# Analysis of Group Practices

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# Abstract

The analysis of group practices can provide unique insight into the accomplishments of teams of students in CSCL settings. The theory of learning can be re-conceptualized at the group unit of analysis as the acquisition of group practices. CSCL pedagogy can be oriented toward orchestrating the adoption of group practices, supported by CSCL technology. This chapter introduces a methodology for analyzing extended sequences of situated interactions to identify the acquisition of group practices.

# Definitions & Scope: Learning as Acquisition of Group Practices

## Theory: Group Practices as Group-level Constructs

This chapter provides a view of small-group practices as central to computer-supported collaborative learning and, indeed, foundational for all human learning. Rather than conceptualizing learning as the accumulation of explicit knowledge, such as the memorization and storage of facts stated in language, one can view cognitive development in terms of tacit practices: knowing how to do things, to behave, to respond, to contribute. In CSCL, this involves focusing on group practices as the constituents of collaborative learning, which can be acquired by groups of learners.

A "group practice" as conceived here is a group-level construct. That is, it is to be distinguished from, for instance, psychological constructs on the level of the *individual* mind, such as mental representations or thoughts. On the other side, it is distinct from *social* practices as studied by social sciences oriented to communities, cultures or societies. A theory of CSCL needs to re-conceptualize all the categories of thinking, knowing and learning at the *group* level.

A focus on group practice in no way denies the existence and importance of individual thinking, knowledge, skills, habits, inclinations, emotions, etc. Nor does it dispute the power of social practices and cultural resources. Rather, practices and other cognitive or epistemological constructs at the individual, small-group and community levels are seen as interacting with each other intimately.

Although it is particularly difficult to find adequate detailed interaction data to analyze the mechanisms of inter-level influences, it is clear that individuals acquire their major cognitive tools like language, narration or argumentation from their larger cultural context, and that such acquisition takes place through small groups such as their immediate family, close friends, gangs, tribes or teams. The following slogans are suggestive of this: "It takes a village to raise a child" and "All I know I learned in kindergarten." These are settings in which young children acquire language, social behavior, norms of interaction, etc. If you look closely, you see that this happens overwhelmingly in games, disputes and modeling within dyads, triads and other small groups within the village or kindergarten, including between adults and children as well as among peers—largely through imitation and repetition.

Analysis of group practices shows that a typical learning process happens as follows, with interactions among different levels of description:

- A small group adopts a practice that may have been introduced into the group by one of its members or been taken from the larger culture.

- The small group may try out the practice and even discuss it explicitly to some extent.
- If the group adopts the practice, it becomes a resource for future behavior of that group and may then be used tacitly, without further discussion.
- Subsequently, members of the group may adopt the group practice as their own individual practice, having learned it collaboratively.

Small-group practices can also have effects in the opposite direction, influencing their communities. Over historical timespans, cultures have evolved new practices for constructing knowledge by adopting practices of small groups. These can then be spread to their citizens through acquisition by small groups and subsequent adoption by individuals. For instance, small groups of ancient Greeks developed the practices of geometry, which included formulating deductive proofs (Netz, 1999). The practices of proving were then acquired by groups of Greek philosophers and eventually adopted throughout Western culture as practices of argumentation (Latour, 2008). In each generation, these practices were introduced to groups of students and ultimately adopted by individuals as rational thinking.

## Pedagogy: Acquiring Group Practices

The recognition of the centrality of group practices to human learning can motivate an approach to pedagogy. Teaching can be driven by the goal of encouraging small groups of students to acquire group practices that are considered foundational to a given academic domain. For instance, school geometry involves practices of constructing and labeling figures, proving theorems and identifying dependencies of geometric elements upon each other.

Analysis of interaction among small groups working on geometry problems in a CSCL environment has identified the adoption of numerous relevant group practices (Çakir, Zemel & Stahl, 2009; Medina, Suthers & Vatrapu, 2009; Öner & Stahl, 2015; Stahl, 2016). The accumulation of these practices by the groups constituted their collaborative learning of the subject. Further analysis at other levels would reveal consequent changes in individual knowledge and in classroom instructional practices.

## Design: Planning for Group Practices

Pedagogy associated with CSCL approaches to teaching a given subject can be designed to promote specific identified practices that are foundational for that subject. It is always important to ensure that groups have acquired basic *collaboration practices*, such as taking turns, involving all group members, directing joint attention and maintaining common ground. Then there are practices involving using the available *technological* affordances, including domain-specific features like constructing figures. In addition, groups must acquire the important practices of the *subject matter*. Then, they need to employ *discourse practices* to maintain group agency and to reflect upon their collaborative learning.

Because learning takes place through intertwined levels of individual, small-group and community processes, it is important to design mutually supportive mechanisms for different levels and to orchestrate their application. For instance, teacher-centered presentations of background information can motivate and orient small-group CSCL activities that follow. The group activities in turn can be reinforced through whole-class discussion that presents, compares and reflects upon the knowledge artifacts produced by the different small groups. Effective orchestration of activities at the different levels can coordinate and mutually reinforce related individual, group and social practices.

### Technology: CSCL Supports for New Group Practices

All these practices can be designed into a CSCL environment through sequencing tasks, providing resources and carefully wording instructions, as well as design of domain-specific technology for construction and modeling. For instance, mechanisms that provide relevant textual information can introduce practices that are established in the broader culture, such as standard procedures.

Shared spaces in a collaborative online environment can support joint attention and stimulate shared exploration leading to group practices. Persistent summaries of collaborative learning can enable the establishment of individual knowledge. Affordances like highlighting text, eye-tracking display, line-coloring options and pointing tools can support joint attention and shared focus within digital group workspaces.

### Methodology: Analysis of Group Practices

For educational researchers, an important question is how an observer can know what group practices the groups being studied have acquired. If all the group interaction has taken place within a well-instrumented CSCL environment, then the necessary data may be readily available for analysis. This assumes that all interaction, including both discourse and visual presentation (drawing, pointing, construction sequence, highlighting, etc.) has been captured and preserved in the data corpus.

Whereas mechanisms of individual and community learning may involve unobservable processes like mental modeling or social dispersion, the acquisition and performance of group practices are necessarily public processes. That is because the discourse moves that make up the acquiring of new group practices must be available to the members of the group to allow them to work together. Consequently, researchers may be able to see the same things as the group members display to each other.

Of course, the researchers observe their captured data from a distanced analytic perspective, whereas the members interact to the fleeting original displays from within their active engaged perspectives. The students may not be aware of their involvement in the adoption of group practices; this is usually a tacit process, which is not articulated in the minds or speech of the participants. However, researchers can analyze and document the process in their reports. This chapter will suggest some procedures for doing this kind of analysis of the adoption of group practices—particularly through methods of interaction analysis.

## History & Development: From Ghosts and Minds to Group-Level Constructs

### Prehistoric Spirits as Explanation of Expertise

How learning takes place, how knowledge is developed, and how some individuals gain above-average expertise are questions that have always been posed by people. In olden times and ancient cultures, the answers generally involved external, non-human sources such as spirits, ephemeral voices or special gods. For instance, artists were inspired—that is, filled from outside with spiritual substances—perhaps by their muse or by divine guidance.

Later, expertise was attributed to a mysterious quality of genius. In this view, it was considered an attribute of an individual person. However, the source of this attribute was not subject to explanation or investigation.

Alternatively, knowledge was taken as an attribute of a culture. The intelligence or sophistication of members of one culture was considered more advanced than that of members of other cultures, who were branded as barbaric or primitive.

## Rational Minds as Thinkers

Views that are more modern treat an individual's behavior and knowledge as rooted in a rational mind. This approach parallels the development of science and is mirrored in the history of Western philosophy. Science dispensed with the world of spirits, eventually substituting hypotheses about mental representations, neural networks and social institutions.

Socrates and Plato (340 BCE) argued against explanations involving Greek gods, and situated truth in the efforts of the self-reflective individual. Aristotle (330 BCE) developed the first system of logical inference and pursued empirical investigation to discover knowledge. The conception of man as a rational mind reached its extreme expression in Descartes' (1633) philosophy, which was expanded in Kant's (1787) analysis of pure reason as the product of an individual human mind.

Rationalist theories still dominate much of science and popular thought. Economics and psychology, for instance, often model people as rational decision makers or as deductive reasoners. However, philosophy since Hegel (1807) paints a more dynamic picture in which human knowledge and reasoning develop over time through interaction with others in groups and cultures. Scientific theories relevant to CSCL have followed the philosophic trends of the past two centuries, as reviewed below.

## Individuals Constructing Understanding

Constructivist theories (e.g., Cobb, 1994; Packer & Goicoechea, 2000) argue that students necessarily construct new knowledge for themselves, using their existing conceptualizations and past knowledge. This is a Kantian view of explicit individual knowledge. Polanyi (1966) proposed an alternative view of knowledge as being primarily tacit. For instance, children learn to ride a bike through bodily feelings that are not spoken in words.

The perspective of tacit knowledge can be generalized to apply to most learning. We learn without being explicitly aware of the processes of learning or articulating them in speech or thought (silent self-talk). Rather, we learn through mimesis (imitation) and routine (repetition). Tacit learning typically takes place in connection with interaction with others in dyads, family units or small groups. It is largely preserved in habits of behavior.

## Social Practice

Theories of social practice (Bourdieu, 1972/1995; Giddens, 1984; Goodwin, 2013; Lave, 1988; 1991; 1996; Lave & Wenger, 1991; Reckwitz, 2002) can be considered a natural consequence of this move away from rationalist theories to tacit conceptualizations. Social practices are not the result of explicit negotiation, agreement or social contract. They arise tacitly through interaction and habituation. Theories of social interaction have been developed by social scientists (anthropologists, sociologists, linguists), so they generally locate the practices at the level of society, culture or community. However, most of their empirical examples of social practices take place situated in the interaction of small groups, such as apprentices with their master (Lave & Wenger, 1991). Thus, the theory can easily be re-conceptualized and studied at the small-group unit of analysis for CSCL.

Perhaps the most detailed analysis of social practices has been carried out in the field of ethnomethodology and conversation analysis. The following sections review major findings of this research.

## Ethnomethodology and Sequential Organization

The sequential ordering of situated interaction is an enduring characterization of joint human activity. An instance of human communication can be seen as a temporally unfolding series of communicative actions. How these actions relate from one moment to the next and from one participant to another within a setting has been the empirical focus advanced in the discipline of ethnomethodology (EM) and its applied field, conversation analysis (Garfinkel, 1967; Goodwin & Heritage, 1990).

The basic structural unit specified in conversation analysis (CA) is the *adjacency pair*. An adjacency pair is characterized by two utterances in which one (second-pair part) follows the other (first-pair part). For example, a greeting, such as “How are you?” invites a response, such as “fine!” at the appropriate next speaking opportunity. This is an oversimplification, as offering no response may be taken as a second-pair part, thus opening up a range of subsequent sequential mechanisms for the participants to work out the non-response as a relevant next action in the setting (e.g., relevant to the greeting in our example, see (Sacks, Schegloff & Jefferson, 1974).

The elementary example given above illustrates an important point in our consideration of interaction. The sequential structure of joint human activity is fundamentally negotiated. Issues emerge in our joint activity (e.g., the relevance or irrelevance of the non-response) that invoke other courses of action and their sequential structures. Here, the implications of the response may be taken up by the first party as problematic or might just as well be accepted as a legitimate response to the initial query. If the response is problematic, the first party may initiate a sequence of locating and repairing the trouble spot. In this case, the first party may repeat the greeting or request a follow up to the problematic response. Studies in CA have been prolific in identifying and describing these kinds of sequentially organized structures in a multitude of different settings. One of the systemic characteristics of sequential organization of interaction formulated by Sacks and his colleagues was the notion of *turn taking*.

A turn-taking system is one structural order above the adjacency pair, as it provides a basis for managing sequences of pairs. It consists of three components: (a) turn constructional units determine the point at which a turn transition may occur, (b) mechanisms for speaker selection such as who speaks next, and (c) a set of rules that delimit the options for action at each turn transition (Sacks et al., 1974). At its inception, the notion of a turn-taking system offered an analytic framework for investigating how interactions might vary structurally within and across specific settings (e.g., differentiating turn taking in casual telephone conversations as opposed to doctor-patient consultations). Turn-taking systems in a variety of different discursive settings expose a number of different contingencies such as the number of parties involved in the interaction, the organization of openings and closings, and the allocation of turns

(Schegloff & Sacks, 1973; Schegloff, 1990). In this framework, features of the setting act as parameters for describing how a particular context is defined through the deployment of particular turn-taking moves.

A turn-taking system, from a CA perspective, is systemic to all forms of joint activity. Any instance of human interaction can be observed with respect to how participants manage turn transitions, how next speakers are selected, and what governs how things are to proceed from turn to turn, where some course of action is preferred and selected over another (Schegloff, Jefferson & Sacks, 1977). We might consider a courtroom setting as one such turn-taking system. The expected ordering of action is presumably shared by all participants involved (e.g., turn allocation is highly managed through established legal discourse practices as well as the roles played by judges, attorneys and witnesses). Deviation from the expected unfolding of turns is constrained; judges and attorneys demonstrate themselves to be competent participants and witnesses are "instructed" on how to participate. Turn taking systems in less institutionalized settings are of a strikingly different character. In casual conversation for example the organization of turns at talk is more loosely managed, but remains structurally discernable.

## Interaction in the Setting

The turn-taking apparatus advanced by CA practitioners has served as a productive analytic tool for clarifying the relationship between setting and interaction. Schegloff (1991) refers to this relationship as a problem of procedural consequentiality—how the external elements (anterior to language) of the situation are made relevant and consequential for the interaction. Relevance and procedural consequentiality rest on the notion that participants' immediate actions are contingent on resources in the setting as relevant structures for coordinating and ordering their interaction. These resources include the stream of talk preceding the next utterance as well as the semiotic and material elements that make up the setting. Relevance and procedural consequentiality provide two heuristics for determining the relationships between action and setting.

First, the notion of relevance requires that analyses seek the points in interaction in which participants organize and account for referents in the conduct of sequential action (turn-taking structure). Second, the analytic requirement for showing procedural consequentiality highlights those instances in which the setting itself informs and shapes sequential structures. That is, how the setting ('in the hospital', or 'in the courtroom') has direct consequences for the organization of sequential action. This view is particularly noteworthy for CSCL as our concern is the role semiotic rich settings and technologies play in shaping learning interactions.

## Multimodal Sequential Analysis and Representational Practice

A wide variety of studies have leveraged the analytic insight of Ethnomethodology and CA to draw attention to the configuration of the body, the semiotic elements of the setting and their coordination in the sequential organization of action (Goodwin, 1994; 2000a; 2018; Streeck, 1996). Goodwin's studies consistently demonstrate how the semiotic, material and embodied elements of the setting are consequential to the structure of interaction. Action is not limited to utterances, but is distributed across a range of multimodal resources available to participants. CA has brought focus to the manipulation of various semiotic resources in talk-in-interaction as a rich site for understanding communicative mechanisms. Discussions of indexicals—how language references elements of the setting—in this regard are often central to explaining and describing the role of media artifacts (Zemel & Koschmann, 2013).

Goodwin (2013) convincingly argues, however, that the semiotic environment is not limited to reference, but is itself manipulated in communicative action in what he refers to as cooperative semiosis—the construction of signs as relevant actions in interaction. One of Goodwin's formidable contributions in this line of thinking is how semiotic action is included in structural explanations of human interaction (Goodwin, 2018).

Ethnomethodology and CA traditions specify the focus of inquiry on the sequentiality of interaction. In so doing, they afford a starting point for empirical analysis of technology-mediated interaction that tightly couples user actions with the particulars of the setting. In CA generally, the setting is established through talk. Other similarly motivated lines of work such as that by Goodwin extend analysis by including semiotic, material and embodied elements of the setting. There has also been some analysis of how sequentiality and turn-taking work in CSCL settings such as text chat (Zemel & Çakir, 2009).

The following section discusses the concept of uptake as a reformulation of sequentiality with particular relevance to CSCL.

## Uptake: A Unit of Interaction

Making sense of the sequential structure of interaction and its deployment within CSCL environments presents a degree of complexity for analysis. Interaction settings may be asynchronous or synchronous, and participants may be co-present or geographically distributed. Further, how is one to organize analyses of communicative actions that extend beyond the verbal modality? A user's action within an online environment might include dragging an object across the screen, or posting a message to a discussion thread. Participants can draw upon semiotic, material and embodied elements of the setting in organizing their interactions. A useful strategy to begin with might be to recognize how participant actions are evidenced to be relevant and consequential for activity. How and where are actions positioned in the sequential unfolding of the larger activity, and how do those actions relate to prior actions? The notion of *uptake* has been proposed as a useful concept for investigating precisely these questions.

Suthers, Dwyer, Medina and Vatrapu (2010) describe uptake as a relational construct that identifies a participant action as appropriating aspects of a prior or ongoing setting as relevant for ongoing interaction. This definition is deliberately abstract, enabling it to be purposed in a wide range of interactional analysis. It is also intended to support a diverse range of theoretic and methodological approaches. Uptake provides an interpretive heuristic rather than a specific method of analysis; it may be described as proto-analytic. Uptake specifies a relation between a user action and some aspect of the environment. The potential gain by interpreting interaction as uptake is that uptake does not privilege one particular communicative modality or granularity over another. A warranted interpretation of uptake only specifies that one human action is appropriating aspects of a prior or ongoing element of the setting while also transforming that setting. The value of uptake for the analysis of technology-mediated interaction is its provision for a more flexible consideration of sociological and technological contingencies. This value also extends into analytic interpretations and reportable findings. A later section discusses in more detail a specific approach for the analysis of socio-technical contingencies.

### Group Cognition

Focusing on uptake or the adjacency pair as the unit of interaction locates research at the small-group level of the discourse or cognition that takes place between or across individuals. It includes contributions from two or more individuals, but cannot be reduced to a mental achievement of either individual, or even a simple sum of their mental representations. The parts of the adjacency pair elicit and respond to each other, thus happening outside the heads of any one participant, but articulating a relationship among them. The relationship between the adjacency parts or the uptake relationship necessarily takes place in the public arena of the group, where it is shared by and visible to the participants (and potentially also visible to researchers). Further, the recognition of the tacit nature of interactional practices implies that the elicitation and response cannot be reduced to rational processes in the minds of participants. The cognition that takes place here is an achievement of the group as such. It can therefore be conceptualized as *group cognition* (Stahl, 2006).

The analysis of group cognition in terms of adjacency pairs or intersubjective meaning making through uptake (Suthers, 2006) provides a methodological basis for studying the adoption of *group practices* as the origin of practices of group cognition. It thereby offers a rigorous approach to the study of CSCL, including a method for providing feedback to the iterative design of CSCL interventions. We now consider how to conduct such analysis.

## State of the Art: Analysis of Group Practices at Multiple Sequential Orders

This section outlines a methodological approach to analysis of group practice. The approach builds on foundations of ethnomethodological inquiry by maintaining a primary concern with the sequential organization of interaction. The overall strategy of the approach attempts to provide a more complete account of observed practices by identifying different structures of sequential interaction as data points (or segments) that when fully assembled provide an informative view of the processes and contingencies of small-group interaction in CSCL settings. Thus, our goal is to build a structural description of observed interaction that can be used as a resource for addressing various kinds of research questions and contributing to different but related research agendas.

The steps of the analysis presented here are extrapolated from the "Eight C's" outlined by Fisher and Sanderson (1996). Their approach to Exploratory Sequential Data Analysis (ESDA) enumerates a sequence of analytic activities for handling observational data. The intent behind the set of procedures is to progressively arrive at a structured understanding and representation (referred to as "smoothing") of sequential data records. The smoothing process adapted for this description can be seen as working with multiple, mutually compositional units of analysis: (a) microanalysis (documentation of turn-by-turn relevancies), (b) structure (determination of interactional structure), and (c) macro-structure (formation of interactional structures as interactional practices).

Our procedure applies three of the eight ESDA smoothing operations as relevant for analysis of small-group practices. These operations are (1) chunks, (2) comments and (3) connections (see following sections). It is important to note that the procedure is iterative, moving back and forth from one operation to the other as the analysis unfolds (see Figure 1).

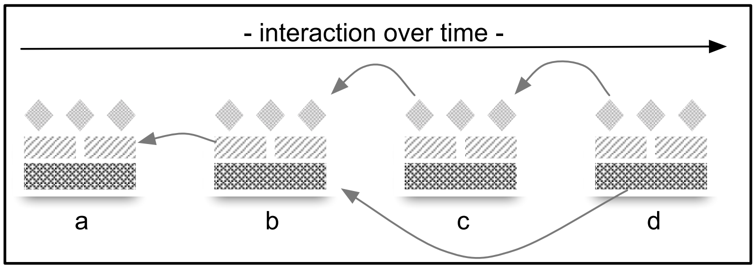


Figure 1. Interactional structures

## Content Logging

An initial pass over the data is conducted to establish and mark off major sections of the data stream and possibly to synchronize time indices across multiple data sources (e.g., video and software-generated log files). Content logging is a preparatory step in the analysis but is crucial for gaining a sense of the scope of the activity captured in each data set. After the initial organization is completed, the analysis cycles through the three relevant ESDA operations.

## 1. Segmentation

Segmentation is the identification of boundaries between adjacent interaction events that together form a sequential structure. A data element at the lowest granularity is an elementary participant action. Participant actions are sequentially organized within the interaction, creating boundary points for segmentation (Jordan & Henderson, 1995). These sequential structures are emic (their identification is derived directly from participant actions). They may range from short exchanges such as a reply to a question or may extend into longer structures concerned with, for example, specific topics or problems of concern to the participants. Despite an apparent etic (derived from analyst's interpretation) attribution of structure, the purpose of this smoothing technique is not to obfuscate the continuous nature of interaction in its setting, but to identify its elements and structure in a tractable manner. Identified segments, on further analysis, may contain smaller chunks or segments. Figure 1 provides a schematic of this process. Each of the four segments (a, b, c, d) may contain sequential structures within it identifiable at different granularities.

An important analytic opportunity that emerges as a result of segmentation is the transition between segments. A transition may be acute, such as the boundary between two separate days of interaction. The gaps between a, b, c and d in Figure 1 indicate this kind of boundary. Transitions may occur within particular episodes more subtly, such as a change of topic or focus (e.g., the gaps between the inner shapes in Figure 1). In general, transitions between segments may dramatically expose the organizational and coordinative work involved in interactional practices (Jordan & Henderson, 1995).

In addition to the segmentation of observed interactions in the data set, it is possible to adjust analytic focus on aspects of the data that are of concern for the study. For example, a segmentation analysis could be conducted on inscriptional activity involving CSCL text or drawing tools. Focused segmentation, in this case, would result in subsequences of inscriptional activity occurring within longer segmentations of interaction.

## 2. Segment Description

Segmentation is useful for setting up investigations of sequential interactions. A segment is then analyzed in a turn-by-turn approach strongly influenced by techniques used in CA. A turn unit consists of an utterance or chat contribution, gesture, gaze, drawing, or a manipulation of the interaction environment. At a fine granularity, we look at the relationship between actions to determine how the prior turn is taken up or handled by the next turn. This close inspection typically yields the identification of communicative mechanisms. Microanalysis of a segment is recorded as annotations that might draw on technical terms commonly utilized in CA studies or, alternatively, as emergent vocabularies for describing the interaction structures observed. For example, an analysis of a sequence of interaction between two participants might be characterized as an instance of communication trouble and repair. This phase of the analysis is not restricted solely to identifying such mechanisms but retains some latitude in effectively describing the kinds of interaction structures and mechanisms that are observed. Thus, the result of this phase is a mixture of common technical terms, labels and terms deemed adequate by the analyst in documenting a segment.

## 3. Relations between Segments

This step in the procedure identifies and describes connections between segments, some of which may extend beyond immediate interaction contexts. Figure 1 illustrates how the scheme is now utilized to determine connections between segments. The arrows between segments indicate relations that emphasize the contingency of a segment on a prior segment. Evidence for drawing connections between interactional structures is based on the following baseline heuristics:

- Uptake of prior resources.
  - Using references to prior elements.
  - Transporting prior elements into the current context.
- Invocation of a prior sequential structure (e.g., turn-taking system).

The microanalysis of segments applied in step 1 and 2 above provides an empirical frame in which to observe how the participants orient to and make relevant their talk as well as their actions. A critical component for making these observations of sequential structure and its elements is the identification of referents that evidence indexical relations between and within turns. Referents that are underdetermined in the immediate interactions but can be located in prior situated settings warrant the identification of a connection (e.g., the arrow between d and b in Figure 1). These "missing" referents provide a demonstration of how prior situated activity is made relevant and consequential for immediate turn-taking sequences (Koschmann, LeBaron, Goodwin & Feltovich, 2001; Koschmann, Sigley, Zemel & Maher, 2018; Medina et al., 2009).

The second heuristic that is applied to determine connections between segments is based on the identification of procedural consequentiality. In this case, we explicitly examine how the setting conditions and constrains immediate actions. Technology-mediated settings are unique in that they are participant-defined spaces that undergo transformations as well as support the deployment and redeployment of sequential organizational structures (Drew & Heritage, 1992; Robinson, 2013). The results of this step in the procedure are annotations and rich descriptions of the connections that were identified and their related evidence. The segmentation and analysis performed in steps 1, 2 and 3 provide the empirical basis for claims made with regard to these connections.

### Identifying Adoption of Group Practices

The methods just reviewed have been applied to the identification of group practices in a number of case studies of mathematics problem solving by groups in CSCL environments (Çakir, 2009; Koschmann, Stahl & Zemel, 2009; Öner, 2016; Stahl, 2009; Zemel & Koschmann, 2013). Some of these studies have applied interaction analysis to "longer sequences" of adjacency pairs, as are required for mathematical problem solving (Stahl, 2019, Chapters 23, 24, 25). A longitudinal study of a small group learning online collaborative dynamic geometry identified the adoption of about 60 group practices, including practices of collaboration, problem solving, geometric construction, technology usage and explanatory discourse (Stahl, 2016). Other case studies have applied this approach to rich data sets containing multiple video and screen recordings of small-group interaction in a science classroom (Medina, 2013). These case studies point the way for a new vision of CSCL, centered on the analysis of group practices.

### Computer Support for Analysis of Group Practices

The above approach to analysis and identification of group practices can be supported by data-driven research agendas that require cataloging segments and annotations and involve linking segments to data in video, log files or other primary (e.g., Dyke, Lund & Girardot, 2009). For example, if segments are viewed as n-gram data points, opportunities arise for automated pattern detection, feature extraction and other computational methods for processing and investigating sequential structures.

## The Future: Education as Fostering New Group Practices

### Theory: Collaborative Learning as Acquiring Group Practices

CSCL can be re-conceptualized as the support of groups of learners to acquire group practices that contribute to their collaborative learning. Collaborative learning itself can be conceived in terms of the adoption of specific group practices, which contribute to various aspects of the group's cognitive abilities. Since students often adopt for themselves practices that they first acquired as part of a group cognitive experience, and communities often evolve new social practices through the transmission of these group practices, collaborative learning and group practices can be considered to play a potentially central, foundational role in human learning at all levels.

Theories of practice (such as Bourdieu, 1972/1995; Goodwin, 2000b; Hakkarainen, 2009; Lave & Wenger, 1991; Lipponen, Hakkarainen & Paavola, 2004; Medina et al., 2009; Polanyi, 1966; Reckwitz, 2002; Schatzki, Knorr Cetina & Savigny, 2001; Suchman & Trigg, 1991) reject the traditional rationalist, cognitivist and individualist views of learning, thinking and knowing. They re-conceptualize the basic processes and products of cognition.

For CSCL, with its focus on collaborative meaning making within small groups in computer-mediated contexts, the practice-oriented conceptualizations of these theories must all be shifted to the group unit of analysis. Underlying effective collaborative learning is the maintenance of intersubjectivity, the ability of participants to understand and interact with each other. Intersubjectivity is based on our living in one world as the ultimate context of our understanding (Stahl, 2019, Chapter 18) and is maintained through the establishment of common ground through interactional mechanisms such as repair of misunderstandings (Clark & Brennan, 1991). Mutual understanding is supported by joint attention to the object of consideration (Tomasello, 2014). Knowledge that contributes to collaborative learning or that results from it is necessarily shared knowledge. Intersubjectivity, joint attention and shared knowledge are some of the many group-level constructs needed for a theory of CSCL oriented to group practice (Stahl, 2019, Chapter 19, 20, 21).

## Pedagogy: Sequencing Group Practices

Analysis of group practices has been carried out primarily with interaction data on virtual math teams engaged in mathematical problem solving of middle-school combinatorics and dynamic geometry. This is because interesting usable data was available from these instrumented online sessions. The same approach could be applied to other learning domains if adequate data is available. For instance, a number of CSCL researchers have studied collaborative learning in which they conclude that group processes played a central role, but they did not have interaction data to explore how these processes actually took place. They only had data to demonstrate that there was a change between two time instances that they analyzed (e.g., Barron, 2003; Kapur & Kinzer, 2009; Schwartz, 1995), and they had to speculate about group cognitive processes.

The studies of dynamic geometry involved a sequence of up to eight hour-long sessions, each with a geometry figure to manipulate, discuss and construct. The collaboration environment included a shared workspace with a geometry application that restricted manipulation of points, lines and figures based on how they were constructed. There were sample figures to manipulate, textual instructions to guide the session and a chat interface for group communication. The tasks for the sequences of sessions were carefully planned—based on previous mathematical experience and numerous trials—to encourage the accumulation of specific group practices (Stahl, 2016). Group practices had to be established in roughly this order:

- Be able to use the computer and the collaboration environment.
- Be able to communicate in chat, repair mistakes and misunderstandings, propose actions.
- Use the dynamic-geometry app, find menu options, create points, lines and figures.
- Drag geometric objects to observe their behavior.
- Construct figures so they would embody desired constraints or dependencies.
- Discuss why a geometric figure behaved the way it did (argumentation, explanation, proof).

Using the methods discussed in this chapter, researchers were able to identify when groups adopted practices such as these, what difficulties they encountered and when they failed to establish these practices.

## Design: Orchestrating Group Practices

CSCL is not a standalone educational approach. Collaborative learning is not always the best approach, and it is usually more effective when combined with complementary approaches in ways that take into account the interactions among the individual, small-group and community levels of description. However, collaborative learning can be uniquely effective in introducing important practices.

In a school context, a teacher may orchestrate CSCL sessions to fit into a sequence of varied learning modes. Perhaps an introductory presentation by the teacher will motivate a new topic. Then individual reading might provide background information. At that point, collaborative exploration can lend a creative and interactive process of discovery, supported by discussion and sociability. Perhaps a homework assignment would open an opportunity for students to adopt recent group practices as their own individual behaviors. The topic could conclude with a class discussion session and an individual writing of reflections. The written reflection could also be shared with group members, perhaps leading to a group position paper on the topic.

The various targeted group practices associated with a topic for study can be supported within multiple orchestrated learning modes. For instance, the use of a particular tool in the geometry app could be demonstrated to the class by the teacher and reinforced by a brief instructional video. Then the task for the group session could involve that tool. Students could explore the tool with their group and later practice its use in homework and reflect on its usefulness in class discussion or a report. Thus, orchestration could be used to coordinate educational modes of interaction in tandem with sequencing the exercise of relevant group practices.

### Technology: Supporting Group Practices

Computer technologies can be used to support specific group practices. For instance, text chat or discussion forums can support argumentation, but there can also be specific affordances of special CSCL argumentation environments that foster negotiation or analysis of argumentation structure (Schwarz & Baker, 2017). Pointing tools can represent references from one screen icon to another (Mühlpfordt & Wessner, 2009). Eye-tracking displays can enhance joint attention by indicating where each participant is looking (Schneider & Pea, 2013).

A shared workspace can be important for providing a "joint problem space" (Teasley & Roschelle, 1993) where a group can work together and acting as a group memory that can even span discontinuities in group presence (Sarmiento, 2007; Sarmiento & Stahl, 2008). The workspace can be taken a step further with simulations or modeling, as with the dynamic-geometry app.

### Methodology: Analyzing Group Practices

The analytic methodology presented in this chapter offers the CSCL researcher a way to discover and document the adoption of group practices as a dynamic view into collaborative learning. Importantly, this view can guide on-going iterations of redesign of the computer support.

The analysis of group practices opens up a contemporary approach to designing and assessing education. Group practices stand at the center of collaborative learning, and collaborative learning is foundational for all human learning.

## Additional Reading

(Medina et al., 2009) ***Representational practices in VMT*** analyzes the adoption of several group practices by a team of students discussing geometry problems.

(Stahl, 2019) - ***Theoretical Investigations*** brings together many of the past articles in the *International Journal of CSCL* and recent essays by the editor that are most relevant to this chapter. Together, they point in the direction of CSCL theory indicated here for the future.

(Stahl, 2016) ***Constructing Dynamic Triangles Together*** follows the collaborative learning of a team of three girls longitudinally over eight weeks as they begin to learn dynamic geometry. The book identifies about 60 group practices that the team adopts.

(Stahl, 2013) ***Translating Euclid*** presents multiple perspectives on the Virtual Math Teams project. It includes the first analysis of the adoption of a group practice more fully discussed in the preceding reference.

(Stahl, 2006) ***Group Cognition*** provides the initial discussion of group cognition as a central concept for analyzing CSCL interactions. The idea of group cognition arose in the writing of this book and led to the focus on group practice a decade later.

# References


Aristotle. (330 BCE). *Metaphysics* (H. G. Apostle, Trans.). Bloomington, IN: Indiana University Press.

Barron, B. (2003). When smart groups fail. *The Journal of the Learning Sciences. 12*(3), 307-359.

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

Çakir, M. P. (2009). The organization of graphical, narrative and symbolic interactions. In G. Stahl (Ed.), *Studying virtual math teams.* (ch. 7, pp. 99-140). New York, NY: Springer.

Çakir, M. P., Zemel, A., & Stahl, G. (2009). The joint organization of interaction within a multimodal CSCL medium. *International Journal of Computer-Supported Collaborative Learning. 4*(2), 115-149.

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: APA.

Cobb, P. (1994). *Learning mathematics: Constructivist and interactionist theories of mathematical development*. Dodrecht, Netherlands: Kluwer.

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

Drew, P., & Heritage, J. (1992). *Talk at work: Interaction in institutional settings*. Cambridge, UK: Cambridge U Press.

Dyke, G., Lund, K., & Girardot, J. J. (2009). *Tatiana: An environment to support the CSCL analysis process.* In the proceedings of the 9th International Conference of CSCL. Proceedings pp. 58-67.

Fisher, C., & Sanderson, P. (1996). Exploratory sequential data analysis: Exploring continuous observational data. *interactions. 3*(2), 25-34.

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

Giddens, A. (1984). *The constitution of society. Outline of the theory of structuration*. Berkeley, CA: U of California Press.

Goodwin, C. (1994). Professional vision. *American Anthropologist. 96*(3), 606-633.

Goodwin, C. (2000a). Action and embodiment within situated human interaction. *Journal of Pragmatics. 32*, 1489-1522.

Goodwin, C. (2000b). Practices of color classification. *Mind, Culture, and Activity. 7*(1&2), 19-36.

Goodwin, C. (2013). The co-operative, transformative organization of human action and knowledge. *Journal of Pragmatics. 46*(1), 8-23.

Goodwin, C. (2018). *Co-operative action*. Cambridge, UK: Cambridge Universtity Press.

Goodwin, C., & Heritage, J. (1990). Conversation analysis. *Annual Review of Anthropology. 19*, 283-307.

Hakkarainen, K. (2009). A knowledge-practice perspective on technology-mediated learning. *International Journal of Computer-Supported Collaborative Learning. 4*(2), 213-231.

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

Jordan, B., & Henderson, A. (1995). Interaction analysis: Foundations and practice. *Journal of the Learning Sciences. 4*(1), 39-103.

Kant, I. (1787). *Critique of pure reason*. Cambridge, UK: Cambridge University Press.

Kapur, M., & Kinzer, C. K. (2009). Productive failure in CSCL groups. *International Journal of Computer-Supported Collaborative Learning. 4*(1), 21-46.

Koschmann, T., LeBaron, C., Goodwin, C., & Feltovich, P. (2001). Dissecting common ground: Examining an instance of reference repair. In J. D. Moore & K. Stenning (Eds.), *Proceedings of the twenty-third annual conference of the cognitive science society.* (pp. 516-521). Mahwah, NJ: Lawrence Erlbaum Associates.

Koschmann, T., Sigley, R., Zemel, A., & Maher, C. A. (2018). How the "machinery" of sense production changes over time. In J. W. a. E. G.-M. S. Pekarek Doehler (Ed.), *Longitudinal studies on the organization of social interaction.* (pp. 173-191). New York, NY: Springer.

Koschmann, T., Stahl, G., & Zemel, A. (2009). *"You can divide the thing into two parts": Analyzing referential, mathematical and technological practice in the VMT environment.* In the proceedings of the international conference on Computer Support for Collaborative Learning (CSCL 2009). Rhodes, Greece. Web: http://GerryStahl.net/pub/cscl2009tim.pdf.

Latour, B. (2008). The Netz-works of Greek deductions. *Social Studies of Science. 38*(3), 441-459.

Lave, J. (1988). *Cognition in practice: Mind, mathematics and culture in everyday life*. Cambridge, UK: Cambridge University Press.

Lave, J. (1991). Situating learning in communities of practice. In L. Resnick, J. Levine & S. Teasley (Eds.), *Perspectives on socially shared cognition.* (pp. 63-83). Washington, DC: APA.

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

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

Lipponen, L., Hakkarainen, K., & Paavola, S. (2004). Practices and orientations of CSCL. In J.-W. Strijbos, P. Kirschner & R. Martens (Eds.), *What we know about CSCL: And implementing it in higher education.* (pp. 31-50). Dordrecht, Netherlands: Kluwer Academic Publishers.

Medina, R. (2013). Cascading inscriptions and practices: Diagramming and experimentation in the group scribbles classroom. In D. D. Suthers, K. Lund, C. P. Rosé, C. Teplovs & N. Law (Eds.), *Productive multivocality in the analysis of group interactions.* (pp. 291–309). New York, NY: Springer.

Medina, R., Suthers, D. D., & Vatrapu, R. (2009). Representational practices in VMT. In G. Stahl (Ed.), *Studying virtual math teams.* (ch. 10, pp. 185-205). New York, NY: Springer.

Mühlpfordt, M., & Wessner, M. (2009). The integration of dual-interaction spaces. In G. Stahl (Ed.), *Studying virtual math teams.* (ch. 15, pp. 281-293). New York, NY: Springer.

Netz, R. (1999). *The shaping of deduction in Greek mathematics: A study in cognitive history*. Cambridge, UK: Cambridge University Press.

Öner, D. (2016). Tracing the change in discourse in a collaborative dynamic-geometry environment: From visual to more mathematical. *International Journal of Computer-Supported Collaborative Learning. 11*(1), 59-88.

Öner, D., & Stahl, G. (2015). *Tracing the change in discourse from visual to more mathematical*. Unpublished manuscript. Web: http://GerryStahl.net/pub/tracing.pdf.

Packer, M., & Goicoechea, J. (2000). Sociocultural and constructivist theories of learning: Ontology, not just epistemology. *Educational Psychologist. 35*(4), 227-241.

Plato. (340 BCE). *The republic* (F. Cornford, Trans.). London, UK: Oxford University Press.

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

Reckwitz, A. (2002). Toward a theory of social practices : A development in culturalist theorizing. *European Journal of Social Theory. 5*, 243–263.

Robinson, W. P. (Ed.). (2013). *Communication in development*. London, UK: Academic Press.

Sacks, H., Schegloff, E. A., & Jefferson, G. (1974). A simplest systematics for the organization of turn-taking for conversation. *Language. 50*(4), 696-735.

Sarmiento, J. (2007). *Bridging: Interactional mechanisms used by online groups to sustain knowledge building over time.* In the proceedings of the international conference on Computer-Supported Collaborative Learning (CSCL '07). New Brunswick, NJ. Web: http://GerryStahl.net/vmtwiki/johann.pdf.

Sarmiento, J., & Stahl, G. (2008). *Extending the joint problem space: Time and sequence as essential features of knowledge building [nominated for best paper of the conference].* In the proceedings of the International Conference of the Learning Sciences (ICLS 2008). Utrecht, Netherlands. Web: http://GerryStahl.net/pub/icls2008johann.pdf.

Schatzki, T. R., Knorr Cetina, K., & Savigny, E. v. (Eds.). (2001). *The practice turn in contemporary theory*. New York, NY: Routledge.

Schegloff, E. (1991). Reflections on talk and social structure. In E. Boden & D. Zimmerman (Eds.), *Talk and social structure: Studies in ethnomethodology and conversation analysis.* (pp. 44-70). Berkeley, CA: University of California Press.

Schegloff, E., & Sacks, H. (1973). Opening up closings. *Semiotica. 8*, 289-327.

Schegloff, E. A. (1990). On the organization of sequences as a source of 'coherence' in talk-in-interaction. In B. Dorval (Ed.), *Conversational organization and its development.* (pp. 51-77). Norwood, NJ: Ablex.

Schegloff, E. A., Jefferson, G., & Sacks, H. (1977). The preference for self-correction in the organization of repair in conversation. *Language. 53*(2), 361-382.

Schneider, B., & Pea, R. (2013). Real-time mutual gaze perception enhances collaborative learning and collaboration quality. *International Journal of Computer-Supported Collaborative Learning. 8*(4), 375-397.

Schwartz, D. (1995). The emergence of abstract representations in dyad problem solving. *Journal of the Learning Sciences. 4*(3), 321-354.

Schwarz, B., & Baker, M. (2017). *Dialogue, argumentation and education: History, theory and practice*. Cambridge, UK: Cambridge University Press.

Stahl, G. (2006). *Group cognition: Computer support for building collaborative knowledge*. Cambridge, MA: MIT Press.

Stahl, G. (2009). *Studying virtual math teams*. New York, NY: Springer.

Stahl, G. (2013). *Translating Euclid: Designing a human-centered mathematics*. San Rafael, CA: Morgan & Claypool Publishers.

Stahl, G. (2016). *Constructing dynamic triangles together: The development of mathematical group cognition*. Cambridge, UK: Cambridge University Press.

Stahl, G. (2019). *Theoretical investigations: Philosophical foundations of group cognition*. New York, NY: Springer.

Streeck, J. (1996). How to do things with things. *Human Studies. 19*, 365-384.

Suchman, L. A., & Trigg, R. (1991). Understanding practice: Video as a medium for reflection and design. In J. Greenbaum & M. Kyng (Eds.), *Design at work: Cooperative design of computer systems.* (pp. 65-90). Hillsdale, NJ: Lawrence Erlbaum Associates.

Suthers, D. D. (2006). Technology affordances for intersubjective meaning making: A research agenda for CSCL. *International Journal of Computer-Supported Collaborative Learning. 1*(3), 315-337.

Suthers, D. D., Dwyer, N., Medina, R., & Vatrapu, R. (2010). A framework for conceptualizing, representing, and analyzing distributed interaction. *International Journal of Computer-Supported Collaborative Learning. 5*(1), 5-42.

Teasley, S. D., & Roschelle, J. (1993). Constructing a joint problem space: The computer as a tool for sharing knowledge. In S. P. Lajoie & S. J. Derry (Eds.), *Computers as cognitive tools.* (pp. 229-258). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Tomasello, M. (2014). *A natural history of human thinking*. Cambridge: MA: Harvard University Press.

Zemel, A., & Çakir, M. P. (2009). Reading's work in VMT. In G. Stahl (Ed.), *Studying virtual math teams.* (ch. 14, pp. 261-276). New York, NY: Springer.

Zemel, A., & Koschmann, T. (2013). Recalibrating reference within a dual-space interaction environment. *International Journal of Computer-Supported Collaborative Learning. 8*(1), 65-87.