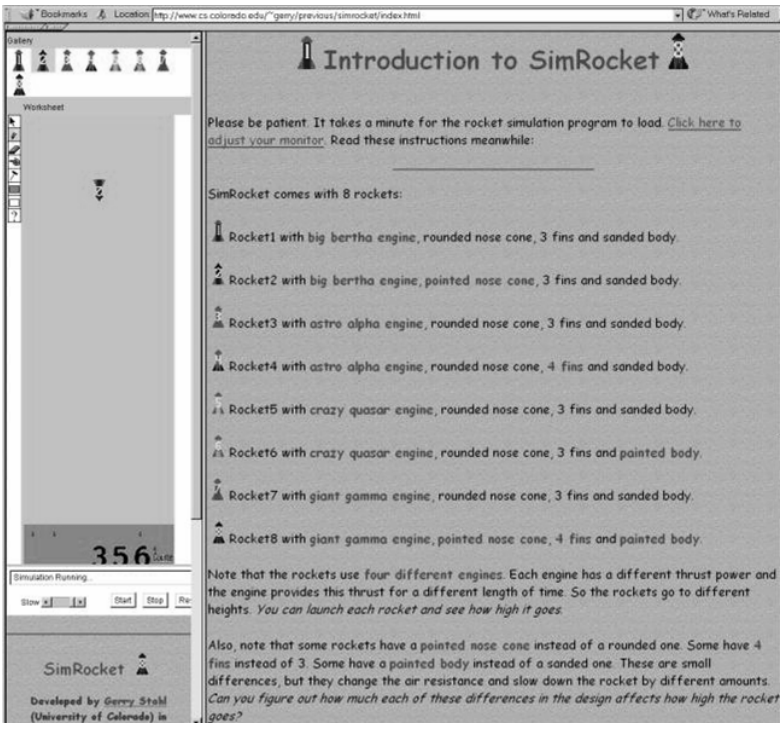

Figure 3. The SimRocket simulation with the list of rocket descriptions.

Phase a. The transcript begins at 1:21:53 with the mentor posing a rhetorical question, which is then clarified at 1:21:59 as asking the students to find a pair of rockets on the list that have the same engine but different nose cones. The students respond that there is no such pair in the list. This is not the expected response to a rhetorical question, and indicates a breakdown in the group discourse.

1:21:53	Mentor	And (0.1) you don't have anything like that there?
1:21:54		(2.0 second pause)
1:21:56	Steven	I don't think so
1:21:57	Jamie	Not with the same engine
1:21:58	Steven	No
1:21:58	Jamie	Not with the same
1:21:59	Mentor	With the same engine … but with a different (0.1) … nose cone?
1:22:01	Chuck	the same
1:22:01	Jamie	Yeah,
1:22:02	Chuck	These are both (0.8) the same thing
1:22:03		(1.0)

Phase b. After a significant pause at 1:22:03, Brent excitedly points to what the mentor had asked for, a pair of rockets with a nose cone difference. Brent lurches forward and physically gestures at the list, forcibly directing the group attention there. This alters the structure of the group. In phase a, the students were united against the mentor; here Brent joins the mentor; in phase c other students successively align with Brent and the mentor; finally in phase d a new consensus is reached.

1:22:04	Mentor	Awright
1:22:05	Brent	This one's different ((gestures with pen at computer 1 screen))
1:22:06	Jamie	Yeah, but it has same no… (1.0)
1:22:08	Chuck	Pointy nose cone

Phase c. While Chuck continues to argue against the implication of the mentor's rhetorical question, Steven, Jamie and Brent successively dispute Chuck's utterances. They point to rockets 1 and 2 as being a pair with different nose cones.

1:22:09	Steven	Oh, yeah
1:22:10	Chuck	But it's not the same engine
1:22:11	Jamie	Yeah, it is,
1:22:12	Brent	Yes it is,
1:22:13	Jamie	Compare two n one
1:22:13	Brent	Number two
1:22:14	Chuck	(0.2) I know.

Phase d. Making explicit which rockets to look at on the list finally gets Chuck to align with the rest of the group. Chuck had apparently been trying to find a rocket to compare with rocket 3 or 4 and had rejected 2 because although it had a different nose cone it did not have the same engine as 3 or 4. Once everyone saw the pair of 1 and 2, the group could proceed with their task and quickly draw a scientific conclusion.

1:22:15	Jamie	(0.2) Are the same
1:22:16	Chuck	Oh
1:22:17	Brent	It's the same engine.
1:22:18	Jamie	So if you compare two n one,
1:22:19	Chuck	Oh yeah, I see, I see, I see
1:22:21	Jamie	(0.8) Yeah. Compare two n one. So that the rounded n- (0.1) no the rounded one is better. Number one.

Keep this concrete interaction in mind when the discussions become more abstract in the following sections. In each phase we can observe phenomena that will be taken up in later sections.

In phase a there is a breakdown in understanding between the mentor and the students. In overcoming this breakdown, the group will build collaborative knowing: by the end, the whole group will know how to find significant pairs of rockets on the list. Section 3 will look at how such knowing is interactively constructed in groups so that it is then available to the group's members.

In phase b and throughout the collaborative moment, we observe very brief utterances, like "This one's different," "The same" or even "Yeah." Such utterances are not meaningful by themselves, but only within the context of the group interaction. They serve mainly to point to other utterances, to reference items in the list or to engage in the group interaction (e.g., aligning, disagreeing, arguing or clarifying). Section 4 will explore how meaning – that is not completely given in these utterances of individuals – can be understood only at the group unit of analysis.

In phase c there is a concerted effort to realign the shared understanding of the group that broke down in phase a. At first, the students argue against the mentor. But in subsequent phases they gradually come to align with him. In the discourse itself (and nowhere else), we can see these shifts as the individual interpretive perspectives of the different students change and align. Section 5 will distinguish "meaning" – that exists in the shared social world – and "interpretation" of that meaning by groups and individuals.

In phase d everyone is able to see the descriptions of rockets 1 and 2 the way the mentor implied. Although the descriptions were in the list all along – and Chuck had even read them aloud an hour and a half earlier – it took a while for the students to see the meaning that had been designed into the artefact. Section 6 will explore how affordances and meanings that are preserved in artefacts and words must be interpreted within concrete and practical situations involving discourse, tasks and other forms of interaction.

3. INDIVIDUAL AND GROUP KNOWING

Theories of learning tend to emphasize either individual or group knowing. It is difficult but important to understand how both take place and influence (or constitute) each other.

3.1. Individual and group learning in the example

Our data about collaborative learning in section 2 is given at the level of a videotaped interaction and transcribed discourse, with some contextual information. To understand the learning that took place, a researcher must analyse it within the context of the group. That is, the activity system of tasks, artefacts, interactions, symbols, social practices, roles and community of practice forms the unit of analysis. It is in this unit that meaning is constructed and new ways of knowing are built. The meanings generated within this unit are absorbed into the group's knowing.

As researchers of learning, we can analyse our data either by looking at the group discourse as a whole or by following the trajectories of individuals within the group discourse. That is, we can focus either on the group (i.e., the activity system as distributed among several people engaged with each other and with artefacts in complex ways) or on the individual as the unit of our analysis. Of course, we can also reflect upon how events at one level effect those at the other; this is, in fact, essential in order to get a full picture (Fischer & Granoo, 1995; Hatano & Inagaki, 1991). In our example data we see that there is a breakdown in the group discourse and that individual contributions shift their positions within the group in order to re-establish a healthy group discourse.

3.2. Shared and personal knowing

We also notice in our sample transcript that individual utterances only make sense within the group context and the shared situation. Closer analysis – presented in section 4 – reveals that individual contributions build on what has taken place within the group discourse, on current features in the shared situation and on future possibilities for joint activity. Thus, the individual utterances rely heavily upon the group discourse; we can argue that the group unit of analysis has an epistemological priority in that it provides prior conditions necessary for the knowing that can then take place at the individual unit.

The group unit is significant particularly in **collaborative** learning. Whereas in cooperative or coordinated work, tasks are often divided up so that individuals actually work and build knowledge on an individual basis and then attempt to share the results, in collaboration, by definition (Dillenbourg, 1999), the work is done by the group as a whole, for instance in meetings or other forms of discourse. For this reason, social approaches to theory are especially appropriate for CSCL. Section 4 will situate individual utterances and personal knowing within their social context.

3.3. Cognitive and social theories

Analyses of learning usually focus either on individual contributions as expressions of psychological states of individual people (the “cognitivist” or “acquisition” perspective) or on the collective accomplishments of a community or a society (the “socio-cultural” or “participation” perspective – see (Sfard, 1998)). The cognitivist perspective takes utterances to be expressions of pre-existing mental representations or ideas of individuals, while the socio-cultural perspective takes elements of the language used to be social creations or conventions of the culture. By analysing our transcript data, however, we can see how both the utterances and the terminology they include are interactively constructed in the discourse as a whole – so that there is no need to posit either pre-existing mental constructs or fixed structures of social conventions independent of the discourse and determining it. Rather, on the contrary, we can see the mental and the social as results or products of previous discourse, now sedimented into meaningful cognitive and linguistic artefacts that function in current activities. Section 5 will discuss in more detail how meaning is thereby constructed and interpreted in group interaction.

3.4. Collaborative learning as building knowing

Learning can be viewed as the gradual construction and accumulation of increasingly refined and complex cognitive and linguistic artefacts. This takes place primarily in collaborative interaction. Secondarily, these products of group collaboration and discourse can be internalised as the internal speech or thought of individuals. The cognitive and linguistic artefacts that develop are tools for knowing. As collaborative learning takes place, both the group in its interactions and secondarily the individuals who adopt and internalise these tools build their ability to know the kinds of things that the group is involved with. In our sample data, the group comes to know how to use the list of rockets as an artefact or tool to accomplish their activity. Section 6 will take a closer look at group mechanisms for building collaborative knowing and for individuals to understand and internalise what their groups and culture have built.

4. SITUATED DISCOURSE

Utterances in our experimental data derive their meaning from the discourse situation, which they in turn contribute to interactively constructing.

4.1. References to the situation

The utterances in our example transcript can be characterized as: indexical, elliptical and projective. That is, they are not meaningful in isolation – the way propositions are traditionally taken to be. They are meaningful only through their references to the current physical context, prior utterances or projected future possibilities within the activity.

Looking at the utterances in our transcript, we can identify some that are **indexical**: their meaning depends upon their reference to some artefact in the environment, like a rocket or a rocket description (e.g., "this one …"). Other utterances are **elliptical** in that they leave out crucial parts of what would be a complete proposition, assuming that the hearer can fill these in based on previous statements in the discourse history (e.g., "Number two"). Finally, some utterances are **projective**: they must be interpreted in terms of a desired future state of the discourse (e.g., "So if you compare …").

The meaning of these utterances is not self-contained, but is constituted by reference to a totality of inter-connected artefacts that make up the world of the group. We call this world the **situation** and refer to the discourse as "situated." Utterances often function as signs, pointing to networks of meaningful terms, artefacts and activities.

4.2. Preserving knowing in words and artefacts

In our example situation, the word "different" plays an important role. In the pivotal utterance, "This one's different," there is an indexical reference to an item on the list artefact as well as to the mentor's previous use of the term "different." Brent appropriates the mentor's term; in the subsequent group discourse, this reference is extensively developed in terms of what is or is not the "same" and the activity of comparing rockets. Through the transcribed interaction, the participants gradually come to see what Brent referred to as "this one" as "different." The vocabulary of "different," "same" and "compare" serves to point out relationships in the list so that everyone in the group can see them. In the process, the terms preserve this new knowing-how-to-look-at-the-list in their extended meaningfulness to the group. At the end of the collaborative moment, the group knows much better how to use both the terms and the list artefact to which they refer. It is likely that the mentor already interpreted the terms and the artefact this way, but that the students had to learn to interpret these meanings as preserved in the terms and artefact.

Brent's interpretation of "this one" as "different" is a first step in articulating a full meaning for the salient differences and similarities among pairs of rockets in the group activity. One can see here the initial phase of the verbal formation of meaning. It is like observing Michelangelo starting to chisel a rectangular block of marble and seeing a human form struggling to emerge from the inert stone in which it is embodied (Figure 4). Brent may first use the term "different" by mimicking the mentor's speech. As he and his fellow students continue to use it, its meaning becomes more differentiated, articulated and refined through its connections among more utterances and their circumstances. Eventually, we can say that the students have learned the meaning of the comparison vocabulary as scientific technical terms.

In the next sections, we will describe how meaning is embodied in artefacts and sedimented in language. Through this, meanings that may have originally been created in ephemeral spoken utterances become **persistent**. This makes possible the preservation of the meanings over time, so that we

can say that knowledge has been created as a product that can be effective over time.

4.3. Common ground and distributed cognition

We have seen that meaning is given by a shared world that is interactively constructed in collaborative discourse. This is somewhat different from some understandings of common ground that start with the individual unit of analysis and then try to account for a shared reality. Common ground is sometimes taken to be an agreement among individuals who all somehow have the same meanings or knowledge as part of their background understanding, and that makes possible further interaction (Clark & Brennan, 1991). But in our theory, as we have started to see and as we will see in more detail in the next section, the meanings are part of a single world, situation or activity system in which the individuals all interact. So the common ground exists from the start for them as a world in which they exist together, and is not something that has to be established through some kind of agreement among mental contents.

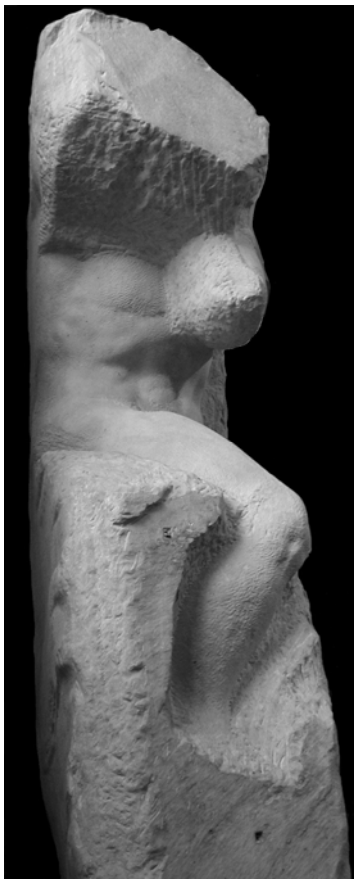

Figure 4. Slaves: Atlas. Michelangelo Buinarroti. c. 1530. Marble. Galleria dell' Accademia, Florence. Photo: G. Stahl, 2002.

This theory is not exactly the same as distributed cognition, which also argues that at least some meaning is "in the world" rather than all being "in people's heads" (Hutchins, 1996). Certainly, meaningful artefacts exist in the physical world. But the meaning is not physically present in the same sense as the body of the artefact itself. The meaning comes from the networks of reference in which the artefact is located (Stahl, 2003).

An artefact is perceived as meaningful, but this perception is a matter of interpretation. In our example, for instance, we saw that the meaning of the list artefact was not immediately perceptible to the students, but they had to learn how to see it. The common ground, that had broken down, was interactively achieved in the transcribed interaction; it was an accomplishment of the group interaction, not a matter of arbitrary agreement among the individuals to pre-existing ideas in their heads. The group discourse had to focus on the list as a salient artefact and develop an

interpretation of its meaning. The ability to include the list artefact effectively in their activity was something that the group had to achieve.

4.4. Creating knowing at the group unit of analysis

Knowing how to use the list artefact was not something that was passed from the mentor to the individual students through propositional instruction. Rather, the group of students evolved that ability by responding to each other's utterances. The mentor had established a context in which this could productively take place by setting up the classroom activity system with designed artefacts, specific activities that required knowing how to use the artefacts, and a pointed question that offered some terminology. The utterances at the start of the transcript disagree with each other ("No. . . . Not with the same. . . ."). Subsequent utterances respond to these, increasingly clarifying differences and justifying views. In the end, there is agreement within the group discourse, established by a process that took place within the group as the actor, subject or unit of analysis.

Collaborative learning took place as the group's increasing ability to talk about the list artefact within the immediate task of responding to the mentor's hypothetical question and within the larger classroom activity of designing effective model rockets. Progress was made through normal discourse processes, specifically repairing a breakdown in shared references to rockets in the list. Overcoming the breakdown involved aligning the interpretations of the individual students within the meanings embodied in the list.

Theories influential within CSCL emphasize assessing learning on the group level and supporting group processes with technology: Scardamalia and Bereiter's (1996) vision of computer-supported learning communities, in which the community as a whole learns, was defining of the field. Lave and Wenger's (1991) situated learning involves changes in the social practices and configuration of the community itself. Engeström's (1999) expansive learning approach even looks at learning taking place when multiple groups interact with each other.

5. MEANING AND INTERPRETATION

Collaborative learning is a process of constructing meaning. Meaning creation most often takes place and can be observed at the group unit of analysis. Meaning in the context of collaborative learning is viewed as an integral part of communication, and therefore necessarily as shared within a community. Meaning can be embodied in physical or virtual (computer-based) artefacts or sedimented in words or gestures. Created by groups, institutionalized in communities of practice and preserved in artefacts, meaning must be reactivated by newcomers to the community as part of their apprenticeship (Lave & Wenger, 1991). Individuals must learn to interpret these meanings, as the students in our transcript learn to interpret the meaning in the list artefact and the meaning in the mentor's use of the term "different."

5.1. Meaning as use and knowing in use

The kind of empirically-based social theory we are proposing here looks at how groups actually create, share, use and interpret meaning as an integral part of social interaction. This is quite different from the mainstream tradition. Philosophers have long struggled to understand the nature of meaning by focusing on the individual unit of analysis. They sought the meaning of words in clear and distinct definitions, the meaning of ideas in their correspondence with reality or the meaning of thoughts in mental representations.

But these attempts to define meaning as a property of individual minds – whose mental representations correspond to realities in the world – did not succeed. In critiquing this tradition, Wittgenstein (1953) argued that the meaning of an utterance involved how it is used to accomplish practical moves within "language games" that are part of the speaker's "form of life." Austin (1952) and Searle (1969) further developed this view of speech acts as having pragmatic effects within group interaction systems, including social institutions and conventional practices. Functional grammar (Halliday, 1985) took this yet another step, analysing the grammatical components of a sentence as relationships within a network of meaning.

Using functional grammar as a tool, Lemke (1990), for instance, analyses the discourse of a science classroom as the construction of a complex network of meaning; this linguistic network constitutes the scientific theory that the students are learning. The collaborative learning of the class consists of the explicit elaboration of this network, and the individual learning of the students consist in their ability to re-state parts of this meaningful network. In constructing the network, the teacher and textbooks use a variety of alternative terms and metaphors, so that meanings can be abstracted from the use of multiple phrasings. Students are then expected to be able to talk, write and reason about parts of the network of meaning in their own words and to understand novel descriptions.

In our sample data, we saw a temporary breakdown in the construction of a network of meaning. Although the students had previously identified rockets with "different" fins, they could not abstract this ability to identify rockets with different nose cones under their specific circumstances. To overcome the breakdown, the students employed gestures, argumentation, peer pressure, the list artefact, clarification and explication. They also built on their practical experience with their model rockets, the simulation rockets and their data collection sheets. Perhaps most significantly, their success in constructing a network of meaning that included consistent references between utterances and rockets on the list artefact came about through group interactions driven by the classroom activity system, including the need to respond appropriately to the mentor's hypothetical question. Thus, the network of meaning grew out of group discourse processes; but these were embedded in contexts of practical social activity. The knowing that the students built was not just a theoretical knowing evidenced by their ability to talk about the rockets consistently, but a practical knowing involving the ability to accomplish tasks within the activity structure context.

5.2. Tacit and practical knowing

It is common to think of "knowing" as the ability to state facts in propositions. But there is also what Polanyi (1962, 1966) calls **tacit knowledge**, which includes the ability to *do* things – like ride a bicycle – even though you may not be able to put that knowledge into words. "Tacit" means "un-stated" and "explicit" means "stated in words." The students know how to follow non-verbal communication cues like gaze, pauses and body orientation, as well as to engage in explicit discussion.

Heidegger (1927/1996) showed that tacit or practical knowing actually has an epistemological priority over explicit or theoretical knowing. To understand a proposition requires that one already have immense amounts of background ontological knowing about the world, about people and about the kinds of objects referred to by the proposition. Language is a form of communication and interaction with other people and with the world – to understand language one must understand it within the context of a broader tacit pre-understanding of social interaction and of the everyday world of ordinary life.

5.3. Interpretation as making explicit

In the process of building collaborative knowing, there is an interplay between tacit and explicit knowing. In Polanyi's analysis, what is explicit is the current focus of attention. It stands forward against a background of tacit knowing. As attention shifts – e.g., as the topic of discourse moves on – what was explicit becomes tacit and something tacit is made explicit by being put into words. Heidegger calls the process of making explicit "**interpretation**."

Interpretation is making x explicit **as** "y." By doing so, it integrates x into the situational matrix (as "y"). X is understood as having the meaning "y," which is defined by "y"'s position in the interpreter's network of references. Discourse is interpretation. It makes things "explicit," puts them into words. As man-made embodiments of meaning, words are semiotic artefacts that are part of the network of significations.

When Brent says, "This one's different," he is making explicit what he sees in the list artefact: he points to rocket 2 as different (tacitly: different from rocket 1 in terms of its type of nose cone). According to Heidegger, perception of the world and engagement in the world is always interpretive, even when it is tacit. The process of explicit interpretation takes the existing interpretation and develops it further. At first, Brent and the other students saw rocket 2 as not being comparable with rocket 3 or 4 because it had a different kind of engine. But then he suddenly saw rocket 2 as comparable but different from rocket 1. This became explicit as he saw the description of rocket 2 differently, leaned forward, pointed to it and said, "This one's different."

Brent's "Aha experience" is an instance of what Wittgenstein (1953) calls "seeing as." Among several ambiguous graphical images, Wittgenstein presents a wire-frame cube (see Figure 5). The viewer might first see a cube facing up to the left; then suddenly it appears as a cube

facing down to the right. One can see the drawing as one cube or the other, or even as a set of lines on a flat surface – but one always sees it **as** something. It is not that there is first an un-interpreted grid of pixels (sense data) that someone subsequently interprets as one of the cubes. Rather, the perception of the image is always given as meaningful and tacitly interpreted. Then it can be either re-interpreted or the interpretation can be explicated: put into words, made a focus of attention and further elaborated.

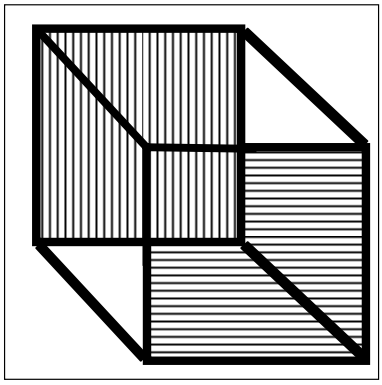

Figure 5. Diagram of a cube. First focus on the horizontal stripes as foremost, then on the vertical. Adapted from (Wittgenstein, 1953, §177)

5.4. Interpretive perspectives

Meaning and interpretation are always intertwined. Artefacts and utterances are immediately perceived as being meaningful. They are given from the start as perceived within a certain interpretation – however vague or confused. The interpretation may be made explicit and further elaborated – but it must always be grounded in the given meaning of the artefact or utterance within its context. For the purposes of this chapter's theory we make a somewhat arbitrary and potentially contentious distinction between meaning and interpretation. We say that the **meaning** is defined for the community involved in the given situation and that the individuals each develop their own **interpretation** of that meaning. (This distinction is worked out in more detail in (Stahl, 2003)).

How do students learn? In our sample data we see how the students learn the meaning embedded in the list artefact through their collaborative interpretive processes. They make explicit the features of the list to each other by interpreting it (as "different") and stating references ("compare two and one").

As researchers studying classroom data, we can develop an explicit interpretation of the group meaning by analysing the network of relationships constructed by the group discourse, taking the group as a whole as our unit of analysis. We call this network the **situation**. Every artefact, action, word or utterance obtains its meaning from its position within this interactive situation.

Alternatively, as researchers we can develop an explicit interpretation of a specific individual participant's interpretation by analysing the behaviour and utterances observed in that individual's trajectory within the group interaction, taking that individual as our unit of analysis. We call this individual trajectory the **interpretive perspective** of that person. We say that the person interprets the group meanings from that perspective.

Roughly stated, meaning exists in the world, determined by the situation, and participants interpret that meaning individually from their personal perspectives. Of course, both the situation and the perspectives are constructed interactively and may be constantly evolving and interacting with each other. As we shall see in section 6, meanings may be embodied in artefacts and sedimented in language, but they were originally constructed through interpretive processes and their significance must be re-constructed by new participants who build knowledge with them in the future.

It is not so much that meaning is "in the world" like a separate set of objects, but that things in the world always appear as meaningful. The students saw the list of rockets as meaningful from the start; to them, it was obviously a designed object with human meaning embedded in its form and its content. Brent understood some, but not all of its meaning; through interpretation (of one entry *as* "different") he articulated the initial meaning and thereby increased his understanding of it.

5.5. Negotiating knowledge

Our transcript begins with the mentor asking, "And you don't have anything like that there?" Our analysis of the transcript interprets the meaning of "like that" to refer to a pair of rockets that differ only by nose cone type, such as rockets 1 and 2. But our analysis also claims that this phrase is initially interpreted differently from the various student perspectives. Because group meaning has to be interpreted by individual participants from their own perspectives, there are many possibilities for divergence and misunderstanding.

The openness to interpretive divergence is a powerful mechanism for creativity in group discourse.[1] It allows different participants to pursue different interpretive lines of exploration of shared themes. Such divergence can continue until it becomes noticeable, possibly causing a breakdown in communication, and the group sets out to resolve the differences. The various discourse methods for establishing convergence of interpretation can be considered forms of **negotiating** knowing.

In our experimental data, prior explicit focus on comparing rockets 3 and 4 made it hard for the students to see rockets 1 and 2 as the thing "like that" that the mentor's question was trying to point out. The students' negative responses to the mentor's hypothetical question apparently violated the perceived social practices of the classroom and motivated the negotiation that gradually shifted the group focus to rockets 1 and 2. Once those rockets were explicitly named, the various interpretive perspectives aligned their references and further progress followed rapidly.

The much touted **synergy** of collaboration has its origin in the negotiation of multiple perspectives. Different viewpoints on the discourse topic interact, are explored and lead to novel results. This takes place at the group level of interpretation. Individual utterances are open to many possible interpretations due to the ambiguity of their indexical references,

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[1] This idea was suggested to the author by Rogers Hall in his review of an earlier analysis of the sample transcript.

the elliptical nature of their expressions and the openness of their projections. But within the flow of the group discourse, certain of these possibilities are selected. One person's response picks up on one of the possible interpretations of a preceding utterance and establishes that as its meaning within the discourse. Through such discourse processes, the meaning of what is said is determined by the interactions of multiple members of the group, not just by the person who made a particular utterance. In fact, it is not the individual utterance that expresses meaning, but the network of consecutive utterances within the situational context. Thus, the meaning is deeply synergistic, arising through the intertwining or negotiation of the individual perspectives within the group situation.

But there are real limits to openness and interpretive creativity. One can attempt to interpret something and fail. This may be due to the resistance of reality: Things have meaningful form, particular utility, specific affordances and cannot be arbitrarily interpreted. Interpretation is a kind of creation/discovery (Merleau-Ponty, 1955) where one can try different things but they will not all work. The objectivity of knowledge arises – gradually and tentatively – through the negotiation with reality and with multiple interpretive perspectives through discourse. This social interaction can, for instance, raise issues of evidence or apply standards of scientific argumentation: Science is itself a prime example of on-going knowledge negotiation (Donald, 1991; Latour & Woolgar, 1979). The status of scientific theories, particularly in the human sciences, does not contradict their origin in processes of building collaborative knowing, but rather derives from the nature of those processes as methodologically structured and intersubjectively accepted.

6. BUILDING KNOWING

Now that the elements of building collaborative knowing have been introduced – such as artefacts, situation, meaning, interpretation, tacit knowing, explicit knowing, perspectives and negotiation – we can outline the process by which groups construct meaning and individuals develop their understanding.

6.1. Internalisation and externalisation

According to Vygotsky (1930/1978, 1934/1986), human intelligence is formed by individuals internalising artefacts and language that are generated socially, that is at the group level. We can think of **internalisation** as the generation of **cognitive artefacts** (Hutchins, 1999; Norman, 1991). Here, the term "artefact" refers to symbolic or linguistic as well as physical or digital artefacts. "Cognitive" means that the artefact has been transformed into a mental process.

Suppose that one of the students took the data sheet with the rocket statistics that the group had compiled and he remembered the format of the matrix of numbers or some of the key statistics. He could later use this memory to format a data sheet for another project or to make arguments

about rocket design. This memory would then be functioning as a cognitive artefact. Its affordances would be different from, but derived from the physical data sheet artefact. Similarly, the students were able to internalise the mentor's vocabulary of "different," "same," "compare." By mimicking the mentor's talk, the students gradually and with varied success internalised this mini-language-game of rocket science.

This example suggests that human memory that is commonly considered to be a biological function is, rather, a complex involving both inherited capabilities and internalised cognitive artefacts. It is probably built on a biological base of episodic memory, by which mammals can recall specific events that took place in their past experience and that may be similar to some aspect of the present situation. As part of the specifically human ability to mimic, we also exercise mimetic memory (Donald, 1991), that allows us to imagine things that are not currently present. The human ability to mediate perception, memory and behaviour – especially generating speech, including eventually self talk and silent internal speech – greatly extends our capacity to imagine and express meanings that reference things not in our immediate perceptual environment (Vygotsky, 1930/1978). In interacting socially to acquire local language and practices through mimesis, human infants develop an extensive array of cognitive artefacts, including more sophisticated forms of memory such as temporally structured narrative memory (Bruner, 1990), that in turn let them develop more complex physical and mental abilities.

Even the concept of self, for instance, can be viewed as a cognitive artefact that is socially constructed and internalised through mimicking. Children learn what is "mine" in contrast to what is someone else's and adopt the view of themselves through the eyes of the other (Levinas, 1974/1998; Mead, 1934/1962). Hegel (1807/1967) analyses the emergence of self-consciousness as a result of the creation of physical artefacts produced for other people, and Marx (1844/1967; 1867/1976) sees self-alienation as a result of the distortion of such social artefact production in commoditization. The modern focus on the individual is an historic product of social organization (Adorno & Horkheimer, 1945; Jaynes, 1976). So the individual-as-mind is not a primitive element of theory, but is itself a socially constructed cognitive artefact.

Externalisation has often been considered to follow upon internalisation, where prior mental representations are expressed in physical form such as speech or drawings. But in our theory, which does not speculate about or hypothesize mental representations, **externalisation** is simply the fact that meaning is embodied in artefacts and sedimented in language. It is unnecessary to speculate on the extent to which that meaning had previously been rehearsed in the internal speech of the people who designed the artefact or uttered the words. In fact, both in terms of the developmental process of the human species and that of each person, meanings are generally internalised first (from some external, inter-personal, group or social form according to Vygotsky (1930/1978)) before they can be (re-) externalised. So external meaning generally precedes

internal (Hutchins, 1996), rather than the reverse which is traditionally assumed. We will explore how externalisation works in the following.

6.2. The interpretation of signs and the affordances of artefacts

The meanings of signs, symbols, terms, phrases, etc. are built up through use. In our transcript, the term "different" takes on a specific meaning through the sequence of its occurrences in the discourse. It is used in conjunction with other terms, in reference to certain rockets, in various functional grammatical roles, as part of several speech acts. Of course, it also brings with it meanings from standard conversational English. All these influences are **sedimented** in the term's meaning for the classroom group – like the layers of sand sedimented in the Earth's geology and visible to the knowledgeable eye as traces of ancient history. Just as sand is compressed and transformed into impenetrable rock over time, the past uses of a word are compressed into its meaning (Husserl, 1936/1989). The meaning is shaped by its history long after the details of its episodic uses have been forgotten. New speakers of the word must learn to read the nuances of its meaning out of the occurrences they experience through interpretation.

An artefact **embodies** human meaning in its physical form. By definition, an artefact is man-made for some purpose. Its meaning has been designed into its form by a community for whom that artefact is part of their culture. The rocket list artefact, for instance, is a scientific inventory list. It includes a line describing each rocket in the simulation, systematically arranged to facilitate the identification of pairs of rockets differing in only one variable from each other. We say the list "affords" such identification, or that the artefact has this **affordance** designed into it. An affordance is not an objective property of an artefact, but is part of its meaning for a community of use (Gibson, 1979; Norman, 1990; Wartofsky, 1973/1979). Moreover, it is something that individual interpreters must learn to see as an affordance: It is only at the end of our transcript that Chuck can say "I see. I see. I see" about the list artefact's affordance.

6.3. The cycle of knowledge building and meaning making

Building collaborative knowing is a cyclical process with no beginning or end (see Figure 6). Any episode starts on the basis of an indefinitely long history of meaning and knowing. It assumes a meaningful language and a world of artefacts, a situation in which everything is already interpreted. Whatever is made explicit was already tacitly known and can only be explicated against an unbounded background of prior understanding – the "hermeneutic circle" (Heidegger, 1927/1996) means that one can only interpret what one already has an interpretation of.

In the small group discourses that drive building knowing, group meanings intertwine subtly with interpretive perspectives that engage in complex negotiations. Unnoticed, new layers of meaning are sedimented in shared jargon. Periodically, persistent artefacts like documents or pictures are produced. If nothing else, cognitive artefacts are internalised in personal memories, intellectual resources, mental abilities, minds.

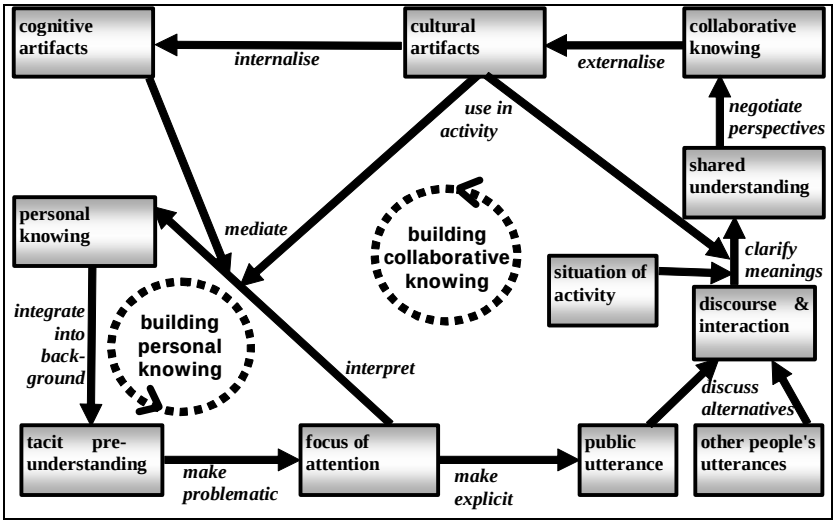

Figure 6. A diagram of the cycle of knowledge building. Adapted from (Stahl, 2000).

Viewed historically, the process feeds on itself and spirals exponentially faster. These days, technology mediates the interactions, the artefacts and the access. Building knowing takes place dramatically differently in a technologically produced environment, interpreted from scientific perspectives. The discourse processes in a CSCL discussion forum, for instance, are very different from those in a face-to-face meeting, partially because they take place in written rather than spoken language. The transition from oral to literate society (Ong, 1998) is taking another major step with computer networked communication. The nature and rate of social interaction and of the building of collaborative knowing are undergoing rapid and continuous transformation.

6.4. The interactive construction of knowing, the situation, temporality

How is an activity system context interactively achieved by a group discourse? The immediate activity for the collaborative moment in the transcript was established by the mentor's rhetorical question. Both the definition of the immediate task and its accomplishment were carried out discursively. His question was precisely formulated to define a mini activity system that could lead to the desired group knowing. The question was not, however, planned in advance by the mentor, but arose spontaneously as his reaction to the on-going conversation. His skilful use of such questions was a discursive, rhetorical resource that he put to use in the specific context in an effort to further the larger activity. This is an example of how an activity context was created as a natural and integral consequence of the very on-going discourse that it structured. That is, the context was not a pre-existing and immutable institutional structure, nor was it the externalisation of someone's prior mental representations or plans (Suchman, 1987).

It is characteristic of persistent objects that they distort or obscure the apparent history of their creation. Marx (1867/1976) pointed this out for commercial products and called it the “fetishism of commodities.” He argued that commodities on the market appeared to have an inherent economic value, whereas his historical, socio-economic analysis showed that their value was based on social relations among the people who produced and exchanged them. Similarly, words seem to have some kind of ephemeral other-worldly meaning, whereas we can deconstruct their meaning and demonstrate how it was constituted in a history of contextualized uses and networks of relationships to other words, artefacts and activities. Artefacts, too, seem to come with objective affordances, but these were designed into them by their creators and must be learned and interpreted anew by their users.

In our theory, collaborative learning – as the extending of group knowing – is constructed in social interactions, such as discourse. It is not a matter of accepting fixed facts, but is the dynamic, on-going, evolving result of complex interactions, primarily taking place within communities of people. The building of knowing is always situated; the situation grants meaning to the activities, language and artefacts that define the extended, inter-related context. Such a cyclical, dialectical process in which people construct elements of the very context that conditions their activity and makes it possible is a process of “social re-production” or “structuration” – the meaningful social situation reproduces itself interactively (Giddens, 1984). The situation reflects previous social activities, and is transformed by current interactions and by projections of the future. Frequently and unnoticed, interactive knowing crystallizes into seemingly immutable knowledge or facts, just as situated action coalesces into habitual practices, conventional rules and dominant institutions.

Even space and time, as the dimensions within which activities take place, are socially constructed interactively. In section 4.1 above we characterized the utterances in the transcript as indexical, elliptical and projective, meaning that they referenced unstated elements of the past, present and future discourse or its situation. In making such references, the discourse weaves an implicit pattern of temporal relations. The interactions of a group narrate the topic of discussion by indexing artefacts in the present situation, elliptically assuming references to past interaction and projecting possible futures. Participants in the discourse interpret and understand this woven temporal pattern as an unnoticed part of their involvement in the discourse. In this way, the situational network of meaning is structured temporally as what Husserl (1936/1989), Heidegger (1927/1996) and Schutz (1967) call “lived temporality.” Out of the social interaction among people, the following elements get produced, re-produced and habituated: the group itself as an interactive unit, the individuals as roles and mental subjects, the situation as network of artefacts and space/time as dimensions of reality.

6.5. The larger social context as constituted by designed artefacts and sedimented language

This chapter focuses on the micro-processes by which the social context is constituted: for instance, how words and artefacts get, preserve and convey their meaning. From these elemental processes that take place primarily in collaborative group interactions, one could then show how larger scale social institutions and human cognitive phenomena are built up.

Analyses of the role of artefacts (Bereiter, 2002; Donald, 1991; Geertz, 1973; Latour & Woolgar, 1979; Marx, 1867/1976; Vygotsky, 1930/1978; Wartofsky, 1973/1979) view human culture as consisting of immense collections of linguistic, physical and technological artefacts. Social theoreticians (Bourdieu, 1972/1995; Garfinkel, 1967; Giddens, 1984; Habermas, 1981/1984) show how social institutions and behavioural codes arise from the elemental processes we have discussed and become institutionalised into large scale social structures that seem impervious to human influence. These views could be summarized as arguing that the social context in which we live is constituted by the products and by-products of building collaborative knowing – taken on a global, historical scale. Just as our own behaviour and cognitive skills as individuals are products of group interaction, so the large social structures are interactively achieved, reproduced and reinterpreted in the momentary practices of communities.

This chapter has attempted to present core elements of a social theory of CSCL. In bringing together terms and approaches from existing theories influential within CSCL work, it has tried to describe some of the micro-processes (like synergy) that are often left as unexplained mysteries in other writings. Section 1 argued for the need to develop CSCL theory. Section 2 provided an empirical example of building collaborative knowing to guide our thinking. Section 3 suggested an answer to the epistemological question of how collaborative knowing is possible by pointing to group interaction as its source. Section 4 analysed the semiotics of meaning in terms of the situation as a network of relations among words, artefacts and activities. Section 5 addressed hermeneutic issues of interpretation with the ideas of background tacit knowing, personal perspectives and knowledge negotiation. Finally, this Section brought these concepts together to see how knowing evolves through a cycle involving externalisation of knowing in artefacts and internalisation as cognitive artefacts, all within a broader context of social institutions and community culture; this defines an ontology of meaningful physical objects and human abilities that develop through interaction with other people within the common meaningful world. The chapter will conclude with a reflection on the practical implications of this theory for the field of CSCL.

7. IMPLICATIONS FOR CSCL METHODOLOGY, PRACTICE AND DESIGN

Once we understand that the nature of learning and the educational institutions that structure it are evolving historical products, we can discuss

how to transform them by carefully designing the language and artefacts of future interactions for building collaborative knowing. That is the goal of CSCL and of this book.

7.1. The empirical analysis of collaborative learning

The evaluation of computer-supported collaborative learning involves the perspectives of three communities: the designers, the learners and the researchers.

The **designers** of software technology (such as web discussion forums), curricular materials (including web content) and classroom activities (e.g., teacher lesson plans) attempt to provide a structured context in which the collaborative building of knowing will take place in a certain way and with a certain subject matter focus. Their perspective may be documented in software user manuals or curriculum guides, for instance. Their perspective may be more or less grounded in some version of CSCL theory. We may consider these designers to be the practitioners of CSCL.

Learners engage in the collaborative building of knowing under the conditions established by the designers. We have seen in our analysis of the sample data of a small group of learners that they must make their learning visible to each other in their discourse in order for them to collaborate successfully. Typically, this learning is not made explicit, but is implicit in the discourse; however, it can be interpreted by researchers through careful analysis of captured data (Fischer & Granoo, 1995). The learning tends to be made more visible in cases of temporary breakdown of group understanding, when it becomes necessary to repair the sharing of references, etc. An important part of the learners' effort to build knowing is their engagement in understanding the meaning of the situation in which they find themselves, including understanding the affordances of the artefacts that they have to work with and the sedimented meanings of the terms they are given in texts, both spoken and written. This is an interpretive effort on their part. While they need to interpret the artefacts and terms, they do not necessarily have to interpret the perspectives of the designers of those artefacts and terms. Nevertheless, there must exist some sort of an interpretive horizon that connects the situation of the learners and the designers (Gadamer, 1960/1988). One possible way to forge this connection is through user-centred design methods. The learners form the CSCL user community.

Through interpretation of the meaning of the designed artefacts and of the captured usage discourse, **researchers** have access to the learning that takes place and to the perspectives of the designers and of the learners. Digital videotape facilitates the capture and analysis of multi-modal data from the learners. The fact that collaborative learning necessarily makes the learning visible provides the methodological basis for empirical analysis by researchers. Researchers of collaborative learning are not restricted to indirect evidence of learning (such as pre- and post-test differences) because they can analyse and interpret the making of meaning as it unfolds in the data at the group level and in individual trajectories of utterances. The analysis of discourse and more generally the deconstruction

of human institutions as socially constructed become powerful methods of empirical analysis (Berger & Luckmann, 1967; Duranti, 1998; Garfinkel, 1967; Heritage, 1984; Sacks, 1992). In addition, to the extent that the learners produce non-linguistic persistent artefacts, these can be brought into the analysis along with all forms of communicative interaction (gesture, pose, intonation, eye contact, etc.) (Streeck, 1983). Of course, the analysis must also take into account the activity structure and other socio-historical context in which the learning takes place. These researchers are the CSCL theoreticians and evaluators.

Other chapters will provide concrete suggestions for thinking about and analysing the designer, learner and researcher perspectives, whose theoretical foundations have been indicated here.

7.2. Classroom practices in higher education

Our guiding example was one of middle school students interacting face-to-face. In moving to computer-mediated interactions in higher education, many specifics of the interaction change, but important features still hold. In the following example, a group of students is working on their first assignment in an online college course. They are designing a web page to represent their group, interacting through a threaded discussion system:

Pat (**15:48**): *Map page*
Draft design is posted in the folder "PowerPoint contributions". Concept is "From afar, to a new home" – map shows where we all came from, destination is just shown as Tech.

> **Alice (15:49)**: *Destination*
> I think destination Tech is great, Is there anything I can do?

> **Boris (15:58)**: *absolutely agree*
> This is perfect to go with our bios.

> > **Alice (16:00)**: *first page*
> > What are we doing for the first page? And name?

> > > **Boris (16:09)**: *Name exists*
> > > Look up demo put by Pat at her final web link. The name was "Super Stars", I think.

> > **Pat (19:01)**: *Boris – map marker placement?*
> > Is my map marker reasonably close to Kathmandu?

> > > **Boris (09:39)**: *Map is correct*
> > > I think it's perfect.

Discourse in this medium allows a person to contribute to multiple threads simultaneously and multiple people to contribute to the same thread at the same time. The utterances tend to be longer, more carefully formulated in grammatical sentences. Nevertheless, there can be quick responses (see first pair above) and many of the same accomplishments can be achieved as in face-to-face, such as proposing, clarifying, negotiating and agreeing. Furthermore, the utterances still often have the indexical,

elliptical and projective characteristics. For instance, Pat's act in the first message above announced the posting of a page that was being proposed as a first page with a name for the group. Although Alice responded to this message, she apparently missed some of its point. Her response indicated this breakdown in shared understanding, and Boris responded to her by explicitly referencing Pat's proposed page and name. Alice's response was projective, in stressing the group's goal of producing a web page with their group name. All the utterances are elliptical in the sense that they assume a background of unstated knowledge for their full understanding: one must, for instance, know that many of the students in the group are foreign students and that they want their web identity to reflect their geographic diversity. Although this approach is proposed by one member in the first message above (and may have been discussed before), it is confirmed, refined and ratified during the group interaction.

Students at the level of higher education may already have most of the skills and background understanding necessary to engage in building collaborative knowing in a professional way. Education at this level can consist largely in guided apprenticeship in practicing typical examples of building knowing that are accepted within the field that the students are studying. For instance, small groups of medical students can engage in the collaborative diagnosis of medical cases. Here, problem-based learning (Barrows, 1994) has proven effective by selecting a large set of typical cases covering the major areas of medicine and motivating the student groups to delve deeply into the considerations needed to make informed decisions about these representative cases.

As implied by this chapter, the important thing is to engage the students in collaborative discourse. Without guidance and a motivating context, a group of students will rarely achieve the building of deep knowing. The teacher's role is to scaffold and guide the learning activities with carefully designed activities (structures), texts (language) and technologies (artefacts). In interpreting the meanings of these, the students will discursively build their group and individual understanding of the situation as a network of inter-relationships. Over time, this interpreted situation will provide the background knowing they will need to function productively in their future worlds.

7.3. The design of technology for CSCL

There are many reasons to use computer-based information and communication technology (ICT) in education.[2] CSCL artefacts should be designed with these explicitly in mind, for instance:

- To provide new media for supporting, structuring and scaffolding discourse and collaboration in ways that foster the building of collaborative knowing.

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[2] The author of this chapter has implemented a number of CSCL software systems illustrating the principles stated in this section. For papers on these systems and on the concepts discussed in this chapter, please visit the links to his work on the website for this book.

- To facilitate the intertwining of interpretive perspectives by allowing comparison of knowledge built by groups, smaller teams and individuals.
- To support knowledge negotiation by collaborative groups.
- To avoid the teacher bottleneck – where all communication must go through the teacher – by offering multiple paths for students to interact with each other directly.
- To avoid the teacher bottleneck – where all progress depends on teachers dispensing knowledge – by providing linguistic, cognitive and digital artefacts for students to interact with and internalise.
- To present new teachable moments or learning moments – relevant experiences – within simulated professional situations.

Just as desktop computer applications have increased the ability of individuals, corporations and institutions to compile, manipulate and visualize large and complex sets of information, networked CSCL applications have the potential to engage groups in building collaborative knowing on a scale previously unimaginable. With asynchronous communication, a hierarchical leader is no longer needed to control sequential interactions; discourse can proceed in a many-to-many fashion, with people participating whenever and wherever they like. Communities can expand virtually, overcoming geographic limitations. Perhaps most significantly, computer mediation can provide tools for dealing with the increasing complexity of information and decision-making.

A system to support the collaborative building of knowing might include support for such functions as:

- **Collaboration**: facilitating complex interactions, helping participants to maintain an overview of them, allowing participants to negotiate group decisions and building tacit knowing on the group level.
- **Social awareness**: displaying or comparing alternative interpretations of different participants in collaboration and keeping track of who knows or does what, when, where (see Chapter 9 by Kreijns).
- **Knowledge building**: accumulating, storing, organizing, preserving and displaying multi-media artefacts that arise in interaction.
- **Knowledge management**: the ability to collect items from broad discourses and organize them flexibly according to various perspectives for further manipulation and sharing.
- **Apprenticeship**: defining tasks, activities and learning goals, simulating pedagogically meaningful experiences and monitoring progress.

In designing CSCL systems, we can conceptualise the software as innovative media for group discourse – as artefacts that structure interaction and that must themselves be learned. The systems must be designed along with pedagogical activity systems to contextualize their use. They should aim at facilitating the collaborative building of knowing by user communities. They should promote the internalisation by individuals of

cognitive artefacts that transform the use of the CSCL artefacts and of the knowing that arises through their use.

7.4. This chapter as a theory artefact

This chapter has not presented a comprehensive and accepted theory. Rather, it has attempted to point in one possible direction for developing a theoretical framework for CSCL. Part of this theory is an understanding of how meaning is collaboratively constructed, preserved and re-learned through the media of language and artefacts – in group interaction. This research complex has barely begun to be explored. To the extent that it has been studied, this has been primarily outside the context of computer mediation or higher education. So, for instance, we desperately need careful investigations of how computer-supported discourse in higher education differs from face-to-face discourse in daily conversation and how students learn the affordances of CSCL artefacts.

If we self-apply our theory of building collaborative knowing to the process of theorizing about CSCL in higher education, we immediately see the importance of coining descriptive terminology, designing effective artefacts and reflecting upon these as a collaborative community in order to achieve the potential of CSCL. What we do not yet know about CSCL in higher education is as important as what we think we know. Hopefully, new researchers can leverage the presented concepts to collaboratively extend the knowing sedimented in this book.

References

Adorno, T., & Horkheimer, M. (1972). *The dialectic of enlightenment* (J. Cumming, Trans.). New York, NY: Herder & Herder. (Original work published in 1944).

Adorno, T. W. (1958). Der Essay als Form [The essay as form]. In *Noten zur Literatur I* (pp. 9-48). Frankfurt am Main, Germany: Suhrkamp.

Austin, J. (1952). *How to do things with words*. Boston, MA: Harvard University Press.

Barrows, H. (1994). *Practice-based learning: Problem-based learning applied to medical education*. Springfield, IL: SIU School of Medicine.

Bereiter, C. (2002). *Education and mind in the knowledge age*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Berger, P., & Luckmann, T. (1967). *The social construction of reality: A treatise in the sociology of knowledge*. New York, NY: Anchor Books.

Bourdieu, P. (1995). *Outline of a theory of practice* (R. Nice, Trans.). Cambridge, UK: Cambridge University Press. (Original work published in 1972).

Bruner, J. (1990). *Acts of meaning*. Cambridge, MA: Harvard U. Press.

Clark, H., & Brennan, S. (1991). Grounding in communication. In L. Resnick, J. Levine & S. Teasley (Eds.), *Perspectives on socially-shared*

cognition (pp. 127-149). Washington, DC: American Psychological Association.

Descartes, R. (1999). *Discourse on method and meditations on first philosophy*. New York, NY: Hackett. (Original work published in 1633).

Dillenbourg, P. (1999). What do you mean by 'collaborative learning'? In P. Dillenbourg (Ed.), *Collaborative learning: Cognitive and computational approaches* (pp. 1-16). Amsterdam, NL: Pergamon, Elsevier Science.

Donald, M. (1991). *Origins of the modern mind: Three stages in the evolution of culture and cognition*. Cambridge, MA: Harvard U. Press.

Dourish, P. (2001). *Where the action is: The foundations of embodied interaction*. Cambridge, MA: MIT Press.

Duranti, A. (1998). *Linguistic anthropology*. Cambridge, UK: Cambridge University Press.

Engeström, Y. (1999). Activity theory and individual and social transformation. In Y. Engeström, R. Miettinen & R. L. Punamäki (Eds.), *Perspectives on activity theory* (pp. 19-38). Cambridge, UK: Cambridge University Press.

Fischer, K., & Granoo, N. (1995). Beyond one-dimensional change: Parallel, concurrent, socially distributed processes in learning and development. *Human Development, 38*, 302-314.

Gadamer, H. G. (1988). *Truth and method*. New York, NY: Crossroads. (Original work published in 1960).

Garfinkel, H. (1967). *Studies in ethnomethodology*. Englewood Cliffs, NJ: Prentice-Hall.

Geertz, C. (1973). *The interpretation of cultures*. New York, NY: Basic Books.

Gibson, J. J. (1979). *The ecological approach to visual perception*. Boston, MA: Houghton Mifflin.

Giddens, A. (1984). *The constitution of society*. Berkeley, CA: University of California Press.

Habermas, J. (1984). *Reason and the rationalization of society* (T. McCarthy, Trans., Vol. One). Boston, MA: Beacon Press. (Original work published in 1981).

Halliday, M. A. K. (1985). *An introduction to functional grammar*. London: Edward Arnold.

Hatano, G., & Inagaki, K. (1991). Sharing cognition through collective comprehension activity. In L. Resnick, J. Levine & S. Teasley (Eds.), *Perspectives on socially-shared cognition* (pp. 331-348). Washington, DC: American Psychological Association.

Hegel, G. W. F. (1967). *Phenomenology of spirit* (J. B. Baillie, Trans.). New York, NY: Harper & Row. (Original work published in 1807).

Heidegger, M. (1996). *Being and time: A translation of Sein und Zeit* (J. Stambaugh, Trans.). Albany, NY: SUNY Press. (Original work published in 1927).

Heritage, J. (1984). *Garfinkel and ethnomethodology*. Cambridge, UK: Polity Press.

Husserl, E. (1989). The origin of geometry (D. Carr, Trans.). In J. Derrida (Ed.), *Edmund Husserl's origin of geometry: An introduction* (pp. 157-180). Lincoln, NE: University of Nebraska Press. (Original work published in 1936).

Hutchins, E. (1996). *Cognition in the wild*. Cambridge, MA: MIT Press.

Hutchins, E. (1999). Cognitive artifacts. In *MIT encyclopedia of the cognitive sciences*. Cambridge, MA: MIT Press.

Jaynes, J. (1976). *The origin of consciousness in the breakdown of the bicameral mind*. Boston, MA: Houghton Mifflin.

Kant, I. (1999). *Critique of pure reason*. Cambridge, UK: Cambridge University Press. (Original work published in 1787).

Koschmann, T. (1999). Meaning making: Special issue. *Discourse Processes, 27*(2).

Latour, B., & Woolgar, S. (1979). *Laboratory life*. Thousand Oaks, CA: Sage Publications.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, UK: Cambridge University Press.

Lave, J. (1996). Teaching, as learning, in practice. *Mind, Culture, and Activity, 3*(3), 149-164.

Lemke, J. (1990). *Talking science*. Norwood, NJ: Ablex.

Levinas, E. (1998). *Otherwise than being or beyond essence* (A. Lingis, Trans.). Pittsburgh, PA: Duquesne University Press. (Original work published in 1974).

Marx, K. (1967). Alienated labor. In L. G. K. Easton (Ed.), *Writings of the young Marx on philosophy and society* (pp. 287-300). New York, NY: Doubleday. (Original work published in 1844).

Marx, K. (1976). *Capital* (B. Fowkes, Trans. Vol. I). New York, NY: Vintage. (Original work published in 1867).

Mead, G. H. (1962). *Mind, self and society*. Chicago, IL: University of Chicago Press. (Original work published in 1934).

Merleau-Ponty, M. (1955). *Visible and invisible*. Evanston, IL: Northwestern University Press.

Norman, D. (1990). *The design of everyday things*. New York, NY: Doubleday.

Norman, D. (1991). Cognitive artifacts. In J. Carroll (Ed.), *Designing interaction*. Cambridge, UK: Cambridge University Press. Retrieved March 10, 2003, from http://www.cs.umu.se/kurser/TDBC12/HT99/Norman-91.html.

Ong, W. (1998). *Orality and literacy: The technologizing of the world*. New York, NY: Routledge.

Pea, R. (1993). Practices of distributed intelligence and designs for education. In G. Salomon (Ed.), *Distributed cognitions: Psychological and educational considerations* (pp. 47-87). Cambridge, UK: Cambridge University Press.

Polanyi, M. (1962). *Personal knowledge*. London, UK: Routledge & Kegan Paul.

Polanyi, M. (1966). *The tacit dimension*. Garden City, NY: Doubleday.

Roschelle, J. (1996). Learning by collaborating: Convergent conceptual change. In T. Koschmann (Ed.), *CSCL: Theory and practice of an emerging paradigm* (pp. 209-248). Hillsdale, NJ: Lawrence Erlbaum Associates.

Sacks, H. (1992). *Lectures on conversation*. Oxford, UK: Blackwell.

Sartre, J. P. (1968). *Search for a method* (H. Barnes, Trans.). New York, NY: Random House.

Scardamalia, M., & Bereiter, C. (1996). Computer support for knowledge-building communities. In T. Koschmann (Ed.), *CSCL: Theory and practice of an emerging paradigm* (pp. 249-268). Hillsdale, NJ: Lawrence Erlbaum.

Schutz, A. (1967). *Phenomenology of the social world* (F. Lehnert, Trans.). Evanston, IL: Northwestern University Press.

Searle, J. (1969). *Speech acts: An essay in the philosophy of language*. Cambridge, UK: Cambridge University Press.

Sfard, A. (1998). On two metaphors for learning and the dangers of choosing just one. *Educational Researcher, 27*(2), 4-13.

Sfard, A., & McClain, K. (2003). Analyzing tools: Perspectives on the role of designed artifacts in mathematics learning: Special issue. *Journal of the Learning Sciences, 11*(2 & 3).

Stahl, G. (2000). *A model of collaborative knowledge-building.* Paper presented at the Fourth International Conference of the Learning Sciences (ICLS 2000), Ann Arbor, MI. Retrieved March 16, 2003, from http://www.cis.drexel.edu/faculty/gerry/cscl/papers/ch14.pdf.

Stahl, G. (2002, June). *Understanding educational computational artifacts across community boundaries.* Paper presented at the International Society for Cultural Research and Action Theory (ISCRAT 2002), Amsterdam, The Netherlands. Retrieved March 16, 2003, from http://www.cis.drexel.edu/faculty/gerry/cscl/papers/ch03.pdf.

Stahl, G. (2003). *Meaning and interpretation in collaboration.* Paper presented at Computer Support for Collaborative Learning (CSCL 2003), Bergen, Norway. Retrieved March 16, 2003, from http://www.cis.drexel.edu/faculty/gerry/cscl/papers/ch20.pdf.

Streeck, J. (1983). *Social order in child communication: A study in microethnography*. Amsterdam: Benjamins.

Suchman, L. (1987). *Plans and situated actions: The problem of human-machine communication*. Cambridge, UK: Cambridge University Press.

Vygotsky, L. (1978). *Mind in society*. Cambridge, MA: Harvard University Press. (Original work published in 1930).

Vygotsky, L. (1986). *Thought and language*. Cambridge, MA: MIT Press. (Original work published in 1934).

Wartofsky, M. (1973). Perception, representation, and the forms of action: Towards an historical epistemology. In M. Wartofsky (Ed.), (1979). *Models: Representation and the scientific understanding* (pp. 188-210). London, UK: Reidel.

Wittgenstein, L. (1953). *Philosophical investigations*. New York, NY: Macmillan.