Analysis of Group Practices

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Abstract. This chapter introduces an approach to CSCL research driven by the analysis of data displaying how groups adopt, adapt and master new collaborative knowledge-building practices. The analysis of group practices can provide unique insight into the accomplishments of teams of students in CSCL settings. It conceptualizes a theory of learning with the group as the unit of analysis in terms of the acquisition of group practices. CSCL pedagogy can then be oriented toward orchestrating the adoption of targeted group practices, supported by CSCL technology.

Keywords. Ethnomethodology, group practice, group cognition, interaction, orchestration, representational practice, segmentation, sequential analysis, social practice, unit of analysis, uptake.

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 explicit propositions, one can view cognitive development in terms of tacit practices: knowing how to do things, to behave, to respond, to contribute, to solve specific kinds of problems, to formulate explanations. 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 institutions, communities, cultures or societies. A theory of CSCL oriented to group practices 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 and norms of interaction. If you look closely, you see that this happens overwhelmingly in games, disputes and modeling within dyads, triads and other small groups within the extended family, village or kindergarten, including between adults and children as well as among peers—largely through imitation and repetition.

Empirical analysis of group practices (see Additional Readings below) 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 drawn 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 skill, 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: Curriculum for 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 could reveal consequent changes in individual knowledge and in classroom instructional practices.

Design: Planning to Sequence Group Practices

Pedagogy associated with CSCL approaches to teaching a given subject can be designed to promote specific identified practices. 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. There are also practices involving using the available *technological* affordances. 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 and individual reading 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 groups' knowledge artifacts. Effective orchestration of activities 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 text highlighting, eye-tracking display, line-coloring options and pointing tools can support joint attention and shared focus within digital group workspaces (Çakir et al., 2009; Schneider & Pea, 2013).

Methodology: Analysis of Adopted Group Practices

For educational researchers, an important question is how an observer can know what practices groups 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, individual motivation or social dispersion, the acquisition and performance of *group* practices are necessarily public processes. 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. This chapter will suggest procedures for doing this kind of analysis of the adoption of group practices—particularly through methods of interaction analysis.

History & Development: From Individual to Group-Level Constructs

Prehistoric Spirits as Explanations of Expertise

How learning takes place, how knowledge is developed, and how some individuals gain above-average expertise are questions that have always been raised. In olden times and ancient cultures, the answers often 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 a mythic 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

Modern views 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.

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 each 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 various philosophic trends of the past two centuries.

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 interaction with others in dyads, family units or small groups. It is largely preserved in habitual 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). For CSCL, the theory can be re-conceptualized and studied at the small-group unit of analysis.

Perhaps the most detailed analyses of social practices have been carried out in the field of ethnomethodology and conversation analysis. The following sections review major findings of this research. For additional rendering of qualitative analysis, including conversation analysis, see Uttamchandani & Lester (this volume).

Ethnomethodology and Sequential Organization

The sequential ordering of situated interaction is a central characteristic 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 of ethnomethodology (EM) and its applied field, conversation analysis (CA) (Garfinkel, 1967; Goodwin & Heritage, 1990).

One of the systemic aspects of sequential organization of interaction explored in CA is the notion of *turn taking* (Sacks, Schegloff & Jefferson, 1974). A turn is defined by an adjacency pair where one utterance by one participant is followed by a second utterance by another participant. 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 (non)-response, thus opening up a range of relevant subsequent sequential mechanisms, or turns, to be worked.

This greeting example illustrates an important consideration for our analysis of small-group practices: 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 shape other courses of action and their sequential structures. Studies in CA have identified and described these kinds of sequentially organized structures in a multitude of different settings. The notion of a turn-taking system offers an analytic framework for investigating how interactions might vary structurally within and across specific settings (e.g., casual telephone conversations versus doctor-patient consultations). Turn-taking in a variety of different discursive settings reveal a number of different contingencies, such as the number of parties involved in the interaction, the organization of topic openings and closings, and the allocation of turns (Schegloff & Sacks, 1973; Schegloff, 1990). Thus, the analysis of turn taking forms an empirical foundation for tracing discernable practices within small-group interaction.

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 how the external elements (anterior to language) of the situation are made *relevant* and *consequential* for the interaction, i.e., how participants’ immediate actions are contingent on resources in the setting 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 and are referenced in the interaction.

This 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). Procedural consequentiality highlights those instances in which the setting itself (e.g., courtroom vs. living room) informs and shapes sequential structures. This view is particularly noteworthy for CSCL, as our concern is the impact that rich semiotic settings and technologies have on collaborative-learning processes.

Multimodal Sequential Analysis and Representational Practice

A wide variety of studies have leveraged the analytic insight of EM and CA to draw attention to the configuration of the speaker's 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 relevant and consequential to the structure of interaction. Action is not limited to utterances but is distributed across a range of multimodal resources available to participants. 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. One of Goodwin's formidable contributions is how semiotic action is included in structural explanations of human interaction (Goodwin, 2018).

EM 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 unfold 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 as the 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, CSCL actions may extend beyond the verbal modality: dragging an object across the screen or posting a graphic. 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 specifies a relation between a user action and some aspect of the environment. A potential gain of interpreting interaction as uptake is that uptake does not privilege one particular communicative modality (e.g., verbal adjacency pairs) 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, as discussed below.

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 shared 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 uptake or adjacency pair elicit and respond to each other, thus happening outside the heads of any one participant, but constituting a relationship among them. The relationship necessarily takes place in the public arena of the group, where it is shared by and visible to the participants (and potentially to researchers). The cognition that takes place here is an achievement of the group as such; it can be conceptualized as *group cognition* (Stahl, 2006).

The analysis of group cognition in terms of interaction through 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 collaborative learning. 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 a procedure 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 practices. The approach builds on foundations of ethnomethodological inquiry by maintaining a primary concern with the sequential organization of interaction (Jordan & Henderson, 1995; Schegloff, 2007). The overall strategy of the approach attempts to provide a hierarchically organized account of observed practices by identifying different structures of sequential interaction as data points (or segments). When fully assembled, these structures provide an informative view of the hierarchical and sequential processes of small-group interaction in CSCL settings (Stahl, 2020, Investigations 16, 24, 25). Thus, our goal is to build a structural description of observed interaction that can be used as a resource -- within the larger understanding of small-group interaction sketched above -- for addressing various research questions and contributing to different theoretical and applied 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 succession 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 such as group practices).

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

**** INSERT FIGURE 1 ABOUT HERE ****

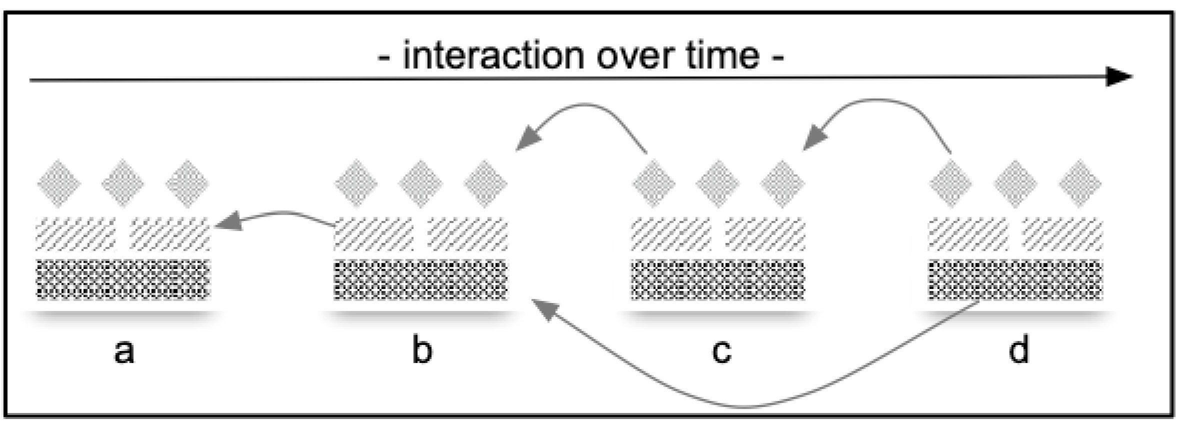

Figure 1. Illustration of four segments each composed of subsequences at different granularities.

0. 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, crucial for gaining a sense of the scope of the activity captured. After the initial logging, 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 interaction (e.g., a conversational turn). Participant actions are sequentially organized within the interaction, creating boundary points for segmentation. These segments 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 introduced by the participants. The purpose of this smoothing technique is not to reorder 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 labeled segments may contain sequential structures within it identifiable at different granularities.

An important analytic feature 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 signaled 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 a research 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 sub-sequences of inscriptional activity occurring within longer segments of interaction.

2. Segment Description

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 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, which it may have elicited. 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. 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 Among Segments

The next step in the procedure identifies and describes connections among segments, some of which may extend beyond immediate interaction contexts or may form repeated behavioral patterns, or *group practices*. Figure 1 illustrates how the scheme is utilized to determine connections: arrows between segments indicate relations that emphasize the *contingency* or *relevance* of one segment to another. Evidence for drawing connections between segments is based on the following baseline heuristics:

- Uptake of prior resources.
  - Using references to prior elements (“indexicality”).
  - Transporting prior elements into the current context (“temporal bridging”).
- Invocation of a prior (established) sequential structure (a conversational “social practice” or a local “group practice”).
- Anticipatory projection of a future (desired) element (“group agency”).

The microanalysis of segments conducted in steps 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 action. 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 under-determined in the immediate interaction but can be located in prior observed 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).

Another heuristic that is applied to determine connections between segments is based on the identification of *procedural consequentiality*. Here, we explicitly examine how the contextual setting facilitates, conditions and constrains immediate actions. Technology-mediated settings are participant-enacted spaces configured through use, which support the redeployment of discernable actions (Drew & Heritage, 1992; Robinson, 2013). Identifying these actions and their relationship to the setting enables the analyst to form empirically grounded claims about observed group practices.

4. 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, 2020, Investigations 23, 24, 25). The analysis of the group interaction must demonstrate how participants make their references relevant and how they establish the procedural consequentiality of their practice within their shared situation.

A group practice can be identified as a segment of interaction that a group periodically repeats in response to certain conditions. If a group is learning/acquiring a new practice, sequential analysis may be able to capture group interactions exploring and deciding upon the new behavior to adopt. For instance, a group of math students might develop a geometric construction procedure through considerable exploration and debate and then adopt it as a regular technique in similar future problems. In mathematics, when such practices are accepted into the broader culture, they may be called "theorems"; once proven explicitly, they can be applied without discussion (Husserl, 1936/1989). Knowledge grows through the acceptance and application of practices and their associated artifacts—by individuals, small groups and communities.

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.

5. Computer-Supported 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 sources (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. To the extent that computer analysis of group practices can be accomplished in real time, it could contribute to learning analytics, potentially informing teachers about which groups adopted certain targeted practices.

The Future: Fostering Group Practices

Theory: 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 provide various aspects of the group's cognitive abilities. Since individual 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.

Contemporary 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 as largely tacit, habitual practices.

For CSCL, with its focus on collaborative meaning making within small groups in computer-mediated contexts, the practice-oriented conceptualizations of these social theories must 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, 2020, Investigation 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, 2020, Investigations 19, 20, 21).

Pedagogy: Sequencing Group Practices

Analysis of group practices has been carried out largely with interaction data on virtual math teams engaged in mathematical problem solving of middle-school combinatorics and dynamic geometry (Stahl, 2009, 2020). 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 process data is collected. 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 detailed, continuous interaction data to explore how these processes actually unfolded. 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 intervening group-cognitive processes.

A longitudinal study of dynamic geometry (Stahl, 2016) involved a sequence of 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. 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. Acquired group practices could thereby influence individual and classroom learning.

Technology: Supporting Group Practices

Computer support for multiple modalities can be used to support specific group practices. For instance, generic text chat or discussion forums can support argumentation, but there can also be designed affordances of special CSCL argumentation environments that foster negotiation or analysis of argumentation structure (Schwarz & Baker, 2017). Pointing and other graphical manipulation 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) and acting as a group memory that can even bridge discontinuities in group presence (Sarmiento, 2007; Sarmiento & Stahl, 2008). The workspace can be taken a step further with simulations or modeling, as with VMT’s dynamic-geometry app or Roschelle’s model of acceleration.

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 design iterations.

The analysis of group practices opens up a contemporary approach to designing and assessing education. Group practices stand at the center of collaborative learning, which is foundational for 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, 2020) - ***Theoretical Investigations*** brings together many of the past articles in the *International Journal of CSCL* and recent essays by the journal 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.

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