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The situated dynamics of peer group interaction: an introduction to an analytic framework

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Abstract

This paper introduces a descriptive system of analysis of peer group interaction. The method takes a dynamic and process-oriented approach to interaction which is seen as socially and situationally developed in students' moment-by-moment interactions. By concentrating on individual and group functioning, the method aims at highlighting the situated dynamics of peer group interaction and learning. The method consists of a three-dimensional analysis of peer group interaction by focusing on the functions of verbal interaction, and the nature of cognitive processing and social processing. These are investigated with the help of micro-analytical maps drawn out from the data based on video recordings, transcriptions, observations, interviews, and questionnaires. In the first part of the paper the theoretical and methodological background of the analysis will be discussed. That is followed by an introduction to the analysis method highlighted with empirical examples. The paper ends with a reflective analysis of the method.

1. Introduction

The social and contextual nature of human learning has received a great emphasis in recent research on learning and instruction (Anderson, Reder & Simon, 1997; Greeno, 1997). More attention is paid to the practices, processes and conditions

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leading to the social construction of knowledge in different learning situations (Fisher, 1993; Lemke, 1990; Palincsar, 1986; Tuyay, Jennings & Dixon, 1995). The focus of analysis is being extended from external factors influencing learning processes and achievements to the student's participation and evolving interpretations of the learning activity (Grossen, 1994; Perret-Clermont, Perret & Bell, 1991). In the midst of these changes in emphasis, new methodological questions concerning the analysis of social activity and learning have arisen. Questions to which researchers try to find answers are, for example; How to show qualitative differences within and between interactive activities across learning contexts and arrangements? Upon what criteria should such judgments be made? and How applicable are the methods used? (Westgate & Hughes, 1997).

This paper introduces a descriptive system of analysis for investigating the dynamics of peer group interaction. The analysis framework has emerged as a result of a number of studies we have conducted of primary-aged students' interactions whilst working in peer groups on various educational tasks both in Finland and in Britain (Fourlas & Wray, 1990; Kumpulainen, 1994, 1996; Kumpulainen & Mutanen, 1998). The main goal in these studies has been to investigate the nature of students' social activity, particularly verbal interaction in different learning situations. The initial development of the method concentrated on the functions of students' verbal interaction as a basis for investigation of students' roles as communicators and learners in teacher-centered and peer-group centered classrooms (Fourlas & Wray, 1990). The functional analysis method was later piloted, modified and applied by Kumpulainen (1994, 1996) in a study which investigated students' social activity during the process of collaborative writing with a word processor. Due to its fine-grained categorizations, the functional analysis method was considered to give a structured overview of the nature and quality of students' verbal interaction in this learning context. Despite the potentials of the analysis method, in our recent studies of peer group learning we found the functional analysis inadequate to unravel the complexities of socially shared learning processes. Firstly, there seemed to be a need to develop a descriptive system of analysis which takes a more holistic and multidimensional perspective to interaction. Consequently, the analysis of verbal interaction alone seemed not to serve this goal. Secondly, it seemed important that more attention be paid to the moment-by-moment character of interaction to highlight the situated processes of knowledge construction within peer groups. Thirdly, it seemed important to take the individual and the group as units of analysis in order to investigate the types and forms of participation within peer groups. In addition to methodological developments, there seemed to be a need to develop more efficient models of interaction data presentation.

In the analysis method we have currently been developing, the dynamics of peer group interaction are approached from three analytic dimensions. The first dimension of the analysis, entitled *the functional analysis*, investigates the character and purpose of student utterances in peer group interaction. It characterizes the communicative strategies used by participants in social activity. The second dimension, *cognitive processing*, examines the ways in which students approach and process learning tasks in their social activity. It aims at highlighting students' working strategies and situ-

ated positions towards learning, knowledge and themselves as problem solvers. The third dimension of the analysis, *social processing*, focuses on the nature of social relationships that are developed in students' social activity. This includes examining the types and forms of student participation in peer groups. Before highlighting the analytical framework with some empirical examples, we shall firstly discuss the theoretical and methodological background of the method. The paper ends with a reflective analysis of the method and considers its possible research applications.

1.1. Social interaction and learning

Recent views of learning emphasize its social and situated nature regarding the construction of knowledge both as an interpersonal and intrapersonal process. Learning is seen to take place as the result of the individual's active involvement and participation in situated social practices and not as the result of knowledge transmission. Views originating from the Piagetian theory of learning stress the importance of social processes in the individual's knowledge building (Perret-Clermont et al., 1991; Piaget, 1970; Teasley & Roschelle, 1993; Tudge & Rogoff, 1989). Cognitive conflicts created by divergent points of view and their resolution in peer interactions are seen as affecting intrapersonal processes (Doise & Mugny, 1984). Moreover, social learning contexts are found to promote explaining to others and self-explanations often leading to cognitive gains (Schwartz, 1995). Consequently, social modes of working are regarded as creating effective learning situations for students to express, discover and construct their knowledge structures at a more abstract level than whilst working on the same problem alone (Light, Littleton, Messer & Joiner, 1994; Schwartz, 1995).

Sociocultural perspectives, which view learning from the cultural point of view, emphasize the role of social interaction in the movement from interpersonal to intrapersonal functioning (van der Veer & Valsiner, 1994; Vygotsky, 1962, 1978; Wertsch, 1985). The social construction of knowledge is regarded as taking place by participating in activities guided by adults or more competent peers (Rogoff, 1990). Thus, social processes are seen as giving rise to individual processes, which in turn are both seen as being mediated by tools created by the culture. According to sociocultural perspectives, the development of mind is related to both biological development and to the appropriation of cultural heritage which works as a mediating tool for humans to interact with each other and with the physical world (Cole, 1996; Wertsch, 1991).

In sociocultural perspectives on learning, particular emphasis is put on the mediation of action through tools on the development of the mind (Cole & Wertsch, 1997; Harré & Gillett, 1994; Vygotsky, 1962, 1978; Wertsch, 1985, 1991). Semiotic artifacts are defined as cultural amplifiers which are central to the appropriation of knowledge through representational activity by the developing individual (John-Steiner & Mahn, 1996). Although language is seen as one of the main sources of mediational means, they also include various other cultural artifacts such as different symbol systems and schemes, maps and works of art (Cole & Wertsch, 1997). By stressing the interdependence of social and individual processes in the co-construction of knowledge, sociocultural approaches view semiotic tools as personal and

social resources, and, hence, uniting the link between the social and the individual (Vygotsky, 1962, 1978).

In the light of sociocultural perspectives and numerous theorists of language and meaning (e.g. Bakhtin, 1981, 1986; Bruner, 1990; Halliday & Hasan, 1989; Lemke, 1990; Vygotsky, 1962) interaction implies communication, social meaning construction, which is socially situated and which sustains social relations. Therefore, explorations between interaction and learning need to concentrate on the interpretation of meanings and purposes in interaction situations. This interpretation should consider the immediate social situation as well as the sociocultural context of the activity (Bakhtin, 1986; Vygotsky, 1978; Wertsch, 1991).

The importance of considering the interdependency between individual and social environment has been pointed out by a number of researchers working within the socioconstructivist and sociocultural framework (e.g. Grossen, 1994; Light & Perret-Clermont, 1991; Rogoff, 1990; Wertsch, 1985, 1991). According to these views, the nature of individuals' activity and cognitive performance cannot be isolated from its social and cultural contexts. The considerations of the dialogical and dynamic relationship between individual and environment have led to the situative view of learning (Brown, Collins & Duguid, 1989; Greeno, Smith & Moore, 1993; Greeno, 1997; Lave & Wenger, 1991) which focuses on the development of participation in valued social practices and on learner identity rather than on individuals' knowledge and contexts of performance.

The notion of context should not only be limited to the physical environment. Instead a more dynamic approach is necessary. This holds that contexts are actively created in situated interactions: They are continuously shaped by social and interactional meanings as well as by participants perceptions and interpretations of the situation (Edwards & Potter, 1992; Grossen, 1994; Lemke, 1990). Schubauer-Leoni and Grossen (1993) highlight the multidimensional nature of contexts by identifying three different levels: the socio/cultural, institutional and interindividual contexts. They argue for their recognition in the analysis of the complex relationship between an individual's activity and social context, both at theoretical and methodological levels.

1.2. The dynamics of peer group interaction

The value of peer group learning is widely recognized due to its positive effects on academic achievement as well as affective and social outcomes (Cohen, 1994; Sharan & Shachar, 1988). Peer group activity is seen as giving students opportunities for self-reflection and joint construction of knowledge (Forman, 1989). Despite the potentials of peer group learning, it appears that we are still remarkably ignorant about the dynamics and processes of peer group interaction and how these are related to student learning. The vast majority of studies have focused on the effectiveness of peer group learning methods as compared to other instructional methods and minimal attention is paid to students' interactions within learning groups (Cohen, 1994). Consequently, a greater number of descriptive studies and adequate methodologies are needed in order to shed light onto the "black box" of peer group learning, i.e. the dynamics and mechanisms of socially shared learning activity.

Different dimensions are present in peer group interaction which are linked to the sociocultural context of the activity as well as to the interpretations and meanings created in the immediate context. The dimensions of interaction are also related to the participants' socio-cognitive and emotional processes, including their perceptions of the aims of the activity in question (Grossen, 1994). Vion (1992) when characterizing the complexity of interaction situations introduces the concept of *heterogenous interactive space*. This refers to the social, cognitive and interactive roles and contexts which interactors have to negotiate in order to achieve a joint understanding (cf. Grossen, 1994).

Although verbal interaction plays an important role in the construction of common understanding between the interactors (Edwards & Mercer, 1987), a shared understanding may in some situations be achieved without verbal communication. Being in the same task situation with others and sharing the task and its tools as well as the whole process of problem solving can create a joint collaboration space for the participants (Teasley & Roschelle, 1993). Studies of young children have shown that they often use non-verbal communication to share meanings and achieve interpersonal co-ordination of actions in social play (cf. Verba, 1994). Also, a study investigating peer interaction during the process of collaborative writing with a word processor showed that the actual computer tool played a role in the construction of joint understanding between primary-aged children (Kumpulainen, 1996). Methodologically there are problems in interpreting non-verbal communication, but some limitations may be overcome by using triangulated research methods to focus on peer interactive dynamics as a whole (Verba, 1994; Westgate & Hughes, 1997). Student interviews, particularly stimulated recall interviews, in addition to observations, and transcriptions of verbal interactions can provide valuable information about the student's cognitive, social and emotional processes, and consequently increase understanding of social activity from a holistic perspective.

1.3. Peer group interaction—focus on methodology

Peer group interaction has already been studied quite extensively in different educational contexts. The research objectives and methodological solutions have also been diverse, being linked with the research goals and theoretical perspectives adopted by the researchers (see e.g. Edwards & Westgate, 1994 for a review). One large group of studies focusing on peer interaction from the educational perspective is located in the systematic tradition, often called as the process-product-studies of peer interaction (e.g. Joiner, Messer, Light & Littleton, 1995; Light et al., 1994; King, 1989; Teasley, 1995; Tudge, 1992; Webb, Troper & Fall, 1995). In these studies, peer interaction is analyzed with coding schemes which categorize interaction into pre-defined categories. Variables like student achievement and performance are statistically linked to the frequency of categories as identified in the data. Usually, the development of the actual interaction process or meaning construction in interaction is not the prime interest, but the focus is rather on some specific features of the interaction and their relationship to student learning or achievement. Consequently, the temporal process of interaction is not highlighted by such studies. The situated

nature of interaction also often receives only cursory inspection. One advantage of the process-product studies is that they enable the analysis of large amounts of data and use of publicly-verifiable criteria to make the categorizations.

Two of the most well known researchers of peer group talk and learning are Barnes and Todd (1977, 1995) who developed an analytic method for studying peer group talk. Their system of analysis was "grounded" in the data, as opposed to having been a pre-existing grid. Consequently, the system tries to take account of the context in which peer talk occurs. In their analysis Barnes and Todd were interested in the actual process of interaction. They were interested in the ways students developed and constructed knowledge without direct teacher presence. In their analysis, a distinction is made between interactive and social aspects of speech events. This was realized by a two-level parallel analysis which at the first level focuses on the coherence of the discourse and at the second level concentrates on the social skills and cognitive strategies employed by the students in their discourse. While conducting their study on peer group talk across a range of discussion tasks, Barnes and Todd realized how difficult it was to identify logical relationships from peer interaction since these are more often left implicit than given a verbal form. The fact that Barnes and Todd had only tape-recordings of peer talk made the analysis even more difficult in terms of logical development. Despite some limitations found in the analytical system and tools used for data collection, Barnes and Todd's work makes an important contribution to the analysis of peer talk since it unites ideas from discourse and conversational analysis with research on learning and instruction. Particularly, with their definitions of *content frames* and *interaction frames* it is possible to investigate how students bring their frame of reference to the interaction situation and how these frames are jointly negotiated and developed.

Many other methods of analysis of peer group interaction, either with distinct categories or more interpretative "modes", have been developed in the past twenty years. To review all of them in one paper would be impossible and not worthwhile. One recent analytic approach which has contributed to our understanding of children's talk during small group learning is the one developed by Fisher (1993), Mercer (1994, 1996), and Phillips (1990) and by the researchers involved in the SLANT project (see Mercer, Phillips & Somekh, 1991). What is interesting in this approach is that it tries to investigate how children use talk to think together, thus, it uses a group as a unit of analysis, not individual children. By taking a socio-cultural approach to children's talk, it tries to show that particular ways of talking permit certain social modes of thinking. The analytic framework was derived from their analyses of children's talk during collaborative peer group learning with computers and it includes three distinct modes of talk which characterize different ways of thinking together. These are (1) Disputational mode, characterized by disagreement and individualized decision making, (2) Cumulative mode, consisting of positive but uncritical decision making, and (3) Exploratory mode, which is seen as the most effective mode of speaking in fostering critical thinking and cognitive development (Mercer, 1996). It is characterized by constructive and critical engagements, including argumentation and hypothesis testing. Theoretically, this analytical framework makes an important contribution towards increasing understanding of the different

modes of talk and social thinking in peer group situations. One of the limitations of this method can be found in that the unit of analysis is the group—the method does not take into account individual students' participation in the "social modes of thinking". Consequently, the method does not highlight how the different types of social thinking are actually constructed within peer groups. Moreover, by concentrating mainly on students' talk, the analysis may not always give a complete picture of the nature of knowledge construction in peer groups. Instead, a more dynamic approach to peer interaction is necessary, which focuses on the whole interactive contexts and their development, including non-verbal communication and the use of different tools, before we can unravel the mechanisms of learning in peer group activity.

1.4. Introduction to the analytic framework

In this paper we propose a descriptive system of analysis for investigating the situated dynamics of peer group interaction. Of particular importance are the mechanisms of social and cognitive dimensions of peer group activity. In addition, the forms, patterns and relationship of peer group interaction with problem solving and learning are considered. The theoretical grounding of the analysis framework is informed by the sociocultural and socioconstructivist perspectives to interaction and learning (Cole, 1996; Resnick, Levine & Teasley, 1991; Wertsch, 1985, 1991), whereas the methodological solutions presented are greatly influenced by the work of Barnes and Todd (1977, 1995); Mercer (1994, 1996) as well as by interactional ethnographers (Green & Wallat, 1981; Green & Mayer, 1991; Tuyay et al., 1995).

In the method, learning is seen to take place as a result of individuals' active participation in the practices of the social environment. Learning is viewed as an interactional process that requires an understanding of language and other semiotic tools as both personal and social resources (Cole, 1996; Halliday & Hasan, 1989; Wells & Chang-Wells, 1992). Peer interaction is treated as a dynamic process in which language and other semiotic tools are used as instruments of communication and learning. Interaction is seen as a complex social phenomenon which is composed of non-verbal and social properties in addition to its verbal characteristics. Peer discourse itself is not treated as representing a person's inner cognitive world, nor even as descriptive of an outer reality, but rather as a tool-in-action shaped by participants' culturally-based definitions of the situation (Edwards, 1993; Edwards & Potter, 1992).

The application of the method is realized with a microanalysis of evolving peer interactions by focusing on three analytic dimensions, namely the functions of verbal interaction, cognitive processing and social processing. Whereas the functional analysis concentrates on students' verbal language, the analyses of students' cognitive and social processing focus on interactive dynamics as they occur across the participants. Consequently, a group is taken as a unit of analysis. The three dimensions are treated separately for analytic purposes, although it is recognized that they are closely linked together in a complex way.

1.5. Dimension 1: functional analysis of verbal interaction

The functional analysis of students' verbal interaction focuses on the purposes for which verbal language is used in a given context. It investigates and highlights the communicative strategies applied by individual students whilst taking part in interaction (Halliday & Hasan, 1989). Analysis of this nature often concentrates on the illocutionary force of an utterance, i.e. on its functional meaning (Austin, 1962; Edwards & Westgate, 1994). The functions for which students use their oral language are closely linked with the topic of discussion as well as with the individuals' expectations and evolving interpretations of the situation shaped by the sociocultural context of the activity. The functions of language used in the course of interaction serve both intra- and interpersonal purposes: On the one hand, the purposes and intentions carried by means of verbal language serve an ideational, i.e. cognitive function. On the other hand, they serve an interpersonal function relating to the personal and social relationships between the interactors (Halliday & Hasan, 1989).

The identification of language functions in peer interaction takes place on the basis of implicature, i.e. what a speaker can imply, suggest or mean may be different to what the speaker literally says. Consequently, the functions are not identified on the basis of linguistic form. Rather, they are identified in context in terms of their retrospective and prospective effects on the actual discourse both in terms of content and form. Data gathered by means of observations and student interviews also give understanding to the functions for which students use their verbal language in interaction. The functions of peer interaction are the minimum units analyzed in the system. They are identified on an utterance basis and defined in terms of source, purpose and situated conversational meaning. An utterance is viewed as a meaningful unit of speech, i.e. a message unit. The boundary between each utterance is linguistically marked by contextualization cues. Given that an utterance may serve multiple functions, more than one function can be recorded for each utterance.

Examples of language functions we have often identified in peer group interaction across learning situations are *the Informative, Expositional, Reasoning, Evaluative, Interrogative, Responsive, Organizational, Judgmental (agrees/disagrees), Argumentational, Compositional, Revision, Dictation, Reading aloud, Repetition, Experiential, and Affectional functions.* Some of these functions describe the nature of interaction more from the activity point of view (e.g. dictation, reading aloud), whereas others take a more interpretative/cognitive (e.g. informative, reasoning, evaluative) or social perspective (e.g. affectional, responsive, judgmental) on the analysis of verbal interaction. However, none of the functions could be clearly seen as only reflecting one of these dimensions. Consequently, each function in the framework is regarded as reflecting the social-cognitive-discursive actions of the participants as they verbally interact in their social activity. The functions in the system are defined further in Table 1. The language functions used in the course of joint problem solving often differ across situations and contexts, thus these functions presented in the analytic framework should not be understood as fixed, pre-defined categories. Instead, the functions must be situationally defined for each interaction situation on a post hoc basis.

Table 1
Analytical framework of peer group interaction

Dimension	Analytical categorization		Description
Cognitive processing	Exploratory/interpretative	EXPO	Critical and exploratory activity which includes planning, hypothesis testing, evaluation, and experimenting
	Procedural/routine	PROC	Procedural on-task activity which focuses on handling, organizing, and executing the task without reflective analysis
	Off-task	OFF	Activity not related to the task
Social processing	Collaborative	COLL	Joint activity characterized by equal participation and meaning making
	• Tutoring	TUTO	Student helping and assisting another student
	• Argumentative	ARGU	Students are faced with cognitive/social conflicts which are resolved and justified in a rational way
	Individualistic	INDI	Student(s) working on individual tasks with no sharing or joint meaning making
	Domination	DOMI	Student dominating the work, unequal participation
	Conflict	FLCI	Social or academic conflicts which are often left unresolved
	Confusion	FUSI	Lack of shared understanding, student(s) do not understand the task or each other, often includes silent episodes
Language functions	Informative	I	Providing information
	Reasoning	RE	Reasoning in language
	Evaluative	EV	Evaluating work or action
	Interrogative	Q	Asking questions
	Responsive	A	Answering questions
	Organizational	OR	Organizing or/and controlling behavior
	Judgmental		
	• Agrees	Ja	Expressing agreement or
	• Disagrees	Jd	disagreement
	Argumentational	AR	Justifying information, opinions or actions
	Compositional	CR	Creating text
	Revision	RV	Revising text
	Dictation	DI	Dictating
	Reading aloud	RE	Reading text
	Repetition	RP	Repeating spoken language
	Experiential	E	Expressing personal experiences
	Affectional	AF	Expressing feelings

1.6. Dimension 2: analysis of cognitive processing

The analysis of cognitive processing examines the ways in which students' approach and process learning tasks in their social activity. It aims at highlighting students' working strategies and situated positions towards knowledge, learning and themselves as problem solvers. In the method, cognitive processes are seen as dynamic and contextual in nature, being socially constructed in students' evolving interactions in the sociocultural context of activity.

In the analytical framework we have distinguished three broad modes to characterize the nature of students' cognitive processing in peer group activity: *Procedural processing* refers to the routine execution of tasks without thorough planning or thinking. Ideas are not developed, rather they are cumulated or disputed without constructive judgments or criticism. The students' activity is often product-oriented and concentrates on procedural handling of information. *Interpretative or exploratory processing*, on the other hand, refers to a situation during which thinking is made visible through language or other tools and the whole activity is focused on strategies, planning, and hypothesis testing. The students' activity reflects their deep engagement and interest in the problem solving task. *Off-task activity* refers to a situation during which the students' activity does not focus on the task, e.g. playing around, discussing break time activities, "absent minded" activity. It is important to recognize that these three broad analytical modes are used as heuristic devices rather than distinct categories in which students' cognitive processing can be easily coded. Rather, the modes are reflected in different ways in different contexts and situations and, hence, require situational definitions.

1.7. Dimension 3: analysis of social processing

The analysis of social processing aims at characterizing the social relationship and types of participation in peer groups. The different modes in which social processing is often constructed in peer group interaction are *collaborative, tutoring, argumentative, individualistic, dominative, conflict, and confusion modes*. The latter characterizes interaction during which there is an obvious misunderstanding or lack of shared understanding between the children. The conflict mode reflects disagreement, usually at a social level. The dominative mode reflects the distribution of power and status in the peer group. The individualistic and dominative modes are contrasts to collaborative interaction. The individualistic mode implies that students are not developing their ideas together but rather working individually in the group. The dominative reflects imbalance in students' social status and power. The argumentative and tutoring modes of interaction characterize the nature of collaboration between the participants. In this sense they can be regarded as sub-modes of collaborative activity. The argumentative mode implies constructive interaction in which students negotiate their differing understandings in a rational way by giving judgments and justifications. This often leads to a shared understanding of the situation. The tutoring mode shows students helping and explaining for the purpose of assisting the other to understand the matter at hand. In addition, collaboration includes interac-

tion in which participants attempt to achieve a mutual understanding of the situation, ideas are jointly negotiated, and discourse is coherent. In collaborative interaction participants often create bi-directional zones of proximal development assisting one another (Forman, 1989).

It must be noted that, apart from the functional analysis of peer group interaction, the unit of analysis for the different modes of cognitive and social processing is not defined by distinct rules, such as an utterance basis. Instead the units of analysis for the modes of cognitive and social processing are based on their development in peer interaction on a moment-by-moment basis (see Tables 2 and 3). In other respects the three dimensions on which the analytical framework concentrates, all emerge from the data as the result of the researchers' and, when possible, also the interactors' interpretations of the situation. The analysis method is summarized in Table 1.

2. Method

In the following, the analytic framework will be highlighted with empirical examples. The examples are derived from our recent study of peer group interaction and learning in heuristic instructional settings and should be understood as prototypical. The main goal in this paper is to demonstrate the application of the method to empirical data as well as to define and justify the three analytical dimensions on which the analysis focuses. It is hoped that the micro analytical maps, figures and summaries of the dynamics of peer group interaction give new ideas for data reporting and also highlight the different opportunities the analysis framework provides for investigating and interpreting the dynamics of peer group interaction and learning.

2.1. Research setting and data collection

In this paper, the analytical framework is applied in order to investigate the dynamics of peer group interaction of two pairs working on a design task located in geometry. Altogether twenty 12-year old students from one Finnish primary classroom participated in the study. The mathematics task was designed in collaboration between the research team and a classroom teacher and it was related to the students' current curriculum contents in mathematics. The actual learning situation in which the students worked in the study did not, however, follow a traditional pedagogy of mathematics but was rather based on an innovative pedagogy which stresses the learner's conceptual framework and social activity in the construction of mathematical thinking (Kaartinen, 1995). From the mathematical point of view, the aim of the study was to investigate the construction of assumptions that guided the students' mathematical thinking whilst socially solving design problems in geometry.

In the design task, the students were asked to construct three-dimensional objects pictorially represented on a plane with the help of two-dimensional objects. The construction was realized with cards representing different faces of objects. The faces were numbered and after the students had constructed the object they had to write

down the relating numbers on paper. The pictures of the geometrical objects could be visualized in different ways and, hence, there was more than one correct answer.

The learning situation was arranged in a classroom of the Learning Research Center of Kajaani Department of Teacher Education. The classroom is equipped with multiple technical instruments to provide effective data collection (Suortti & Atjonen, 1995). Each data collection session was videotaped as a whole and supplemented with the researchers' field notes. The videotapes included real-time information of the students' working processes. Each session lasted between 25 and 45 minutes. After finishing the task, the students were asked to fill in a questionnaire which aimed at shedding more light onto their collaboration, attitudes towards the tasks and perceived goals. Stimulated recall-interviews were also held for each student individually in order to clarify the students' orientation, working strategies and understanding of the concepts dealt with within the task, as well as to increase understanding about the nature of their collaboration and interaction. The stimulated recall-interviews were audio-taped. The triangulation of research methods was considered necessary to increase the validity of interpreting the dynamics of social activity within peer groups.

The data were analyzed in several phases. In the first phase, the video material of the students' social activity was examined together with the field notes written down during observations. Next, the verbal interaction of the pairs was transcribed, the questionnaires encoded, the students' work assessed and interviews summarized. After that, the interaction and behaviors apparent in the videotapes were analyzed by taking account of the real-time information as well as by following the written transcripts. Particular attention was paid to the nature of students' verbal interaction, and cognitive and social processing. The other features observed and analyzed involved the students' use of the instructional tools available in the problem solving situations (e.g. texts, computers, cards, etc.) and the students' construction of time and task within their activity. The data analyses were reflected upon in the light of the contextual knowledge acquired through observations, stimulated recall interviews and pre-study teaching experiences in the classroom. The data were collected and analyzed by two researchers together. Disagreements concerning the analysis of peer interaction were negotiated until joint agreement was established.

2.2. Analytical maps

In the present method, the dynamics of peer group interaction are illustrated with the help of analytical maps which have been created for each peer group under investigation. The product of the analysis is a series of situation-specific analytical maps that describe the sequential evolution of peer group interactions as they are constructed by students interacting with and acting on each other's messages. In addition to highlighting the dynamics of peer interaction, the maps show the construction of time in the students' activity as well as some contextual information necessary for the interpretation of the social activity in question. Although a structural map is always a simplification, it gives a coherent and temporal picture of a complex situation making comparisons across educational contexts, peer groups and

students possible. Moreover, the structural maps help one return easily to the original data to check the validity of interpretation. In addition, when presenting extracts from the data, one is able to investigate the co-text, i.e. the data context to which the extract belongs.

3. Empirical examples

3.1. Case 1

Table 2 describes the interactive dynamics of a pair, Sami and Teemu, whilst working on the design task. The social activity of the pair is highly collaborative including tutoring and argumentative episodes during which the students help one another, usually by explicating their point of view through verbal and non-verbal interaction, as well as with the help of the tools they are using. The cognitive activity of the pair, during which strategies and solutions are jointly created and tested, reflects intensive task engagement and is very exploratory in nature.

As can be noted from the transcript, Teemu first questions, in a critical manner, why they should put a particular card at the bottom. In order to make his understanding clear, Sami, in turn, explains why he thinks the solution is correct. Teemu is still not convinced and argues further. Speculation and disagreement lead both children to test their ideas in practice as well as to investigate the problem in depth by looking closely at the paper in which the geometrical object is presented. The argumentation episodes lead the students to reason their points of views over and over again.

The analysis of the whole data of the dynamics of Sami's and Teemu's interaction shows that the pair's social activity is composed to a great extent of a task-oriented problem solving including organizing working processes and exploratory activity, characterized by intensive negotiation and high-level reasoning of the problems encountered. Also many speculative episodes are found in which the students are doubtful about the solution or the opinions of the partner. The speculative episodes are often followed by testing episodes during which solutions and opinions are tried out. The social interaction of the pair is coherent and highly collaborative, reflecting mutual understanding and equal participation in problem solving. The collaborative nature of interaction is also highlighted by tutoring and argumentative episodes during which the students are helping one another to grasp their way of thinking and understanding. The quality of the pair's work was also assessed to be high, 11 points out of 12.

The functional analysis of student's verbal interaction shows that the pair's interaction is mostly characterized by the reasoning, judgmental, organizational, argumentative, evaluative and demonstration functions. In the flow of student interaction, the use of these functions often formed reasoning, argumentational, and organizational episodes. Fig. 1 further highlights the communicative strategies used by Teemu and Sami in their social activity.

Fig. 1 shows that there were slight differences between the students' communicative strategies. Whereas Teemu seems to agree more often with the ideas and sugges-

Table 2
An analytical map of peer interaction: the case of Sami and Teemu

Session: 1.1.2 Mathematics
Pupils: Sami and Teemu
Working time: 09:09–09:23

Time	Participation		Transcribed peer interaction	Language functions	Cognitive processing	Social processing	Contextual notes
09:18	125	TEEMU	bottom … how come *miten nii pohja*	Argumentative question Q(AR)	Speculating	Collaborative	Solving task No. 6
09:19	126	SAMI	no … but that's the bottom … that's that sort of a triangle and the lid is that sort of a triangle … they are connected … it shows there how they are connected *eikö tuosta tullee pohja tuosta tommonen kolomio ja kansi tommonen kolomio … ne ossuu yhteen … tuola näkkyy ko ne ossuu yhteen*	Answering by demonstration A(EX)	Explaining	Collaborative tutoring	
	127	TEEMU	no … look … this is *ei vaan tämä on kato …*	Argumenting (AR)			
	128	SAMI	yeah … its connected *nii se ossuu …*	Argumenting (AR)			
	129	TEEMU	wait *Ootappa*	Organizing (OR)			
	130	SAMI	that could be created by side triangles in a way *tuohon pitäis tulla sivukolomiot sillee*	Reasoning (RS)	Speculating		
	131	TEEMU	triangle comes here … triangle comes here … triangle comes here and here comes a rectangle *tähän tullee kolomio … tähän tullee kolomio … tähän tullee kolomio … ja tänne tullee suorakaide*	Demonstrating (EX)	Explaining		Outlining the geometrical object
	132	SAMI	yeah … exactly and here to the roof as well *nii justiin ja tähän katolle myöskin*	Agrees (Ja) and reasons (RS)			
	133	TEEMU	could it go here *no käviskö se tämmöseen*	Reasons (RS)	Speculating		Sami tries to speak at the same time

Table 2
Continued

Session: 1.1.2 Mathematics
Pupils: Sami and Teemu
Working time: 09:09–09:23

	134	SAMI	this one … this one yeah … wait a minute … yeah this is the rectangle *tämä, tämä … hetkonen … joo tämä on se suorakaide*	Reasons (RS)	Testing	
	135	TEEMU	and this belongs to there too *ja tämä kuuluu kans siihen*	Reasons (RS)		
	136	SAMI	should we find another one similar to that *pitäsikö löytää toinen semmonen samanlainen*	Reasoning question Q(RS)	Proposing strategies	
	137	TEEMU	like this *tämmönen näin*	Answering by reasoning A(RS)		
	138	SAMI	no its smaller *eikö se on pienempi*	Argumentation (AR)		
	139	TEEMU	its smaller … there … no it isn't *se on pienempi … tuolla … ei olekkaan*	Agrees (Ja) and Reasons (RS)		
09:20	140	SAMI	no it isn't … what if that bottom is different … let's take these bigger ones you suggested … since these are of equal size here at the back … now I found another one … the little triangles go there … the little long ones go … *ei ookaan … entä jos tuo pohja on eri … otetaanpä nämä isommat, mitä sinä ehotit … koska nämä on samankokoset täältä takakohalta … no nyt löyty toinen semmonen … (muminaa) … tuonne tullee semmoset pikkukolomiot … semmoset pikkuset pitkät*	Agrees (Ja), Organizes (OR), and Reasons (RS)	Exploratory solving	Collaborative

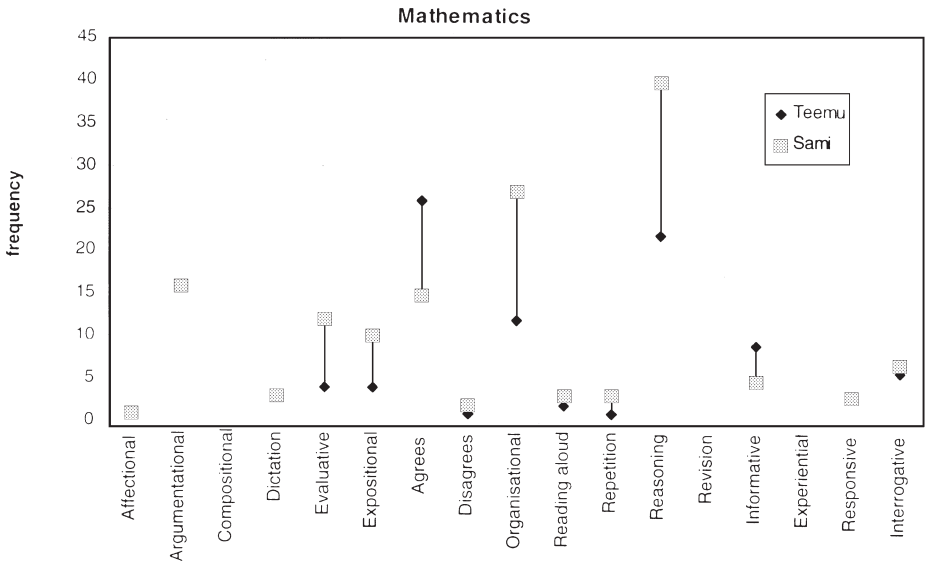

Fig. 1. Communicative strategies and types of participation in the light of the functional analysis of students' verbal interaction.

tions created (Ja; $f = 26/15$), Sami is more involved in reasoning (RS; $f = 40/22$), organizing (OR; $f = 27/12$), evaluating (EV; $f = 12/4$) and demonstrating (EX; $f = 10/4$). These differences may be partly explained by Sami's somewhat greater subject knowledge as assessed by the classroom teacher. Yet, as shown by the other data, the differences in the students' communicative strategies seemed not to hinder the pair's problem solving or collaboration.

The data gathered by means of student questionnaires and interviews support the researchers' interpretations of the nature of peer interaction. Both students considered their collaboration to have gone very well and felt that joint work made problem solving easier. The students also considered that they had not faced any problems, that the quality of their problem solving was high, and that they had learned from each other. Also the goal of the exercise had been understood by both in the same way. Interestingly, both students thought the goal of the exercise was related to the development of concentration skills.

3.2. Case 2

Table 3 describes the social activity of another pair, Joni and Kimmo, working on the design task. The social interaction of this pair is different in nature if compared to the other pair described earlier. Within this pair there is imbalance in the students' collaboration and joint problem solving. As the extract below shows, Joni seems to dominate the activity in social and cognitive terms. Although at the beginning Kimmo is eagerly involved with the task, Joni's domination gradually affects Kimmo's working processes and participation, leading to the signs of a "free-rider effect".

Table 3
An analytical map of peer interaction: the case of Kimmo and Joni

Session: 1.1.2 Mathematics
Pupils: Kimmo and Joni
Working time: 11:05–11:30

Time	Participation		Transcribed peer interaction	Language functions	Cognitive processing	Social processing	Contextual notes
11:16	147	JONI	where is the large triangle? *missä täälä on iso kolmio?*	Asking for information Q(I)	Looking for a face	Slight domination from Joonas' side	Students are trying to find correct faces to construct the geometrical object
	148	KIMMO	oh, yeah … *oujeeh …*	Affectional utterance (AF)	Kai is holding the construction students have already made		
	149	JONI	take those away *otapa pois nuo ete*	Organizing (OR)			
	150	KIMMO	hahah … what are you looking for? *hähä … mitä nää niiku etit?*	Affectional utterance (AF) and Asking for information Q(I)		Kai initiates collaboration	
	151	JONI	a kind of a triangle to the center … these tasks are a bit too difficult … *jotaki kolomiota tuohon keskelle … on nää vähän liika vaikeita nää tehtävät …*	Answering A(I) and Evaluating the task (EV)	Explaining		
	152	KIMMO	how about this one then? *ei se mikkään tämmönen sitte?*	Reasoning in a question form Q(RS)	Speculating		

Table 3
Continued

Session: 1.1.2 Mathematics Pupils: Kimmo and Joni Working time: 11:05–11:30						
	153	JONI	it might be … perharps two of these there … *se voi olle … jos vaikka kaks tämmöstä sinne …*	Reasoning (RS)		
	154	KIMMO	basically no *ja periaatteessa ei*	Reasoning (RS)		
11:17	155	JONI	show me … hmm … let's turn to next exercise … let's solve that one since it is easier … it is what one sees … hey, could it be these … *näytäppä … hm … hy … hy … vaihetaan tehtävvää … ratkassaan tuo, ko tuo on aika heleppo … se on nimittäin miten sen näkkee ↘ onko nämä hei … katoppa … onko nämä …*	Organizing (OR), Evaluating (EV), and Reasoning (RS)	Organizing working, Speculating	Slight domination from Joonas' side
	156	KIMMO	do you mean these small ones? *tämmösiä pieniä vai?*	Reasoning in a question form Q(RS)		Kai initiates collaboration
	157	JONI	these *tämmösiä*	Answering A(RS)		
	158	KIMMO	what about these big ones, I think they look big … like this … *vai semmosia isoja … minusta ne näyttää niiltä isoilta … tämmösiltä näin …*	Reasoning (RS)	Speculating	
	159	JONI	I think … (indistinct) *minusta …*	—		

Table 3
Continued

Session: 1.1.2 Mathematics Pupils: Kimmo and Joni Working time: 11:05–11:30					
160	KIMMO	I don't know … *en tiiä yhtään …*	Informing (I)		Signs of "a free rider effect" starting to appear
161	JONI	that's a bit too thick that one there … that's there … rather small … *tuo on vähän liika paksu tuo osa tuossa … se oli siinä aika lyhhyitä …*	Reasoning (RS)	Comparing cards	
162	KIMMO	that's not it … heheheh … *se ei ole sitte sen enempää … ähäh*	Reasoning (RS)		
163	JONI	its all the same really *se on ihan sama oikeastaan*	Reasoning (RS)		
164	KIMMO	let's try both *no kokkeillaan kumpiakin*	Organizing (OR)		
165	JONI	let's take … this is there below, isn't it? … bigger one … hold it *no otetaan … tämmönen on siinä alla, eikö ookin … isompi … tämmönen … noni piä sitä*	Organizing (OR), Reasoning (RS), and Organizing (OR)	Organizing working	
166	KIMMO	no, I don't want to *enkä piä*	Disagrees (Jd)		Social conflict

In this extract Joni asks Kimmo to find a large triangle. Kimmo seems to agree with this with an affectional statement, although his attention is directed to holding the cards the students have already constructed. Joni continues his orders but does not explain what he is actually trying to do. Kimmo tries to ask Joni to clarify his thinking and strategies but Joni seems to be thinking aloud rather than aiming towards joint problem solving or understanding. The lack of shared understanding can also be noticed in the pair's incoherent verbal interaction (e.g. conversational turns 152–155, 158–161). The lack of argumentation and explaining episodes in peer interaction further demonstrates the imbalance in the students' social activity.

The analysis of the whole data of the dynamics of Joni's and Kimmo's social interaction shows that at the beginning the students were task-oriented and interested in the design task. Both students started the activity eagerly. Soon, however, Joni started to dominate the task, for example, by handling the cards and giving orders, and did not give Kimmo much space. Kimmo did not seem to notice this at first but gradually started to be a bit restless since his ideas or suggestions were not taken up by Joni. Interestingly, Kimmo soon accepted his role and started to withdraw from the activity, letting Joni do most of the problem solving. From the data it appears that Joni was rather thinking aloud than trying to solve the design task collaboratively. Only in those instances when Joni regarded the task as difficult to solve did he start to seek confirmation of his ideas from Kimmo. The quality of the pair's work was average, 7 out of 12 points.

The functional analysis of students' verbal interaction shows that the pair's interaction was mostly characterized by the reasoning, organizational, questioning, and affectional functions. As with the other pair, reasoning and organizational episodes reflect the nature of the design task, which seemed to encourage exploratory activity (Kumpulainen, Kaartinen & Mutanen, 1998). Fig. 2 highlights the communicative strategies used by Joni and Kimmo in their social activity.

Fig. 2 demonstrates differences in the students' communicative strategies and the nature of their participation. The data show that Kimmo expressed more affectional statements than Joni (AF; $f = 31/10$). Kimmo also posed more questions (Q; $f = 18/9$). Joni, on the other hand, organized the activity (OR; $f = 43/11$) and reasoned (RS; $f = 68/42$) more frequently than Kimmo. The differences in the students' communicative strategies and types of participation demonstrate further the imbalance in the students' social activity. In addition, they highlight differences between the students' subject knowledge and social behavior. Kimmo's subject knowledge in mathematics was assessed as being much lower than that of Joni by the classroom teacher.

The data gathered by means of student questionnaires and interviews give slightly different interpretations of the nature of peer collaboration and joint problem solving than those made by the researchers. According to the students, their collaboration was good and pair group work made problem solving easier. Yet, the students expressed the view that they had not learned anything from each other and that they would have needed some help from the teacher. There were also differences between the students in their interpretations of the task goals. Kimmo considered the goal of

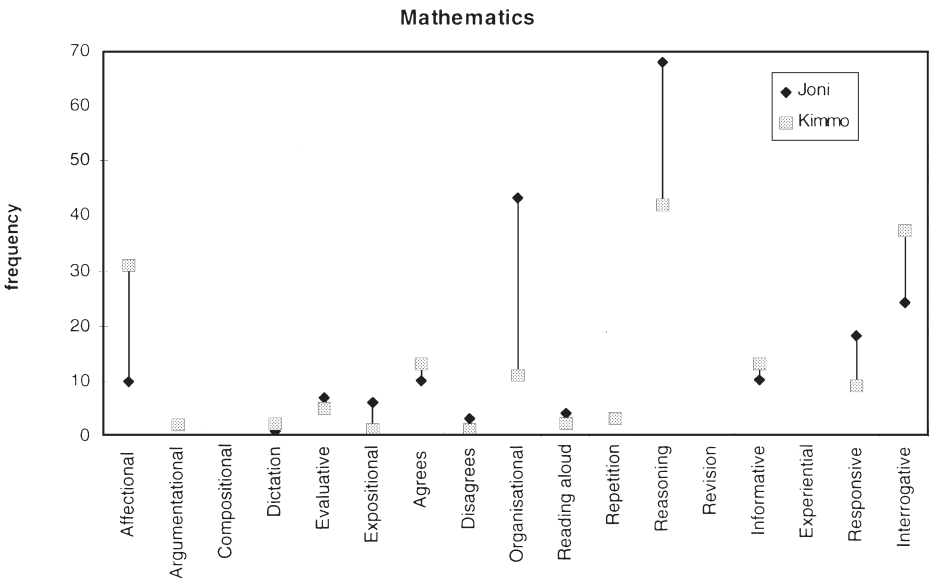

Fig. 2. Communicative strategies and types of participation in the light of the functional analysis of students' verbal interaction.

the design task to be related to the development of concentration skills, whereas Joni thought they were related to mathematical thinking.

4. Discussion and conclusions

The importance of understanding the mechanisms underlying peer group interaction and how they support or inhibit learning has become an important topic for current research on learning and instruction (Cohen, 1994). Yet, to investigate and interpret the dynamics of peer group interaction is extremely complex. In every interaction situation there is a close interplay between the different dimensions of which social activity is composed. Furthermore, the mechanisms of social activity are not static in nature but evolve over time in students' interactions (Edwards & Potter, 1992). It is clear that wider research is needed in this area and, in particular, that a more sophisticated methodology is required.

In our analytic framework we have concentrated on the social and cognitive dimensions to unravel the mechanisms of peer group interaction and learning. We have also been concerned with the differing demands of learning tasks and situations on students' evolving interactions and consequent learning opportunities. In this method, we have tried to take a synchronic as well as a diachronic view of peer group interaction: On the one hand, the method investigates peer group interaction across different analytical dimensions, on the other, the method investigates the processes of meaning making, characterizing the evolution of peer group interaction

over time. The different levels of analysis support and complement one another by giving a holistic and structured picture of the complex phenomena.

In our empirical studies of peer group interaction, we have used multiple data collection methods by employing video-recordings, field notes, direct observations, stimulated recall interviews and questionnaires. The data gathered through these triangulated means has been re- and cross-analyzed in order to obtain an in-depth understanding of peer group activity and of those meanings underlying it.

The methodological principles that guide the present analytical method draw from the constructivist, interpretivist approaches to human inquiry (Schwandt, 1998). These approaches see learning as a social and individual construction process which is situationally embedded in the sociocultural context of activity. Instead of investigating cause and effect relationships typical of the positivistic research tradition, the interpretative approaches aim at unravelling the mechanisms and dynamics of social activity. In this line of research, human interaction is investigated from different dimensions with multiple methods, with the aim of constructing an in-depth and holistic understanding of the phenomena.

The empirical examples presented in the present paper demonstrate the potentials of the current system to shed light onto the mechanisms of peer group interaction. The dynamic nature of peer interaction is acknowledged in the system by focusing on the whole interactive spaces created by the students in their verbal and non-verbal interactions on a moment-by-moment basis. These interactive spaces are viewed from three analytic dimensions by concentrating on the functions of peer interaction, and the nature of cognitive and social processing. The different categories identified within the analytical dimensions should not be seen as pre-defined or hierarchical in nature. In the present method, we do not want to suggest that there are only certain ways of interacting that indicate that quality learning is taking place. The "quality" interaction conducive to students' learning must always be defined in context. The need for situational definitions also applies to the development of analytical categories that aim at describing the social activity under investigation. Consequently, the whole analytical method introduced should be understood as an analytical lens or a flexible framework through which social activity within peer groups can be studied and highlighted.

The method introduced in this paper can be applied and modified to different studies of peer group interaction and learning. The patterns and mechanisms of peer group interaction can be investigated in the light of students' subject knowledge, interpretations of the learning situation, motivational orientation, age, gender, social background, learning outcomes, or of the effects of certain pedagogical arrangements and learning tasks on students' social practices and learning opportunities. The method can also be applied to cross-cultural studies of peer group interaction in a variety of classrooms and curriculum areas as well as to the investigations of the relationship between particular interaction patterns and learning outcomes. Knowledge of these matters can provide valuable information about the mechanisms of peer group work interaction and learning, and pedagogically, for the organization of effective small group learning and the design of powerful learning environments.

This includes increasing understanding of the nature of the instructional support students need in peer groups.

Despite the potentials of the analytic framework, it still needs further clarification and development. The system must be modified to different settings, the analytical categories need critical examination, and the sociocultural context and history of social activity should receive more profound consideration. Nevertheless, we firmly believe that the current method offers one analytical tool to investigate the dynamics of peer group interaction and learning and will hopefully stimulate new ideas and developments in relation to collecting, analyzing and reporting data of situated social activity.

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References

Austin, J. L. (1962). *How to do things with words*. Oxford: Clarendon Press.

Anderson, J. F., Reder, L. M., & Simon, H. A. (1997). Situative versus cognitive perspectives: Form versus substance. *Educational Researcher, 26*, 18–21.

Bakhtin, M. M. (1981). In M. Holquist, *The dialogic imagination: Four essays by M. M. Bakhtin* (C. Emerson, & M. Holquist, Trans.). Austin: University of Texas Press.

Bakhtin, M. M. (1986). In C. Emerson, & M. Holquist, *Speech genres and other late essays* (V. McGee, Trans.). Austin: University of Texas Press.

Barnes, D., & Todd, F. (1977). *Communication and learning in small groups*. London: Routledge & Kegan Paul.

Barnes, D., & Todd, F. (1995). *Communication and learning revisited, making meaning through talk*. Portsmouth, NH: Boynton/Cook.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*, 32–42.

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

Cohen, E. (1994). Restructuring the classroom: Conditions for productive small groups. *Review of Educational Research, 64*(1), 1–35.

Cole, M. (1996). *Culture in mind*. Cambridge, MA: Harvard University Press.

Cole, M., & Wertsch, J. (1997). Beyond individual-social antimony in discussions of Piaget and Vygotksy. [http://www.massey.ac.nz/~ALock/virtual/colevyg.htm]. 6 March 1997.

Doise, W., & Mugny, G. (1984). *The social development of the intellect*. Oxford: Pergamon Press.

Edwards, D. (1993). Concepts, memory, and the organization of pedagogic discourse: A case study. *Educational Research, 19*, 205–225.

Edwards, D., & Mercer, N. (1987). *Common knowledge*. London: Methuen.

Edwards, D., & Potter, J. (1992). *Discursive psychology*. Newbury Park, CA: Sage.

Edwards, D., & Westgate, D. (1994). *Investigating classroom talk* (2nd ed.). Basingstoke: Falmer Press.

Fisher, E. (1993). Distinctive features of pupil–pupil classroom talk and their relationship to learning: How discursive exploration might be encouraged. *Language and Education, 7*(4), 239–257.

Forman, E. (1989). The role of peer interaction in the social construction of mathematical knowledge. *International Journal of Educational Research, 13*, 55–70.

Fourlas, G., & Wray, D. (1990). Children's oral language: A comparison of two classroom organisational

systems. In D. Wray, *Emerging partnerships, Current research in language and literacy* (pp. 76–86). Clevedon: Multilingual Matters.

Green, J., & Mayer, L. (1991). The embeddedness of reading in classrom life: Reading as a situated process. In C. Baker, & A. Luke, *Toward a critical sociology of reading pedagogy* (pp. 141–160). Amsterdam: Benjamins.

Green, J., & Wallat, C. (1981). Mapping instructional conversations—a sociolinguistic ethnography. In J. Green, & C. Wallat, *Ethnography and language in educational settings* (pp. 161–228). Norwood, NJ: Ablex.

Greeno, J. G. (1997). On claims that answer the wrong questions. *Educational Researcher, 26*, 5–17.

Greeno, J. G., Smith, D. R., & Moore, J. L. (1993). Transfer of situated learning. In D. K. Detterman, & R. J. Sternberg, *Transfer on trial: Intelligence, cognition, and instruction* (pp. 99–167). Norwood, NJ: Ablex.

Grossen, M. (1994). Theoretical and methodological consequences of a change in the unit of analysis for the study of peer interactions in a problem solving situation. *European Journal of Psychology of Education, 11*(1), 159–173.

Halliday, M. A. K., & Hasan, R. (1989). *Language, context, and text*. London: Oxford University Press.

Harré, R., & Gillett, G. (1994). *The discursive mind*. London: Sage.

John-Steiner, V., & Mahn, H. (1996). Sociocultural approaches to learning and development: A Vygotskian framework. *Educational Psychologist, 31*, 191–206.

Joiner, R., Messer, D., Light, P., & Littleton, K. (1995). Investigating the relationship between communicative style and productive interaction. A paper presented at the *6th European Conference for Research on Learning and Instruction*, Nijmegen, the Netherlands.

King, A. (1989). Verbal interaction and problem-solving within computer assisted cooperative learning groups. *Educational Computing Research, 5*, 1–15.

Kaartinen, S. (1995). *Konstruktivismi luonnontieteiden oppimisessa. Yhteistoiminta arkitiedon ja tieteellisen tiedon yhteensovittamisen vaikuttavissa kysymyksissä [Constructivism in learning science. Constructing collaboration between real life knowledge and scientific knowledge]*. Unpublished licentiate thesis, University of Oulu.

Kumpulainen, K. (1994). *The nature of children's oral language interactions during collaborative writing experience at the computer*. Unpublished doctoral dissertation, University of Exeter, Exeter.

Kumpulainen, K. (1996). The nature of peer interaction in the social context created by the use of word processors. *Learning and Instruction, 6*, 243–261.

Kumpulainen, K., & Mutanen, M. (1998). Collaborative practice of science construction in a computer-based multimedia environment. *Computers & Education, 30*, 75–85.

Kumpulainen, K., Kaartinen, S., & Mutanen, M. (1998). Constructing joint understanding of solids in a collaborative design task. A paper presented at the *Annual Conference of the European Educational Research Association*, Ljubljana, Slovenia.

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

Lemke, J. L. (1990). *Talking science: Language, learning and values*. Norwood, NJ: Ablex.

Light, P., & Perret-Clermont, A-N. (1991). Social context effects in learning and testing. In P. Light, S. Sheldon, & M. Woodhead, *Learning to think, child development in social context 2* (pp. 136-150), London: Routledge.

Light, P., Littleton, K., Messer, D., & Joiner, R. (1994). Social and communicative processes in computer-based problem solving. *European Journal of Psychology of Education, 11*(1), 93–109.

Mercer, N. (1994). The quality of talk in children's joint activity at the computer. *Journal of Computer Assisted Learning, 10*, 24–32.

Mercer, N. (1996). The quality of talk in children's collaborative activity in the classroom. *Learning and Instruction, 6*, 359–377.

Mercer, N., Phillips, T., & Somekh, B. (1991). Research Note, Spoken Language and New Technology (SLANT). *Journal of Computer Assisted Learning, 7*, 195–202.

Palincsar, A. S. (1986). The role of dialogue in providing scaffolded instruction. *Educational Psychologist, 21*, 73–98.

Perret-Clermont, A.-N., Perret, J.-F., & Bell, N. (1991). The social construction of meaning and cognitive

activity in elementary school children. In L. B. Resnick, J. M. Levine, & S. D. Teasley, *Perspectives on socially shared cognition* (pp. 41–62). Washington: American Psychological Association.
Phillips, T. (1990). Structuring context for exploratory talk. In D. Wray, *Talking and listening* (pp. 60–72). Leamington Spa: Scholastic.
Piaget, J. (1970). *Structuralism*. New York: Basic Books.
Resnick, L. B., Levine, J. M., & Teasley, S. D. (1991). *Perspectives on socially shared cognition*. Washington: American Psychological Association.
Rogoff, B. (1990). *Apprenticeship in thinking: Cognitive development in social context*. New York: Oxford University Press.
Schubauer-Leoni, M. L., & Grossen, M. (1993). Negotiating the meaning of questions in didactic and experimental contracts. *European Journal of Psychology of Education, 8*, 451–471.
Schwartz, D. L. (1995). The emergence of abstract representations in dyad problem solving. *The Journal of the Learning Sciences, 4*, 321–354.
Schwandt, T. (1998). Constructivist, interpretivist approaches to human inquiry. In N. K. Denzin, & Y. S. Lincoln, *The landscape of qualitative research, theories and issues* (pp. 221–259). London: Sage.
Sharan, S., & Shachar, H. (1988). *Language and learning in the cooperative classroom*. New York: Springer.
Suortti, J., & Atjonen, P. (1995). The teaching-learning laboratory. A learning environment with a challenge. *Aktuumi, 4*, 42–45.
Teasley, S., & Roschelle, J. (1993). Constructing a joint problem space: The computer as a tool for sharing knowledge. In S. P. Lajoie, & S. J. Derry, *Computers as cognitive tools* (pp. 229–257). Hillsdale, NJ: Erlbaum.
Teasley, S. (1995). The role of talk in children's peer collaborations. *Developmental Psychology, 31*, 207–220.
Tudge, J. (1992). Processes and consequences of peer collaboration. A Vygotskian analysis. *Child Development, 63*, 1364–1379.
Tudge, J., & Rogoff, B. (1989). Peer influences on cognitive development: Piagetian and Vygotskian perspectives. In M. Bornstein, & J. Bruner, *Interaction in cognitive development* (pp. 17–40). Hillsdale, NJ: Erlbaum.
Tuyay, S., Jennings, L., & Dixon, C. (1995). Classroom discourse and opportunities to learn: An ethnographic study of knowledge construction in a bilingual thrid grade classroom. In R. Durán, *Discourse processes (literacy among latinos: Focus on school contexts)*, (Vol. 19, pp. 75–110).
van der Veer, R. & Valsiner, J. (1994). *The Vygotsky reader*. Oxford: Blackwell.
Verba, M. (1994). The beginnings of collaboration in peer interaction. *Human Development, 37*, 125–139.
Vion, R. (1992). *La communication verbale. Analyse des interactions*. Paris: Hachette.
Vygotsky, L. S. (1962). *Thought and language* (E. Hanfmann, & G. Vakar, Trans.). Cambridge, MA: MIT Press.
Vygotsky, L. S. (1978). In M. Cole, V. John-Steiner, & E. Souberman, *Mind in society: The development of higher mental processes*. Cambridge, MA: Harvard University Press.
Webb, N. M., Troper, J. D., & Fall, R. (1995). Constructive activity and learning in collaborative small groups. *Journal of Educational Psychology, 87*(3), 406–423.
Wells, G., & Chang-Wells, G. L. (1992). *Constructing knowledge together: Classrooms as centers of inquiry and literacy*. Portsmouth, NH: Heinemann.
Wertsch, J. (1985). *Vygotsky and the social formation of mind*. Cambridge, MA: Harvard University Press.
Wertsch, J. (1991). *Voices of the mind: A sociocultural approach to mediated action*. Cambridge, MA: Harvard University Press.
Westgate, D., & Hughes, M. (1997). Identifying "quality" in classroom talk: An enduring research task. *Language and Education, 11*, 125–139.