# Investigating Classroom Interaction

## Methodologies in Action

Kristiina Kumpulainen, Cindy E. Hmelo-Silver and Margarida César (Eds.)

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INVESTIGATING CLASSROOM INTERACTION

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SENSE PUBLISHERS
ROTTERDAM / TAIPEI

A C.I.P. record for this book is available from the Library of Congress.

ISBN 978-90-8790-760-0 (paperback)
ISBN 978-90-8790-761-7 (hardback)
ISBN 978-90-8790-762-4 (e-book)

Published by: Sense Publishers,
P.O. Box 21858, 3001 AW Rotterdam, The Netherlands
http://www.sensepublishers.com

*Printed on acid-free paper*

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# INVESTIGATING CLASSROOM INTERACTION: METHODOLOGIES IN ACTION

## INTRODUCTION

How can researchers understand the complexity of classroom interactions? That is a key question for many scholars in education. This book has grown out of a series of professional meetings as well as formal and informal dialogues the authors, discussants and editors have participated in during the past ten years or so. These gatherings have often been facilitated by the Special Interest Group (SIG) "Social interaction in learning and instruction" of the European Association of Research on Learning and Instruction (EARLI) and they have been hosted by active members of the association in different universities located in northern and southern Europe. The dialogue has also stretched across the Atlantic where many of the authors have engaged in the professional meetings of the American Educational Research Association (AERA). These professional meetings and their discourses have gradually formed an international community of professionals committed to making sense of learning and education as a cultural, social and discursive process.

What has become clear among the research community is that although great accomplishments have been achieved in research on social interaction in learning and instruction, we still lack a coherent understanding of how methodologies illuminate learning and education as a social process and also how these conceptual tools "work" in empirical studies. In addition to handbooks that offer distinct and insightful introductions to different methodologies, there is a need for opportunities to discuss and demonstrate how these methodologies are used, how they become alive in the actual research studies of classroom interaction. Not only is this knowledge important to advanced researchers but also -perhaps even more importantly- to beginning researchers are making methodological choices and and considering the possibilities of different methods and analysis tools.

This edited collection of papers introduces strands of research on classroom interactions whose logic of inquiry produces different approaches, analyses and interpretations of social interactions and discourses in contemporary classroom settings. The methodological approaches which are introduced and discussed within the context of empirical investigations of classroom interactions mediated by different pedagogies and artifacts draw on studies of language and discourse, ethnography, as well as on sociological, psychological, and domain-specific

*K. Kumpulainen et al. (Eds.), Investigating Classroom Interaction, 1–5.*

analyses. In recognizing the complexity and challenges in mapping out the complex research territory focusing on classroom interactions, the prime goal of this book is to build a complementary context for discussion of the ways in which different approaches to classroom interaction are realized and how they produce different analyses because of their purpose, conceptual framework, and methodological choice. The illumination of diverse approaches to studying classroom interactions and discourses will demonstrate the potential and challenges each strand of research can bring to understanding the psychological, social and cultural life of the classroom and how it mediates the situated practice of teaching and learning in today's schooling.

Despite these diverse approaches, there are several themes that run through many of the chapters. They are generally deeply theoretically grounded. Some chapters focus on understanding the origin of ideas whereas others focus on processes. The chapters study interactions over extended periods of time. They use multifaceted and/or multidimensional approaches to studying classroom interactions. Several of the chapters examine the roles that learners take on during classroom interactions.

The chapter authored by Mäkitalo, Jakobsson and Säljö is very relevant to this book in several respects. Not only does the paper powerfully highlight the sociocultural perspective in action but it also discusses relevant educational challenges currently confronted by many contemporary classrooms that are no longer based on a recitation model. In specific, the chapter deals with examining the processes of learning to reason in the formal school setting. The paper introduces a sound theoretical and methodological base for the analysis of genres and framing in ongoing classroom discourses. In doing so, the paper illuminates what discourse genres are relevant within the context of solving socio-scientific problems. The detailed micro-level analysis and interpretation demonstrates and concretizes the analysis procedure. Through these analyses, the chapter makes visible the kinds of activities that follow when students engage in socio-scientific problem solving in the science classroom.

Mercer, Littleton and Wegerif introduce a range of methods for analyzing collaborative learning practices around computers. The authors remind us that educational researchers should have an open mind to different methods and methodologies so that they can flexibly harness them in order to address the specific research questions under study. The paper demonstrates what qualitative and quantitative research approaches allow us to study when the focus of analysis is joint activity with computers. The possibilities of using different, yet, complementary methods in the analysis of collaborative interaction and learning are also discussed. In all, this is a very relevant chapter to this book. Not only does the chapter address methodological issues related to analyzing collaborative activity, interaction and learning with computers but also -via its methodological arguments- it offers insights to any research on classroom interaction.

In their chapter Kovalainen and Kumpulainen focus on how classroom interactions can be analyzed using a multilevel coding scheme to understand the construction of shared meaning during problem solving. The rationale is set in the

increasing interest in understanding the nature of social interactions for understanding classroom learning. A sociocultural framework provides the context for these analyses as well as the use of sociolinguistic perspectives. The method presents three different dimensions of analyzing interactions: communicative functions, interaction sequences, and authority. The methodology is presented in the context of the study of a third grade mathematics lesson and provides an interesting illustration of the shifting nature of classroom discourse. It provides a particular nice demonstration of teacher scaffolding interpreted in the larger interactional context. The narrative clearly shows the relation of authority to the progress of the problem solving.

Hmelo-Silver, Chernobilsky, and Nagarajan's chapter examines collaborative problem solving and knowledge construction during online learning based on the Problem-Based Learning model (PBL). The paper draws on relevant studies and theories elaborating the processes involved in collaborative learning and knowledge construction. Similar to the chapter of Mercer and his associates also this chapter argues that collaborative interaction and learning are complex processes, which requires multiple and innovative analysis methods. Here, the study and its analyses highlight the potential of mixed quantitative and qualitative methods in analysing collaborative discourse and demonstrate how these can be complementary. What is unique in this chapter is that the analytical focus has been directed to several elements, that is, focus on the facilitator, collaborating peer-groups and the enabling role of technology. The study discussed is of particular interest to researchers who analyze collaborative knowledge construction in technology-enabled settings (i.e. STELLAR system) that provide additional support for social activity and knowledge creation. The CORDTRA analysis tool introduced in the chapter provides an innovative representation for analyzing the evolution of discourse and tool-related activity across time.

Vass and Littleton introduce an interaction analysis method, based on the functional approach. This approach has been purposefully developed to the study of role distribution and meta-cognitive processes during children's collaborative creative writing. The paper provides an informative review of relevant analyses methods of collaborative interaction. It also provides an informative introduction to the relatively under-researched area of collaborative creativity as well as identifying how computer tools can both help and detract from creative activity. The empirical study discussed draws on longitudinal observational data collected from elementary classroom communities. The potential of the functional analysis approach is discussed in the light of other approaches developed to the study of collaborative creativity. The empirical examples and their analyses are very informative and helpful in demonstrating the analysis method in action.

The chapter authored by Suthers, Dwyer, Medina, and Vatrapu adds an important contribution to this book by introducing innovative methods and tools for the analysis of online interactional construction of meaning. The chapter is theoretically and methodologically very sound and it powerfully draws on recent significant research literature in the field. This is highly important when considering novice readers who are likely to be in the process of growing into the

research community of online learning. What is also significant in the paper is its justified argument for the need to extend present online resources for collaborative meaning making from textual resources to a richer media. As the chapter states, if we are to do this we also need to develop our research approaches including methodologies and methods accordingly to address the heterogeneity of collective meaning making potentials. The chapter provides a chronological account of the evolvement of the analysis method. The authors also engage in critical reflection of the possibilities of the analysis method, including its current limitations and future developmental needs. This gives the reader an honest reflection what it is to engage in investigating classroom interactions whether virtual or local.

In their chapter Castanheira, Green and Yeager highlight interactional ethnography in action, namely in the study of inclusive practices in the classroom. A close, multifaceted analysis of one student, Sergio, powerfully demonstrates what interactional ethnography allows us to see and research. The analysis methods are described in detail as the authors demonstrate how they worked backwards through the data to understand how learning opportunities were created. They present examples of how they moved from particular instances of practice to theorize more general understanding. The analytic techniques and representations are presented in sufficiently fine detail to provide an excellent model for scholars exploring educational research methodologies.

Yamakawa, Forman, and Ansell introduce positioning and re-voicing as conceptual and analytic tools to examine identity work that goes on in a 3rd grade mathematics classroom community. The empirical study discussed in the manuscript illustrates how positioning and re-voicing stemming from discursive psychology provide powerful tools for educational researchers and practitioners to understand the social construction of identities for students as learners of mathematics in the evolving classroom interactions across time. While drawing on an ethnographic data gathered from two target students, the study highlights how the interactions between the teacher and the target students created qualitatively different possibilities for the students to participate in the social learning practices of the mathematics classroom. The teacher's positioning and re-voicing of the students' classroom interactions created different identities for the students as learners of mathematics. The study demonstrates the value and importance of researching the interactional micro-moments of the classroom and how teacher's participation in those interactions is pivotal in shaping students' identity building processes.

The chapter authored by van der Aalsvoort, van Geert, and Steenbeek introduces a microgenetic methodology as a means to investigate the relationship between learning and development in the classroom. The paper illuminates the methodology in action via two different empirical studies, and it ends by considering the possibilities and limitations of the method. In the theoretical section of the paper, the authors discuss the theoretical underpinnings of the microgenetic methodology and its connections to other relevant perspectives, such as, the Vygotskian notions of learning and development. In order to demonstrate how the methodology can be potentially used in empirical studies of classroom

learning, the chapter draws on two empirical studies. The empirical studies are interesting in their own right. They are carefully conducted and the analyses reveal insights into the dynamics of children's learning and development within the individual-social continuum. In sum, the chapter demonstrates how microgenetic methodology can be helpful in gaining insight into the learning and developmental processes of your learners in the classroom.

The chapter authored by Hamido and César discusses a very important and challenging topic. The chapter provides a meta-review of the authors' research work on classroom interaction over the past twelve years. While introducing and discussing their rich and inter-disciplinary research studies, the authors provide epistemological and pragmatic reflections on the changes and developments research on classroom interaction has faced during its history, including its conceptual frames, theories and methodologies. The chapter introduces and discusses several conceptual frameworks (both theoretical and methodological) that have guided research on classroom interaction and research on social interaction and learning, in more general. This is a powerful paper and very relevant for all researchers studying classroom interactions.

We end our book with a commentary chapter that has been written by a widely recognized researcher in the field, Michèle Grossen from the University of Lausanne. We hope her reflections on the chapters embedded with her own work and conceptual framings give us additional guidance for their interpretation.

Finally, we would like to thank all the authors for their amazing and important contributions to this book. Our special thanks go also to Minna-Rosa Kanniainen at the University of Helsinki for her editorial work with the chapters. In all, this has been an extensive, multi-faceted and highly communal process enriched by our lives and experiences. That is what learning is all about and making sense of it.

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# LEARNING TO REASON IN THE CONTEXT OF SOCIOSCIENTIFIC PROBLEMS

*Exploring the demands on students in 'new' classroom activities*

## INTRODUCTION[1]

The point of departure of this study is the increasing use and popularity of so-called socioscientific problems in educational practice. For the study of learning, such problems are interesting from theoretical as well as methodological points of view. Such problems can be articulated in terms of the relationship between learning in the context of science education, and what Bakhtin (1986) referred to as "heteroglossia." This exotic term captures something that is, we argue, not so cryptic. In fact, it is close to our everyday experiences. What the term alludes to is the observation that there are diverse ways of communicating and knowing about objects and events. In other words, and to continue in Bakhtinian parlance, in the complex society there are many "speech genres" that reflect how different social groups or institutions communicate about what they do. If we take a simple object as, let us say, an orange, it can be discussed, analysed, and thought about in many different ways and in many different genres. The satisfied consumer may speak of its delicious taste and its juicyness, the dietician will speak of it in terms of nutritional value and richness in vitamin C, and the artist may attend to it in terms of its colour, shape and texture in the context of what is to be a still life. At more abstract levels, we can think of the importer of oranges, the transport companies shipping oranges from their sites of production to consumers all over the world, and the economist, in her role as advisor to a multinational company, analysing the supply and demand in the market for oranges, as thinking and communicating about oranges in very diverse manners. In the latter cases, the terms and concepts that are productive are very different from those that characterize the consumer enjoying his morning fruit or the shop owner trying to persuade customers to purchase fresh oranges. Thus, the orange as a physical object is embedded in diverse social practices where very different "speech genres" and conceptual frameworks are relevant. Learning, in the sense of mastering what Vygotsky (1986) refers to as scientific concepts, implies being able to contextualize phenomena in discourses that are often at odds with those that are used in everyday settings. Furthermore, in many situations there will be multiple, sometimes rivalling, scientific discourses that are relevant.

*K. Kumpulainen et al. (Eds.), Investigating Classroom Interaction, 7–26.*

In the present chapter, we want to illustrate how heteroglossia, and complexities of speech genres, are related to learning and thinking in the context of understanding scientific argumentation. Our ambitions are a) to argue for the significance of considering the complexity and diversity of speech genres (or discourses) when studying and theorizing about learning, and b) to illustrate the difficulties students encounter when faced with problems where multiple contextualisation must be handled in face-to-face interaction.

We will do this by means of some examples from a case study, which illustrate the difficulties students have in dealing with so-called socioscientific problems (see below) that have become so popular in many science classrooms. We will also address the analytical challenges related to studying the demands on students in such complex settings. In our opinion, the methodological and theoretical consequences of this complexity of speech genres for our understanding of human learning are significant.

*Transformation of learning practices*

In spite of claims about the stability of education and instructional practices, classroom activities and learning tasks appear to have changed rather dramatically in recent decades in many parts of the world. This does not imply that lecturing and traditional question and answer patterns have disappeared, but rather that such practices are challenged by other modes of communicating and learning, where the demands on students are different from those that characterize traditional, teacher-dominated, classroom interaction. Today, pupils from an early age are often engaged in group-work and various forms of problem-based learning. Learning tasks in such settings are often more open-ended and presuppose rather complex skills on the parts of pupils of being able to search for, select, structure, and evaluate information and arguments of different kinds.

There are many factors contributing to these changes in communicative practices within institutionalized forms of education. The quite dramatic recent transformations of media ecology, and the changes in public expectations of what skills and competences are relevant for citizens in modern society, are but two such factors. A strong interpretation of the consequences of digital technologies, the information overflow, the impact of Internet, and of many other changes, would be that human learning is transformed, and that it becomes something very different from what it was in the context of traditional book-culture (Kress, 2003; Säljö, 2005). A related line of argumentation, present in many normative pedagogical texts, is that in order to close the gap between people's everyday experiences and schooling in science education, and to motivate students for further study, it is necessary to ground learning activities in what is perceived as 'real issues' and socially significant problems that matter to students (Driver et al., 2000; Nagel, 2001; Yager, 1996). In modern society, where the public discussion concerns issues such as genetic modification of food, cloning of animals and perhaps even human beings, energy consumption, global warming and many similar issues, it is imperative that such matters are given considerable attention in schools as well.

Learning to handle such complex problems, to structure and analyse them, and to reach an informed opinion, are seen as essential for citizenship and thus as increasingly important goals of schooling (Aikenhead, 2000; Fensham, 2000; Kolstø, 2001).

Science education has been criticized for its puristic, ivory-tower attitude of staying within the "heroic Enlightenment mode," where science is portrayed in a "triumphalist" tone as "almost exclusively concerned with basic or fundamental science" (Jenkins, 2002, p. 21). For science education, which is our concern here, the inclusion of socioscientific problems of the kind we have mentioned above offers challenges and opportunities. Socioscientific issues tend to be less well structured, more value-laden and open-ended than the standard learning tasks that are framed within accepted disciplinary discourses. In fact, tasks based on socioscientific issues are to a large extent in sharp conflict with traditional pedagogy in science teaching, which relies heavily on simplifying and reducing complexity. As Lee and Roth (2002, p. 39) point out, in schooling "the main narratives of science are divided into units of subject area and, within subjects, into groups of decontextualized 'facts'." Differing perspectives and conflicting values are more likely to come to the fore and create heated arguments when students encounter issues such as genetic modification of food, energy consumption in the world, and cloning, than when they meet science in its standard, pedagogical form. Or, to put it differently, heteroglossia will be less characteristic of the latter kind of communication than in the context of most socioscientific issues.

Inviting heteroglossia and open argumentation, however, produces a dramatically increasing complexity in terms of the demands on students with respect to how to act in learning situations. Handling the diversity characteristic of socioscientific problems requires developing a range of meta-level skills. Students must learn to recognize and take positions and counter-positions and consider "what counts as evidence, what evidence should be gathered, and what decisions flow from this" (Tytler, Duggan, & Gott, 2001, p. 826). They must be taught to use concepts and models critically and to develop their awareness of the presuppositions built into conceptual constructions and analytical frameworks they encounter. The current transformations of classroom activities, in our opinion, for many reasons need to be thoroughly scrutinized through empirical research. Success and failure in schooling will to an increasing extent reflect students' abilities to identify the speech genres that are relevant for problems where multiple perspectives are possible, and they must learn how to argue within and between them.

The overall purpose of the present chapter is to contribute to the understanding of such problems of learning how to reason and identifying what genres are relevant and expected in a specific setting. In order to do this, it is also important to be able to theoretically conceptualize such challenges to learning in educational settings. In addition, an analytical approach to empirical investigation is needed, which is sensitive enough to explore the challenges students meet in such complex school activities. We address these issues by means of some examples from a case study. The empirical context is a science classroom and the students are working

on issues of 'climate change'. But before attending to our empirical case, we shall add a few theoretical and analytical points with respect to our object of inquiry.

## HETEROGLOSSIA, CONTEXTUALIZATION AND SENSE-MAKING

Meaning making is, from our perspective, always embedded in a particular form of discourse or genre (Bakhtin, 1986) and reasoning, in this sense, thus always implies participants' contextualization (Rommetveit, 1974). The contextual nature of people's meaning making has been articulated by theorists in many disciplines. One of the most influential proponents of such a view on meaning is Wittgenstein (1953), who pointed to the centrality of "language games" for human understanding and social action. There are many language games by means of which different human activities are co-ordinated. To illustrate with a simple example consider the following extract from Sports Illustrated:

> Torres controlled a cross inside the area and beat Inter goalkeeper Julio Cesar with a low shot in the 64th minute. Inter played the last 40 minutes a man down after defender Nicolas Burdisso was sent off with his second yellow card. (Posted on the internet: Tuesday March 11, 2008)

To make sense of this utterance you need to know something about football as a cultural activity and perhaps also something about the teams and the particular game referred to. To be able to reason and make relevant contributions in a discussion of this kind also implies knowing how to make relevant "moves" within this specific language game which is grounded in a subculture's "way of life." Another scholar who has contributed significantly to understanding this issue of how meaning-making relates to contextualization of human activities is the sociologist Erving Goffman. In his micro-sociological analyses of human interaction he points to the centrality of participants "framing" (Goffman, 1974) of social action. We, for instance, see a line of people waiting on the pavement as a 'bus cue,' and we perceive people running on a field with a ball as an instance of the activity of 'playing football.' Framing is, in this sense, an act of contextualizing and making sense of an activity, and it is an essential feature of institutionalized activities.

In order to work successfully as a context for learning, schools organize learning activities in manners that have a long tradition within the institution. The grammatical exercise, the history essay, and the experiment in chemistry, all exemplify specific institutionalized activities which maintain forms of communication and modes of 'doing schooling.' As most of those active in education know, it is generally not easy to change traditional ways of organizing and doing schoolwork. Some ways of framing tasks and contents have become more or less invisible to the participants and are very hard to modify. In classrooms, events unfold according to what the participants have learned to identify as relevant framings for the social activity of schooling. The framing of an activity is, in this sense, reflexively related to our experiences of what is relevant for social action in a particular situation. The concept of framing thus draws

attention to the presuppositions and the taken-for-granted assumptions participants hold, and the inferences they make, as they engage in activities. When doing a word problem in mathematics, for instance, experienced students know that they are not supposed to respond to the contents of the task, but rather to treat it as an exercise of a particular kind where calculations are supposed to be carried out (Säljö, 1991; Verschaffel et al., 2000). In terms of our conceptualization of learning, it is important to note that this way of 'being competent' in doing mathematics, is a result of a long process of socialization of students into the locally relevant framing of this particular school activity.

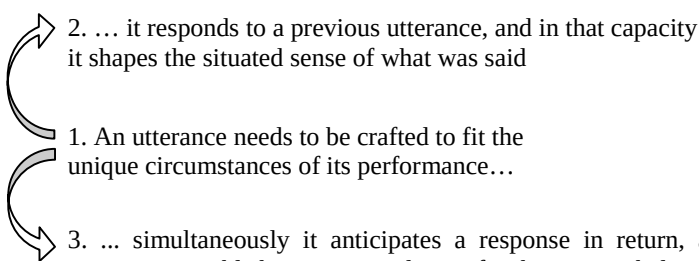
The introduction of socioscientific issues in education, which makes problems of heteroglossia and conflicting arguments a part of schooling, implies that the complexity of unpacking what is considered as relevant to learn and pay attention to increases dramatically for students. Meaning, as we have already mentioned, is always embedded in a particular form of discourse or genre (Bakhtin, 1986). No single speech genre is completely exhaustive and even if we have multiple genres at our disposal when speaking or writing about something, we always have to talk about it in specific manners that are situationally appropriate. This means that we need more precise analytical concepts that can help us explore what it means to master different genres in general, but also what it implies to do it in a particular institutional activity. These problems of learning to use terms and concepts that belong to specific speech genres in locally relevant manners relate to the interesting tensions between "meaning" and "sense" that Vygotsky (1986) discussed at some length. The sense of a term or expression, i.e. the locally relevant interpretation, is in complex manners related to its lexical meaning as expressed in a dictionary genre. In the following we will address the analytical concepts used in our analysis, which we have found to be sensitive enough to empirically explore the complexity of genres and the demands on students in this 'new' kind of classroom activity.

*Analysing thematic patterns and accountability in interaction*

In the context of empirical research on science learning, Lemke (1990) has operationalized the idea of the embeddedness of meaning within genres by identifying processes of "thematic contextualization," i.e. interaction that produce "thematic patterns." Such contextualizing implies "placing anything said or written in the context of some larger, familiar thematic pattern of semantic relationships" (p. 202) that we identify as a particular genre (or language game). To exemplify this rather abstract notion, the students in our science classroom can frame climate change, as a scientific, economical, religious or democratic issue (to mention but a few possibilities) What specific categories they use to make sense of the problem, how they generalise and exemplify both draw on and make up specific forms of arguing and reasoning. In interaction, the students need to produce such thematic patterns and make them recognizable and relevant to their discussion partners. Thus, "meanings of sentences are not made up out of the meanings of words." Rather, we "must arrive at both simultaneously by fitting words and their semantic

relations with the sentence to some thematic pattern" (p. 33) that is part of a conventionalized manner of speaking and thinking. This implies that learning to reason within a thematic pattern, such as probability theory or classical mechanics, is a problem of identifying the interplay between the semantics of a term/concept and the discursive context in which it is used. Central to this observation is also that a thematic pattern does not specify in detail what words are used or exactly how sentences are produced. There is a flexibility, which implies that there is considerable freedom at the level of terms and concepts when producing utterances and written statements that satisfy a particular thematic pattern. To master the thematic pattern of a specific genre, thus implies knowing how to generalize and particularize an issue according to its argumentative tradition.

To make sense in accountable ways is to be able to respond to an utterance as a move (or an action) in the unfolding social activity of which it is part (Mäkitalo & Säljö, 2004). Accountability points to the moral-cognitive dimension of situated action, the normative feature of the obligation to speak in an understandable and locally relevant way (Buttny, 1993; Mäkitalo, 2003). In discussions of socioscientific issues conflicts in framings will occur. Such conflicts are often unanticipated by the participants themselves. People usually interact on the assumption that certain premises are shared until an utterance is heard as in some sense irrelevant, unexpected, or unintelligible. At such moments "gaps" occur. These gaps need to be bridged by an account in order for the participants to be able to continue their activities (Scott & Lyman, 1968). Accounts, such as, for instance, clarifications, explanations, factual descriptions or justifications, are the devices used by participants to bridge gaps in interaction. By providing accounts, participants thus "take active steps to mark out what they are saying as meeting or not meeting what is expected of them" (Antaki, 1994, p. 70). Participants' sense making may thus be analysed through the accounts they need to provide in order to make themselves comprehensible and accountable to each other in situated practices. Analytically, this means that the analyst never categorise individual utterances produced in interaction. As we illustrate below, utterances are analysed in terms of their communicative consequences.




In this way, it is possible to scrutinize the interactive work done to establish a shared contextualization, which serves as a platform from which the participants

can continue their joint tasks. In the context of dealing with socioscientific issues, this problem of bridging gaps and creating shared platforms for communication are interesting to observe, since the participants themselves must actively attend to these bridging problems.

## SOCIOSCIENTIFIC ISSUES IN SCIENCE EDUCATION: CLASSROOM SETTING AND TASK

Socioscientific tasks are often given as part of some kind of inquiry based pedagogy, where students should learn to argue and 'talk science' (Lemke, 1990; Hansen, 1998). Our empirical case is an ordinary Swedish class in which activities were organized according to such ideals. The pupils, 14-15 years of age, were given a typical socioscientific issue to work with in groups – it concerned 'global warming' and the 'greenhouse effect.' The task was first presented verbally by the teacher, and throughout the work it was available in written form at a website. It was formulated as follows:

Anna: There are researchers who claim that we are heading towards a new ice age. Big parts of the Northern hemisphere will be covered by a layer of ice several hundreds of metres thick. No people will be able to live here then? Are these experts right?

Jonathan: Other researchers claim that the mean temperature will continue to increase. What if the polar ices will melt? What will happen then? Are animals and humans able to survive if the temperature of the Earth increases? Are these experts right?

Who is right? Are both claims correct? Are they both wrong? How can different researchers claim that we are heading both towards a colder and a hotter climate?

Your task:

– Find out as much as you can about what influences the climate and temperature of the Earth!

– Discuss within your group and explain as much as you can to each other!

– Ask as many questions as you can in the group, and try to answer the questions by using the Internet, books and articles!

– After the work is finished, every group member must be able to explain to the others what influences the global climate and temperature!

> Assistance: What is the greenhouse effect? How do ice ages emerge? What is meant by greenhouse gas? Can humans affect the climate? What is known about the future climate? In what ways may a changed climate affect animals and humans? NOTE! It is not enough to just answer these questions! You should formulate your own questions within the group!

This task lasted five weeks and was arranged as project work in the science classroom. The students worked in groups of between three and five members. They conducted the project work themselves and the teacher functioned merely as an advisor; there were no traditional lectures given on the topic by the teacher during these five weeks. As can be noted, the socioscientific issue was presented as one where there are conflicting ideas and positions. Students were encouraged to interact with each other and to discuss the issues, and they were told to formulate their 'own' questions. They were given access to different kinds of resources; textbooks on different levels of difficulty, scientific articles, newspapers, the Internet, and they were even offered e-mail contact with university professors.

The pupils' interaction was documented using several video cameras with which the activities in each group were recorded. The empirical material as a whole consists of 50 hours of video recordings of five groups of pupils (Jakobsson, 2001). For our purposes, this transcribed material was scrutinized looking for sequences with gaps in participants' interaction. These sequences were picked out for more detailed analysis of the accounts provided to bridge such gaps. Such accounts were analysed in terms of thematic patterns and participants conflicting framing of the issues discussed. Our empirical questions concerned two dimensions of the demands on students:

1. What difficulties did the participants encounter when dealing with this kind of socio-scientific issue?

2. In what ways were they held accountable as actors in this setting for their claims and contributions to the discussions?

To not loose sight of the analytical purpose of this chapter, we will only give some illustrative examples which address these questions, and which will show how our analysis was concretely carried out.

## RESULTS: EXPLORING CHALLENGES IN THE 'NEW' SCIENCE CLASSROOM

Disparate or conflicting framings were common in the empirical material, and participants were made accountable for their claims and arguments; they tested, contested and evaluated each other. To a considerable extent the pupils' problems with the intended framing seemed to emerge as a result of the problems they were expected to solve. They were uncertain how the questions were to be answered, and how they were to use the kinds of resources they had at their disposal. The uncertainties with respect to framing and perspectives are obvious at the very start

of the activities, as they pick up different meaning potentials from the very concept of "the greenhouse effect" itself. The discussions reveal differing interpretations of what it is that is to be explained.

*Dealing with the meaning potentials of 'the greenhouse effect'*

Excerpt 1

| | | |
|---|---|---|
| 1 | Gandalf | why d'ya think the greenhouse effect came about? |
| 2 | Ilahija | hasn't it always been there? |
| 3 | Lars | [no] |
| 4 | Gandalf | [no] |
| 5 | Laura | yeah but it *must* always've been there 'cause then it would |
| 6 | Ilahija | wait, I read somewhere [was it- ] |
| 7 | Laura | [the earth'd] be forty degrees colder |
| 8 | Ilahija | [it was made of] look |
| 9 | Lars | [now lets look] in this text- |
| 10 | Gandalf | yes, but now the substances that cause this have become, there are much more of those, so the temperature rises |
| 11 | Ilahija | Mm |
| 12 | Laura | yeah, but it's not [such- ] |
| 13 | Gandalf | [before] that, it worked fine |
| 14 | Ilahija | it comes [from] |
| 15 | Gandalf | [humans] let those substa[nces out] |
| 16 | Ilahija | [such che]micals |
| 17 | Gandalf | so they contributed, the greenhouse effect has emerged like that [(inaudible)] |
| 18 | Laura | [yeah but ] if, if *all* those substances disappeared, it would get *much* much colder |
| 19 | Gandalf | yes but there was no *greenhouse effect* before |
| 20 | Ilahija | There wasn't? I [didn't know that] |
| 21 | Gandalf | [there was no sur]plus- then, we didn't have any surplus of energy, as we have now |
| 22 | Ilahija | Uhu |
| 23 | Laura | but it says that we are not able to manage- |
| 24 | Ilahija | but the ozonosphere [has always been] there right? |
| 25 | Laura | [to live without] |
| 26 | Ilahija | hasn't the ozonosphere always been there, then? |
| 27 | Gandalf | [(inaudible)] |
| 28 | Laura | ((impatiently:)) yes the ozonosphere has been there but,[the *greenhouse effect*!] |

| | | |
|---|---|---|
| 29 | Ilahija | [ that comes from ] photochemical fog or whatever it says… in cities and also binds heat |
| 30 | Laura | but *hey*! the greenhouse effect must- otherwise it would be *too* cold for life on earth if it didn't exist the greenhouse- |
| 31 | Gandalf | I know, but that's not what I said |
| 32 | Laura | what did you say?! that it didn't *exist,* if it wasn't that much it wouldn't be-! |
| 33 | Gandalf | humans have caused an increase in those substances |
| 34 | Laura | yes! |
| 35 | Gandalf | they are the ones to contribute to- |
| 36 | Laura | it's getting warmer I *know*, but *you said* that once it didn't [exist!] ((leaves the table)) |
| 37 | Gandalf | [no ] |

Gandalf asks how the others think the greenhouse effect (GE) appeared. There are several meaning potentials embedded in this first question, but the situated sense Ilahija makes available through her comment triggers a lively discussion. Her response does not address the question as posed by Gandalf, but, rather, she focuses its premise which is that there was a time when there was no GE. Through her question, `hasn't it always been there?` (utterance 2), she contests Gandalf's implicit assumption that the GE is something that has set in more or less recently. Ilahija's response in this manner makes public another possible meaning of the phenomenon that we characterize as GE. What she claims through her question is that the GE has `always been there`. The two boys, however, do not initially recognize and address this other meaning potential. They respond by simultaneously saying `no` (3 and 4), and they do not provide any account or clarification. They take their own premise for granted, and simply imply that Ilahija is wrong. Laura, however, in utterances 5 and 7 picks up this other meaning potential as an argument for contesting their claim. Her point is that the Earth would have been much colder had there not been a GE. This challenge is picked up by Gandalf (10) and the discussion intensifies.

The uses of two differing premises a) the GE is a natural phenomenon that has always been there, and b) it is a new phenomenon that is connected to human activities, respectively, create what we refer to as a gap in the conversation. It was initiated by Ilahija questioning the premises of the first utterance. The gap needs to be bridged by the participants in order for them to be able to continue with their task as a group.

While Lars and Ilahija start searching for accounts in terms of factual descriptions in the literature at hand to bridge the gap in their discussion, Gandalf and Laura instead use the content of the texts to support their respective claims. Accounts are frequently provided. A justification by Laura (5-7) `'cause the earth'd be forty degrees colder` is met by a clarification from Gandalf (10) `yes, but now the substances that cause it have become,`

there are much more of those, so the temperature rises. This clarification, however, does not address the contested premise. Laura tries to refute his argument (12), but she is interrupted and Gandalf gives further clarifications and explanations (13 and 15) supporting his line of argumentation. He ends up answering his own initial question: so they contributed, the greenhouse effect has emerged like that (17). In utterance 18, Laura now explicitly addresses the premise of Gandalf's argument through hypothetical reasoning at the meta-level of talk. She argues but if, if all those substances disappeared, it would get *much* much colder. Gandalf now explicitly persists on the premise of his claims (19), yes but there was no *greenhouse effect* before. In utterance 23 Laura refers to the texts as authoritative voices in her claim (in 25) that one could not live on the earth withouth the GE. Gandalf (31) now accepts Laura's framing of how to talk about the GE. He now also denies his earlier claim that there was a time when the GE did not exist. This makes the personal conflict between the two escalate. Laura (35) holds Gandalf accountable for his current claim in relation to his utterances during the earlier phases of the discussion: but *you said* that once it didn't exist! As Gandalf again responds to this by denying that he had said it did not exist (37), Laura leaves the table and the interaction is temporarily interrupted.

The sequence illustrates that we are accountable for what we say and do in interaction with each other. We need to contribute with comprehensible and recognizable contributions to a conversation or discussion. But we are also morally accountable in terms of our behaviour as conversational partners. Laura insists that Gandalf had made the claim that there was a time when there was no GE, and his failure to acknowledge this seems to be treated by Laura as a breaching of this very fundamental principle of moral accountability in talk.

With respect to the issue of the GE, however, it can be argued that both sides are right, and, furthermore, they do provide valid arguments for their respective claims. Depending on how we decide to talk about this issue of a greenhouse effect, and what points we want to make, the metaphor GE is used differently. Instead of putting all effort into the question of *what the GE is* in an ontological sense, the question the pupils need to address here is *how to talk about GE and for what purpose*. And this is a different issue.

In the literaure they have at their disposal there are several texts that have been written for different purposes and audiences. These texts make different points and arguments in relation to global warming. In some texts, the GE is framed as a *natural phenomenon* (which implies that it has always been there as Laura insists), in others it is talked about as an additional effect that has set in as a consequence of *human activities* (which is the interpretation insisted on by the boys). Since there are several, and equally reasonable, ways of making sense of the GE, what is considered an accountable way of using this metaphor is dependent on what needs to be addressed *in situ.*

An interesting thing to note here is that the participants in one sense share the framing of their joint activity. They all take for granted that the question to address and solve in their discussion is one of *what the GE is.* This is what the discussion is

about, and even though they have a conflict going, their communication in this more basic sense is well co-ordinated. This presupposition is very much part and parcel of our traditional ways of doing schooling, in terms of how tasks are usually framed and what kind of answers are expected: they are to provide a definition of the 'essence' of the GE. This traditional framing of the activity; however, is in some respects in conflict with the new pedagogy introduced through the socioscientific issue. The task given, and the texts and other resources included, do not effectively support this traditional framing of looking for a clear definition of what the GE is, and this is probably the reason why the discussion takes off in the first place. The new pedagogical arrangement seems productive in the sense that the group is not able to answer the initial question of what the GE is. They first have to resolve the conflict by arriving at a situationally shared working definition of the GE.

This sequence in our opinion illustrates several interesting features and dilemmas of student learning in the context of using socioscientific issues that are possible to address from different perspectives. The interactions illustrate what many teachers hope to get out of such an exercise. The students are committed to the issue and the conceptual difficulties it represents. They take positions, they argue and counter-argue in a fairly intense manner. They are persistent in their argumentation, yet listen to their partners in spite of disagreements. Towards the end of the conversation they also seem to reach some consensus, which we know from the next session of their work, is a considerable step on the way of understanding some of the complexities of the greenhouse effect and its significance for life on earth.

But the discussion also illustrates some of the dilemmas of this kind of conversation. For instance, the pupils have to know what is relevant to attend to within one particular thematic pattern. Ilahija, for instance, repeatedly introduces the issue of the ozonosphere. This issue has been frequently addressed in the public debate and is also discussed in some of the texts used as resources. Ilahija assumes that the issue of the ozonosphere is relevant, and she is not capable to distinguish the different thematic patterns of these separate issues. As we have already mentioned, the texts and learning materials, also differ in the thematic patterns within which they present the GE. As a context for learning, this situation is very different from the classical text book setting, where the relevant thematic pattern of a problem is given in the presentation. In most cases, such texts would be explicitly designed so as to avoid causing conflict with respect to which thematic pattern is relevant. Thus, the framing of the situation of consulting a text that has been dominant in education is one of 'looking for information' relevant for an issue.

In the present case, however, the intended framing is different. Students are supposed to read the texts, look at pictures and graphs, and consult web-sites for information, while at the same time being aware of the problems of thematic patterns and perspectives. Thus, they must be aware of the definitions used, the trustworthiness and authority of the texts, the audiences addressed, and similar factors that are relevant for interpreting the text *vis-à-vis* their own situated interests of arriving at a scientifically accepted conceptualization of something as

complex as the greenhouse effect. In their discussions, they must be able to discuss the topic of the greenhouse effect, while at the same time attending to the meta-issue of how different texts and members of the group perspectivize the topic and what thematic patterns they assume to be relevant. This implies that the discussion is not just a giving and taking arguments *pro* and *con* a claim, it must also be about how one argues in a specific activity and for a specific purpose. Thus, the framing of the pedagogical situation must be more like that of a problem-solving setting in which one attends to the problems of how to talk and think. Gandalf and Laura can thus not just insist on their own version of what the GE is, they must also be attentive to the partially conflicting perspectivization that the other may use.

In terms of cognitive socialization, these demands are very interesting. Engaging in meta-talk of this kind can be seen as a preparation for acting in social realities and work situations where a multiplicity of perspectives and analytical frameworks is frequent. An interesting point in this context, however, is to what extent students get assistance in conducting meta-talk, discerning different positions and arguing *in situ*.

### *Heteroglossia and sense-making in the school setting: Reasoning as an accountable student or a concerned citizen?*

As we enter the conversation of another group, it is evident the students have established the distinction between GE as a natural phenomenon and GE as an environmental problem influenced by human activities. This group has just been discussing earlier periods of climate change in history, and they start addressing the current issue of climate change as an environmental problem:

Excerpt 2

| | | |
|---|---|---|
| 1 | Nicklas | I've found out .. that the emission of carbon dioxide needs to be reduced or everything will go to hell |
| | | [x lines of off-task communication left out] |
| 2 | Ameli | ((reads from a text:))and the researchers predict that there will be a rise in mean temperatures of one point thirtysix point three degrees Farenheit, and that's during the next century, and that increase is sufficient to cause a rise of the sea level so it will be put under water and the rise in temperature *this time* is to a large extent due to humans combustion of fossil fuel (inaudible) |
| 3 | Nicklas | if this conti[nues-] |
| 4 | Ameli | [yes ] |
| 5 | Nicklas | well listen I've found out that if it continues like this with all these effluents |
| 6 | Ameli | yes animal life will [die out] |
| 7 | Nicklas | [yes ] |

The issue of GE as an environmental problem is introduced by Nicklas (1): `the emission of carbon dioxide needs to be reduced`. Ameli who is reading aloud from texts responds within the same framing with a discussion about the consequences which include that the sea level will rise. Within this utterance, however, she introduces an important shift in the framing of the problem. She emphasizes that *`this time`* the effect to a large extent is a consequence of human activities and the `combustion of fossil fuel` (2). This remark recontextualises the problem and thus alters the thematic pattern within which the discussion continues. As is seen in Excerpt 3, the group now continues discussing in a moral or political genre stressing the need for humanity to consider issues of responsibility and to take appropriate action:

Excerpt 3

| | | |
|---|---|---|
| 8 | Ameli | earlier it wasn't our fault, but now it's our fault, and there are some people, smart people who… in the autumn of '98 they were in Buenos Aires and babbled and stuff but nothing- |
| 9 | M-R | ((laughing:)) babbled!? |
| 10 | Ameli | yeah about what to do and stuff, and *no one* is willing to pay in order to reduce the emissions, so they sort of disagree about *who's to pay* for the reduction of the [emissions] |
| 11 | M-R | [but ] why pay? why just don't stop all the [damned cars? ] |
| 12 | Ameli | [yeah but many-] there will be too many unemployed, they say |
| 13 | M-R | yeah, but hey, it would've been *much* better if we hadn't taken hadn't had any cars and things like that at all |
| 14 | Ameli | or electric [cars ] |
| 15 | M-R | [if you] yeah, if you lived during the 18th century how do you think they drove in Europe then? |
| 16 | Ameli | they just had horses and carriages |
| 17 | Nicklas | look at this ((looks at the computer screen)) |
| 18 | M-R | oh that's the increase in global warming look up here in China |
| 19 | Nicklas | is that? ((points at the screen with his pen)) |
| 20 | M-R | yeah, oh *shit!* look at the increase… by the Arctic [Ocean] |
| 21 | Nicklas | [but ]<br>look here [ you see] |
| 22 | M-R | [three ] |
| 23 | Nicklas | there it's pretty warm it will increase quite a bit and here is the Arctic Ocean, think what will happen…uhh! the water ((simulates holding his nose over the surface of water)) |
| 24 | M-R | but it will take at *least* a hundred years |
| 25 | Nicklas | in ten, ten years it will be up one metre |
| 26 | M-R | yeah…uuh |
| 27 | Helen | hey now, let's start a campaign! |

Through the move by Ameli of claiming that `now it's our fault`, a moral genre in which people are responsible for the climate change is made relevant. The discussion as a whole oscillates between very different issues and addresses disagreements between scholars and nations, but the thematic pattern is one of who is knowledgeable, who is responsible for the negative development, and what could (or should) be done and the consequences of such action. This moral theme organizes the discussion and provides opportunities for the pupils to address the issues and dilemmas and to voice their opinions. It allows them to quickly shift between scientific, sociopolitical, and economic arguments. However, what is interesting from a learning point of view is if the students are aware of this mix of arguments. In the argumentation, there are no clear signs that they realize that they are alluding to a diversity of genres – each with its own thematic pattern and presumptions.

After an extensive discussion about the causes, consequences, and moral implications of the issue, the group calls for the teacher (Anders). The students now believe they have done what is expected of them. But as will be evident from what follows, being accountable in a school setting implies being able to argue and make sense within another framing:

Excerpt 4

| | | |
|---|---|---|
| 1 | Ameli | Anders, we think we're finished ((the teacher arrives)) |
| 2 | Teacher | but uh.. have you discussed so you can tell someone what the greenhouse effect is? if I come and ask, for instance, you ((nods at Nicklas)) what's the greenhouse effect? explain it to me |
| 3 | Nicklas | …it's… gases 'round the earth… |
| 4 | Teacher | Yes? |
| 5 | Ameli | And I know what it'll cause |
| 6 | Teacher | What, what is.. what do these gases do? |
| 7 | Ameli | I know! I know! I know! They increase the temperature |
| 8 | Nicklas | it locks in, locks in heat first ((moves his hand downwards from above)) the heat comes thru and then it all goes around like this ((moves his hand in a circle)) |
| 9 | Teacher | You mean that the heat comes from the sun? |
| 10 | Nicklas | ((nods)) |
| 11 | Teacher | and because there are gases it won't come out, or? ((looks at M-R and Nicklas and nods)) the heat doesn't come out…but how does it…you say the heat… or sun comes in… |
| 12 | Nicklas | that's- |
| 13 | Teacher | but not out? |
| 14 | Nicklas | what I read |
| 15 | M-R | show it! ((points to the computer screen)) |
| 16 | Nicklas | ((turns to the computer and retrieves a picture)) here… check |
| 17 | Teacher | mm explain it to me |
| 18 | Nicklas | ((scratches his forehead, hesitates)) well, a little comes |

| | | |
|---|---|---|
| 19 | M-R | I can explain it! ((holds up her hand)) move over, I will explain |

When Anders comes to the table, the relevant framing becomes that of doing a school task. This change in framing is initiated by Ameli (1) as she turns to the teacher and claims: we think we're finished. Anders hesitates, but he responds in accordance with this framing of the activity. He continues the conversation by invoking the traditional category tied obligations and entitlements of a 'teacher': he checks if they have discussed the problem. He uses a traditional and familiar type of question when asking if they can tell someone what the greenhouse effect is (2). The group, recently very engaged in argumentation about the GE, becomes more hesitant and quiet. It is clear that the question the teacher has posed, and the premises on which it relies, was unexpected and did not fit into the genre and the thematic pattern already established within the group. Nicklas is made accountable as a student, and he has to respond to the teacher within an explanatory genre rather than a moral/political one. The classic interactive format of doing schoolwork is, however, quickly established. The framing of the activity, and the questions posed by the teacher, thus result in a very typical kind of evaluative activity characteristic of schooling and intimately tied to the institutional category pair 'teacher-student.'

The students are held accountable by being asked to present an *explanation of what the greenhouse effect is*. This is only one of the many questions and issues they were given when starting the project, and it was not focused in the interaction preceding their decision to consider the task as finished**.** At this stage, the task can obviously not simply be framed as primarily a socioscientific dilemma. Rather, in the situated activity, they are now accountable as 'students,' and they need to be able to explain what GE *is* as a traditional school task. They are expected to provide terms/concepts, definitions, to comment on the development of climate changes and so on within a scientific, explanatory framework. The shift required by the teacher at this moment causes considerable problems.

## CONCLUDING REMARKS

The point of departure for our study and analysis has been the increasing use and popularity of so-called socioscientific problems in educational practice. For the study of learning, such problems are interesting from theoretical as well as methodological points of view. The issues we have tried to shed light on concern what kinds of activities that follow when students engage in such tasks, and what kind of learning that can be assumed to take place. Simultaneously, we have conceptualized our theoretical understanding of these issues and in line with this understanding suggested what kind of object of inquiry and analytical tools are sensitive enough to guide an empirical exploration of such complex classroom interaction. Observing gaps in interaction is a productive way to pinpoint the demands on students and the difficulties they run into as they learn how to reason and argue in a complex school setting. Such gaps are a participants' concern in all

kinds of interaction, but in our material they are revealing in terms of the specific normative expectations that have to be met in today's classroom setting. As meaning making is an act of contextualization, participants' framing of the task in recognisable thematic patterns here became a focus in the analysis. The gaps observed, often pointed to conflicts in framing. This was observable through the specific accounts that the participants delivered (i.e. the explanations, justifications and so on). To bridge gaps participants need to make explicit the current *framing* of the issue at stake.

Socioscientific problems are interesting as pedagogical challenges, since they are complex and can be framed in different discourses or disciplinary genres; they are characterized by heteroglossia. This is the reason why they are used and why teachers find them appealing; they are about the 'real world.'

When tackling such problems, students are faced with a challenging task of identifying genres and of relating what is expressed in each of these genres to the others in manners that are contextually relevant and that accord with some recognizable thematic pattern. In the case of climate change and global warming, for instance, different scientific genres (from physics, chemistry, environmental science etc.) are used, but the issues also relate to domains such as politics and justice, economics, and so on. In each of these disciplinary discourses there are important and productive ways of understanding and discussing climate change. The students we have observed struggle with the various genres to create a coherent narrative that is informative from some point of view about climate change.

Using a visual metaphor, learning to see what framings and thematic patterns are used in a particular text or speech event is important in modern society. Learning of this kind is very different from the traditional approaches of institutionalized schooling building on a conduit metaphor of communication (Reddy, 1979). It is not a matter of absorbing information or even of understanding basic concepts in a piecemeal fashion. As we have argued, the situation has more of a problem solving character and requires considerable attention to meta-communicative features: how are we communicating?, and what are the relevant thematic patterns for modelling, analysing, and discussing a problem? This implies that our theoretical interpretation of what learning is, and the methodological procedures that are used for analysing learning processes, have to be based on an object of inquiry that represents this complexity of identifying and reasoning in terms of different disciplinary genres.

The use of socioscientific problems in schooling is grounded in a perception of the complex nature of many, if not most, social problems which are focussed in media and public discourse, and in which scientific knowledge plays a part. The skills students need to develop to master such challenges require that they learn to pay attention to from which position a particular argument or hypothesis is formulated and what the premises are. They must attempt to discern the framings used and the thematic patterns that are relevant, and they must learn to argue both within and between thematic patterns. When engaging in such tasks, the activities presuppose sensitivity to different kinds of gaps in communicative practices, and

the ability to bridge within and between patterns. As readers/learners we continuously have to dialogue with ourselves about such differences in framing, and, when interacting in the kinds of situations we have seen, we have to be sensitive to such gaps in talk.

In our opinion, the observations we have made point to interesting challenges in the relation between individual sense-making and features of how the collective memory of society is organized. Thus, the uses of this kind of problems in schooling testify to the changes in media ecology where people now encounter complex problems as they listen to the news, read magazines or in other ways participate in public discourse. The manners in which problems are packaged in such settings deviate from how school tasks by tradition have been organized. The traditional learning ladder going from the specific details and elementary facts and concepts in order to reach the general picture in these cases is generally reversed. The challenge for the individual instead is one of being able to work from the general picture to the particulars as these are talked about in different genres.

Success in such tasks presupposes a specific, perhaps we can call it late-modern, attitude to learning and cognitive socialization. Thus, one may argue that this is a relatively new type of learning for much of institutionalized schooling, at least below the tertiary level. Most pupils are accustomed to practices where the textbook and/or the teacher have managed problems of framing of the kind we have pointed to. The pedagogical genre has implied a reduction in complexity in this respect. In fact, this has to a large extent been seen as the defining characteristic of such a genre; the expected framing and thematic pattern are clear when tasks are initiated. In the kinds of situations we have documented, students themselves face the problem of identifying the relevant framing and thematic patterns. In Billig's (1996) terms this requires an understanding of the point of a discussion, and of how to categorise and particularise an issue within an argumentative tradition. But the students also have to construe narratives with thematic patterns that are relevant for the tasks they encounter in the specific activity of schooling. An interesting problem, as we have pointed out, is to what extent pupils receive assistance in handling such complex hermeneutic exercises. Anecdotal evidence, but also some research findings (Nilsson, 2002; Østerud, 2004), indicate that the rather passive attitude to intervening in problem solving activities (for instance when using material from the Internet) that is characteristic of much of the child-centred pedagogy of recent decades may result in a situation where pupils are left without productive support and guidance. It seems very clear from our observations that learning productive problem solving in the context of dealing with socioscientific issues requires support and guidance in how our expanding collective memory is organized.

## NOTES

1 The research reported here has been conducted at The Linnaeus Centre for Research on Learning, Interaction and Mediated Communication in Contemporary Society at the Department of Education, Göteborg University and within the project "Cognitive socialisation and institutional discourse: A

sociocultural approach to the study of traditions of argumentation and their organisational embeddedness" funded by the Swedish Research Council.

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NEIL MERCER, KAREN LITTLETON, & RUPERT WEGERIF

# METHODS FOR STUDYING THE PROCESSES OF INTERACTION AND COLLABORATIVE ACTIVITY IN COMPUTER-BASED EDUCATIONAL ACTIVITIES

## INTRODUCTION

In this paper we will describe and evaluate some methods for analysing the talk and interaction of students, or other types of partners, when they are working together, face-to face, on educational activities at the computer. We focus on situations where partners are literally working side-by-side, but many of the methodological issues we raise are relevant to the study of online collaborations. The various methods we include have not emerged only from computer-related research, but draw on a much longer line of methodological development concerned with the study of pairs or small groups engaged in educational activities. So far as we are aware, not all the methods we describe have actually been used for studying ICT-related talk and interaction in recent years, but that does not mean they are inappropriate. The limited range of methods used in the study of computer-based interaction may well reflect such factors as researchers' relative familiarity with, or attachment to, different disciplines and methodological paradigms, rather than being the result of informed choice. Our view is that choices of method – such as whether to use qualitative or quantitative methods, or to use experimental or naturalistic investigations – should never be made in the abstract, but only in response to the question: is this the most appropriate way of investigating my research questions? Because such methods are not specific to the study of computer-related interaction, they need to be evaluated against more general concerns about how human interaction in educational settings can best be studied. We will also argue that the most effective forms of enquiry may involve the complementary use of more than one type of method.

## QUANTITATIVE OR QUALITATIVE?

The most common contrast made between methods for analysing interaction in educational settings is whether they provide qualitative or quantitative results. The relative strengths and weaknesses of the various qualitative and quantitative methods for analysing talk can be summarised as follows:

*K. Kumpulainen et al. (Eds.), Investigating Classroom Interaction, 27–42.*

*Quantitative analysis*

This includes methods which use coding schemes, such as systematic observation and some sociolinguistic methods, but also computer-based text analysis if used to measure relative frequencies of occurrence of particular words or patterns of language use.

Strengths:
– an efficient way of handling a lot of data; for example a researcher can 'survey' a lot of classroom language relatively quickly;
– enables numerical comparisons to be made, which can perhaps then be subjected to a statistical analysis.

Weaknesses:
– actual talk, as data, may be lost early in the analysis. All a researcher works with are the pre-defined categories;
– pre-determined categories or other target items will limit analysts' sensitivity to what actually happens;
– the analysis cannot handle the ways that meaning is constructed amongst speakers, over time, through interaction.

*Qualitative analysis*

This includes methods such as ethnography, discourse analysis and conversation analysis.

Strengths:
– any transcribed talk remains throughout the analysis (rather than being reduced to categories at an early stage);
– any categories emerging are generated by the research data (i.e. are outcomes), not based on prior assumptions underlying the coding scheme;
– in research reports, examples of talk and interaction can be used to show concrete illustrations of your analysis: you do not ask readers to take on trust the validity of your abstracted categorization;
– the development of joint understanding, or the persistence of apparent misunderstandings or different points of view, can be pursued through the continuous data of recorded/transcribed talk;
– because the analytic scheme is not established *a priori*, the analysis can be expanded to include consideration of any new aspects of communication that emerge in the data.

Weaknesses:
– it is difficult to use these methods to handle large sets of data, because they are so time-consuming: it is commonly estimated that transcribing and analysing

one hour of talk using such methods will take between 5 and 12 hours of research time;
– it is difficult to use such analyses to make convincing generalizations. Researchers are open to charges of selecting particular examples to support their arguments.

We will next discuss some quantitative approaches, and then deal with qualitative methods.

## QUANTITATIVE METHODS

### *Systematic observation*

A well-established type of research on classroom interaction is known as 'systematic observation'. It essentially involves allocating observed talk (and sometimes non-verbal activity such as gesture) to a set of previously specified categories. The aim is usually to provide quantitative results. For example, the observer may record the relative number of 'talk turns' taken by partners, or measure the extent to which each partner produces types of utterance as defined by the researcher's categories. The basic procedure for setting up systematic observation is that researchers use their research interests and initial observations of classroom life to construct a set of categories into which all relevant talk (and any other communicative activity) can be classified. Observers are then trained to identify talk corresponding to each category, so that they can sit in classrooms or work from video-recordings and assign what they see and hear to the categories. Today, researchers may develop their own categorising system, or they may take one 'off the shelf' (see for example Underwood and Underwood, 1999, who used Bales' 1950 Interaction Analysis schedule to analyse the dialogue between children as they negotiated their way through a computer task). Teasley's work (1995) offers an interesting example of the use of this type of method applied to the study of collaborative learning. In her study the talk of children working in pairs on a problem-solving task was recorded and transcribed and each utterance attributed to one of fourteen mutually exclusive categories. These categories included such functions as 'prediction' and 'hypothesis'. Transcripts were coded independently by two coders and the level of agreement measured to ensure reliability. A count of categories of talk in different groups was correlated with outcome measures on the problem-solving activity in order to draw conclusions about the kinds of utterances which promote effective collaborative learning.

The use of statistical techniques to ascertain whether there is any evidence of an association between particular features of the learners' talk and success on task or learning gain is a common one and has been adopted by many other researchers. For example, many experimental studies of collaborative interactions around the computer have handled 'talk data' by effectively reducing them to pre-defined coded categories which in turn lend themselves to treatment by statistical analyses.

Correlation techniques can be used, as for example by Howe and Tolmie (1999) and Barbieri and Light (1992), to determine whether there is any evidence of an association between particular features of the learners' talk and success on task or learning gain. Similarly, regression analyses have also enabled researchers, such as Underwood and Underwood (1999), to determine which, if any, facets of the paired or group interaction are successful predictors of on-task performance.

As well as allowing an examination of any associations between aspects of collaborative activity and measures of 'outcome', the use of coding schemes also affords other distinct advantages. A positive feature of the coding method is that a lot of data can be processed fairly quickly. It allows researchers to survey life in a large sample of classrooms without necessarily transcribing it, to move fairly quickly and easily from observations or recorded records of classroom events to numerical data and then to combine data from many classrooms into quantitative data which can be analysed statistically. Its use thus permits the handling of large corpora of data, affords explicit criteria for comprehensively categorising an entire data set and offers a basis for making explicit comparisons between the communicative behaviour of groups of learners (Mercer & Wegerif, 1999). Systematic observation has undoubtedly provided interesting and useful findings regarding the nature of interactions amongst children working in pairs or groups (e.g. Bennett & Cass, 1989; Underwood & Underwood, 1999); but it is also important to recognise that this kind of method has some inherent weaknesses. These include problems in dealing with ambiguity, and the multi-functionality of utterances. There are also difficulties in determining the appropriate size of the unit of analysis – especially as the phenomenon under study involves a continual, evolutionary process of negotiation and re-negotiation of meaning. Crook (1994) highlights a further difficulty, pointing out that a collaboration could be rich in instances of supposedly 'productive talk', in the sense that there is evidence of conflict, predicting, questioning and so on and yet not lead to any worthwhile outcome. A simple count of such language features would not capture the extent to which talk is mobilised towards a particular goal or the creation of shared knowledge. Used in isolation, it would effectively reduce collaborations to atemporal 'inventories of utterances' (Crook, 1994, p. 150).

Studying and understanding the temporal dimensions of collaborative work represents a considerable theoretical and practical challenge (see for example, Issroff, 1999). Categorical coding schemes are inappropriate tools to use for studying the processes by which learners build shared understandings, and the use of experimental studies involving brief circumscribed sessions of computer-based collaborative work computer is far from ideal. In order to gain a fuller understanding of the processes of collaborative work researchers need to recognise that collaborative experiences are typically more than just brief, time-limited, localised sessions of joint activity. When researchers observe a pair or group of learners working together, the interaction observed is located within a particular historical, institutional and cultural context. Learners have relationship histories. As Crook (1999) comments, any productivity of interaction observed within a particular session may arise from circumstances that have previously been

established. This point is echoed by Light and Light (1999) who also assert that observable interactions are likely to have unobservable determinants in the histories of individuals, groups and institutions.

### *Computer-based text analysis*

Research in linguistics has recently been revolutionised by the development of computer facilities for analysing large databases of written or spoken (transcribed) language. Software packages known as 'concordancers' enable any text file to be scanned easily for all instances of particular target words. (Commonly used examples are Monoconc, Wordsmith and Conc 1.71. Recent versions of qualitative data analysis packages such as NVivo offer some similar facilities.) Not only can their frequency of occurrence be measured, but the analysis can also indicate which words tend to occur together, and so help reveal the way words gather meanings by 'the company that they keep'. The results of such searches can be presented as tabular concordances. One practical application of this method (outside educational research) has been in compiling dictionaries. Lexicographers now can base their definitions on an analysis of how words are actually used in a large databank (or 'corpus') of naturally-occurring written and/or spoken language. Concordances can reveal some of the more subtle meanings that words have gathered in use, meanings which are not captured by literal definitions.

Once recorded talk has been transcribed into a word file, a concordancer allows a researcher to move almost instantly between occurrences of particular words and the whole transcription. This enables particular words of special interest to be tracked in the data, and their relative incidence and form of use in particular contexts to be compared. The basic data for this kind of analysis, throughout, remains the whole transcription. By integrating this method with other methods, the analysis can be both qualitative (analysing particular interactions, by say using discourse analysis) and quantitative (comparing the relative incidence of 'key words', or of types of interaction as might a systematic observer). Initial exploratory work on particular short texts (or text extracts) can be used to generate hypotheses which can then be tested systematically on a large text or series of related texts. For example, a researcher may want to see if a technical term introduced by a teacher is taken up by students later in a lesson, or in their group-based activity. By locating all instances of the term in the transcription file, the ways it is used by teachers and students can then be considered (see for example Monaghan, 1999; Wegerif & Mercer, 1997; Mercer, 2000).

## QUALITATIVE METHODS

### *Ethnography*

The ethnographic approach to analysing educational interaction emerged in the late 1960s and early 1970s. It was an adaptation of methods already used by social anthropologists and some sociologists in non-educational fields (see e.g.

Hammersley, 1982; Woods, 1983 for accounts of this). Ethnographic analysis aims for a rich, detailed description of observed events, which can be used to explain the social processes which are involved. In early studies, ethnographers often only took field notes of what was said and done, but fairly soon it became common practice for them to tape-record talk, to transcribe those recordings, and to report their analysis by including short extracts from their transcriptions. Ethnographers are normally concerned with understanding social life as a whole, and while they will record what is said in observed events, language use may not be their main concern. Their methods do not therefore usually attend to talk in the same detail as do, say, discourse analysts or conversation analysts (as discussed below).

*Sociolinguistic analysis*

Some research on talk in educational contexts has its roots in sociolinguistics. Sociolinguistics is concerned, broadly, with the relationship between language and society. (See Swann, Mesthrie, Duemert, & Leap, 2000, for a general introduction to this field). Sociolinguists are interested in the status and meaning of different language varieties (e.g. accents and dialects, different languages in bilingual communities) and in how these are used, and to what effect, by speakers (or members of different social/cultural groups). Both qualitative or quantitative methods may be used. For example, researchers have compared the extent to which girls and boys dominate interactions (French, & French, 1988; Swann, 1992), and recorded the incidence of switches from one language to another in the course of educational events (Edwards, & Siemkewicz, 1990). Qualitative sociolinguistics sometimes resembles ethnographic research, but can also incorporate the methods of descriptive linguistics – such as the identification of distinctive sound patterns (phonology), grammatical constructions or vocabulary items.

*'Linguistic' discourse analysis*

The term 'discourse analysis' has no precise meaning; it is used to refer to several different approaches to analysing language (both spoken and written) and hence to some quite different methods. Within linguistics, it usually indicates an interest in the way language is organized in units longer than sentences. Educational research following this approach has focused on the structural organization of classroom talk. The classic investigation of Sinclair and Coulthard (1975) showed that in teacher-led lessons the language has characteristics which mark it out as a distinct, situated language variety, and one which assigns particular roles to speakers (see also Stubbs, 1983; Willes, 1983). They devised a method for categorising all talk in a lesson into a hierarchical system of 'acts', 'moves' and 'exchanges' and 'transactions'. The basic unit of teacher-pupil communication in this system is the 'IRF exchange', in which a teacher Initiates an interaction (typically by asking a question), the student Responds (usually by providing an answer) and the teacher then provides some Follow-up or Feedback (for example, by confirming that the

answer was correct). The IRF concept has since been used by many classroom researchers, although few employ the whole of Sinclair and Coulthard's rather complex hierarchical system.

One obvious function of the IRF exchange is for teachers to maintain control in interactions with students. These observations have been used to claim that teachers' frequent use of questions is unfortunate as it prevents students from taking any initiative in classroom dialogues and tends to encourage only short, factual responses (Young, 1991; Wood, 1992). The concept of IRF has also been applied to interactions with tutorial software (Crook, 1994; Fisher, 1992). In many tutorial software packages the computer asks a question, the user offers a response of some kind and the computer evaluates that response, either explicitly or through the selection of the next screen or prompt. The constraining effects of the frequent use of questions might seem to apply also to IRF-type exchanges with computers.

However, there are good reasons to doubt the validity of blanket criticisms of the use of questions by teachers, or by educational software. One of the most important is that questions can have a range of communicative functions. They need not be associated only with 'closed' tests of curriculum content or with tightly controlled dialogues. Moreover, the special nature of computers as interactional partners makes other types of interaction also possible. Having been asked a question by a computer, users can 'sit back' from the computer screen and consider their response at length. Because the computer is a machine, it can be made to wait until a user is ready in a way that would not normally be appropriate with a human conversational partner (especially an authoritative one such as a teacher). Of course, computer-based tasks are sometimes designed as 'timed', so that users are encouraged to respond as quickly as possible. But this is an arbitrary and easily modifiable feature, quite different from the social norms and imperatives that shape human interaction.

This potentially infinite patience of the computer is of special relevance when users are working not individually, but in pairs or groups. A pair of children who are 'asked' by a computer to provide a solution to a problem can pause and discuss their possible response before keying it in. That is, they can introduce some discussion (D) between the computer's initiation (I) and their response (R). If the computer then provides them with some evaluative feedback (F) on that response, we have a new kind of pedagogic exchange – the IDRF (Wegerif, 1996) within which the users/learners take on a more active and controlling role in the construction of their own knowledge. IDRF exchanges make good educational use of a computer's ambivalent nature. Through its initiations the computer can stimulate and direct the talk of the children towards curriculum relevant problems, topics, concepts or procedures. In the discussion phase children construct their own meanings, to their own schedule. The computer then provides formative feedback on their joint efforts. The IDRF can be seen as way of using the computer to 'scaffold' children's learning, embodying a sociocultural model of teaching and learning which transcends both transmission teaching and discovery learning to enable the guided construction of knowledge (Mercer, 1995).

*'Socio-cultural' discourse analysis*

The term 'socio-cultural' has become associated with research which draws explicitly on the developmental psychology of Lev Vygotsky (1978; see also Wertsch, 1985; Daniels, 2001; Mercer & Littleton, 2007). It represents an approach in which language is considered a 'cultural tool' for learning, which each parental generation of a society uses to guide the cognitive and social development of its children. 'Sociocultural' discourse analysis differs from 'linguistic' discourse analysis in being less concerned with the organizational structure of spoken language, and more with its content, function and the ways shared understanding is developed, in social context, over time. As with ethnography and conversation analysis, reports of such research are usually illustrated by selected extracts of transcribed talk, to which the analyst provides a commentary. A socio-cultural method has been used to analyse and evaluate the talk of children working together in pairs or groups (Lyle, 1993, 1996; Hicks, 1996), sometimes on computer-based activities (Wegerif & Scrimshaw, 1997). We have used this approach, along with other methods, in action research projects aimed at improving the quality of primary children's collective reasoning during ICT-based activities, as described in the next section of this paper. Kumpulainen and Wray (2002) offer a detailed sociocultural analytical framework for the analysis of peer-group interaction, and show how it was used in a study of children's collaborative computer-based writing. Their framework is designed to focus on three dimensions of activity: cognitive processing, social processing and language functions. They use the results of their analysis to argue for the importance of student characteristics for determining the educational value of ICT-based activities, including the established learning culture of students, their skills in working collaboratively and their grasp of the relevant conceptual knowledge.

A socio-cultural analysis examines education as interpersonal and intrapersonal process, in which the computer would be seen as one kind of cultural tool which mediates that process (Kumpulainen & Mutanen, 1999; Mercer, 1996; Kleine-Staarman, 2003). From this perspective, 'learning' means participating in cultural practices (Lave & Wenger, 1991) and the learning activities can never be seen separately from the context in which they take place (Sfard, 1998) and the artefacts that mediated them (Säljö, 1995). In Computer Supported Collaborative Learning (CSCL) practices, both the computer mediated communication system and the ideas from other participants that influence one's own thinking can be regarded as mediating tools (Gunawardena, Lowe, & Anderson, 1997; Kleine-Staarman, 2003).

*Conversation analysis/discursive psychology*

Conversation analysis (CA) grew out of a radical sociology called ethnomethodology, which was founded on a dissatisfaction with the focus of conventional sociology on studying the structural organization of society on a grand scale aimed instead to explain how the social world operates by focusing on

the micro-level of social interaction. The more specific goal of conversation analysts pursue is understanding how social interaction is achieved, minute by minute, through everyday talk and non-verbal communication. Discursive psychologists who are often similarly concerned with analysing talk to understand the structure of social action and how people account for their actions, sometimes use similar methods (see Potter & Wetherell, 1994; Edwards & Potter, 1992).

CA is a demanding methodology, because it uses a very detailed and laborious style of transcription and sets very strict criteria for the kinds of interpretations which an analyst can make from the data of recorded talk; and it also involves the use of a very specific and detailed method of transcription. (as explained in Drew & Heritage, 1992). Widely used in the analysis of talk in work-related settings (see for example Drew & Heritage, 1992), it has still to be applied to any great extent in classroom research (but see Baker, 1997; Stokoe, 2000).

## COMBINING METHODS

With their various strengths and weaknesses, it may seem logical to use two or more methods of analysing talk in a complementary way. In doing so, however, it is important to recall a point made earlier in this paper – that different methods may embody different conceptions of the nature of talk and what counts as a valid analysis. As Snyder (1995) argues on the basis of her studies of children's computer literacy, the successful combination of different methodologies depends on research being underpinned by a 'sensitive, flexible theoretical framework' for understanding the complexity of real-life events. Given such a framework, there are ways of combining at least some methods which will satisfy most reasonable concerns about validity and methodological consistency.

### *Integrating qualitative and quantitative methods: an illustration*

Both qualitative and quantitative methods have served our recent research on using computer-based activities to stimulate and improve the quality of children's talk and collaborative activity in primary maths and science (as reported in Mercer, Dawes, & Wegerif, 2004). One of our methodological aims was to ease the tension between wanting to analyse talk as contextualized activity (as is enabled by naturalistic observation and the use of qualititative methods such as sociocultural discourse analysis) and to provide generalizable results based on a large sample of case, as is made possible by experimental methods and quantitative analysis. The research was an intervention study in which we worked with teachers to teach Exploratory Talk and to apply this to learning through ICT activities in the science and maths curriculum for a whole school year (Year 5). Our main hypothesis was that if children were taught to use Exploratory Talk when working together, and then were provided with suitable opportunities to do so when using ICT-based science and maths activities, they would improve not only the quality of their collective activity but also achieve significantly better individual learning outcomes in those subjects. One source of data was children's performance on

SATs items in science and maths, taken before and after the intervention period. A comparison between the improvements on these SATs questions of our experimental classes (those who had taken part in the intervention programme) with matching control classes (consisting of children in matched schools who had not been involved in the intervention) showed that the experimental children had made significantly greater improvements than the control children ($F(1, 245) = 10.305$; two-tailed $p = 0.002$). However, we also wanted to elucidate the processes underlying these different levels of achievement.

A first step for this was a detailed analysis of the talk of a sample of children while working together (one group from each of the experimental and control classes). Transcripts 1 and 2 below illustrate the kinds of comparisons that emerge from the post-intervention qualitative analysis of the talk of small groups working with computers in experimental and control classes. In the first extract, a group of children in a control school are using the simulation facilities of Granada Science Explorer software to carry out an investigation into the relative effectiveness of materials for providing soundproofing.

*Transcript 1: A 'control' group select materials*

| | |
|---|---|
| Hannah | (*reads from screen*) 'Keep it Quiet. Which material is the best insulation? Click 'measure' to take a sound reading. Does the pitch make a difference?' |
| Darryl | No we don't want clothes. See what one it is then. (*Points to screen*) |
| Hannah | No it's cloth |
| Darryl | Oh it's cloth. |
| Hannah | Go down. This is better when Stephanie's in our group. |
| Darryl | Metal? |
| Hannah | Right try it. |
| Deborah | Try what? That? |
| Hannah | Try 'glass' |
| Darryl | Yeah |
| Deborah | No one. |
| Hannah | Now– |
| Darryl | Measure. |
| Hannah | Now measure. Hold. (*Turns volume control dial below screen*) |
| Darryl | Results, notes. |
| Hannah | Results. We need to go on a different one now. Results. |
| Darryl | Yeah, you need to go there so you can write everything down |
| Hannah | I'm not writing. |

Our qualitative analysis of the talk of this group indicated that this extract was fairly typical of their interactions – and of most of the other control groups. They did not work collaboratively. They did not share knowledge, build on each other's suggestions, provide reasons for their proposals or seek joint agreement.

For comparison, the next transcript is of a group of children in an experimental class. They are engaged in a Science Explorer activity about the effectiveness of materials for blocking out light.

*Transcript 2: An 'experimental' group plan an investigation*

| | |
|---|---|
| Ross | OK. (*reads*) 'Talk together about a plan to test all the different types of paper.' |
| Alana | Dijek, how much did you think it would be for tissue paper? |
| Dijek | At least ten because tissue paper is thin. Tissue paper can wear out and you can see through, other people in the way, and light can shine in it. |
| Alana | OK. Thanks. |
| Alana | (*To Ross*) Why do you think it? |
| Ross | Because I tested it before! |
| Alana | No, Ross, what did you think? How much did you think? Tissue paper. How much tissue paper did you think it would be to block out the light? |
| Ross | At first I thought it would be five, but second – |
| Alana | Why did you think that? |
| Ross | Because when it was in the overhead projector you could see a little bit of it, but not all of it, so I thought it would be like, five to block out the light. |
| Alana | That's a good reason. I thought – I thought it would be between five and seven because, I thought it would be between five and seven because normally when you're at home if you lay it on top, with one sheet you can see through but if you lay on about five or six pieces on top you can't see through. So that's why I was thinking about five or six. |

For this group, qualitative analysis revealed that the children engaged in discussions which had many of the features of Exploratory Talk. They asked each other for information and opinions, they sought reasons and provided them, they shared their thoughts and evaluated proposals that were made. Any challenges participants made were generally constructive and all members of the group were involved in working towards joint decisions.

By examining the talk of these groups of children as they worked through activities, we were able to see if their talk appeared to lead to positive learning outcomes – for example, a better-designed experiment, or an explicit and accurate account of aspects of the scientific knowledge involved. In this way, our qualitative analysis provided insights into how the joint construction of knowledge might succeed or fail in the course of particular computer-based learning events. However, we were aware that an illustrative selection of such extracts could only provide limited support for a general claim that changes in the talk of the experimental children as a whole could be related to better learning outcomes. We

therefore also used a standard computer-based task designed to elicit talk, software called Kate's Choice, and we video-recorded experimental groups of children (mixed-gender, mixed ability groups chosen by teachers as representative of the spread of ability in the class) in each of the experimental and the control groups at the beginning and again at the end of the project. We then used concordance software (of the kind described earlier in this paper) to explore changes in the way that the children used language. First we looked at how key words, related either to the curriculum knowledge or to the processes of reasoning, were used. Using a concordancer made it easy to explore changes in the extent and ways in which these key words were being used. For example, we could quickly identify all uses of words like 'test' and 'force' and 'strong' and then use the linguistic context in which they occurred as an indicator of the relevant understanding by the children of these terms. The concordancer also made it easy to make quantitative comparisons of the relative incidence of key words.

*Table 1. Relative incidence of key words while doing Kate's Choice*

| Key word | Pre-intervention talk in focal group in target classes | Post-intervention talk in focal groups target classes |
|---|---|---|
| Because | 13 | 50 |
| I think | 35 | 120 |
| Would | 18 | 39 |
| Could | 1 | 6 |
| Totals | 65 | 215 |

Table 1 shows a change in the number of these key terms that were used to advance and rebut reasons. No similar change was found in the control classes. We could therefore claim that this change was an effect of our intervention.

By combining our qualitative and quantitative analyses, we were also able to show that longer utterances tended to be associated with children providing more explanations and justifications for their views. From a comparison of the two transcript extracts above it is easy to see why. Reasoning requires the linking of clauses to justify or modify claims. (Note for example this utterance by Ross: "Because when it was in the overhead projector you could see a little bit of it, but not all of it, so I thought it would be like, five to block out the light.")

Our methods also enabled us to examine the relative incidence of long utterances in the talk of the groups – we used the arbitrary criteria of utterances with over 100 characters when transcribed. This showed that there was only one long utterance in the pre-intervention talk of all the experimental groups, compared with 46 in their post-intervention talk.

To summarise, then, the integration of the different analytic methods made possible a cumulative gathering of evidence to test our hypotheses about the effects of the intervention programme. The statistical comparison of the SATs performances of the experimental and control children (as outcome measures of the intervention effects) supported the hypothesis that the intervention had made a positive impact on children's study of science and maths. But those results alone did not directly support or refute our hypothetical explanations about why those changes had occurred. The qualitative analysis of selected group interactions appeared to show that Exploratory Talk, in the context of our specially designed ICT tasks, led to more reasoned involvement by children in the computer-based activities, and so did provide some support for our explanatory account. The computer-based analysis of transcripts was able to link these two kinds of data by showing that the relative incidence of certain features of talk across the transcription data as a whole could be directly related, through the qualitative analysis, to learning outcomes. It therefore became more justifiable to argue that an intervention programme which focused on improving the quality of talk around ICT activities was responsible for statistically significant improvements in children's performances on a test of subject knowledge.

## CONCLUSIONS

Understanding collaborative activity and the creation of shared knowledge and understanding brings with it many challenges for researchers. For example, as learners establish a shared history and develop common knowledge, the need to be verbally explicit about their work declines. For collaborating participants, this is undoubtedly an asset. For researchers of interaction, however, the development of shared, covert knowledge is problematic. This issue of the 'contextualized' nature of talk and interaction has figured strongly in debates about methods for analysing interaction in educational settings. As we have tried to explain, researchers studying computer-based collaborative activity need be aware of this and other issues related to understanding the nature of talk and collaborative activity when making methodological choices. They can take advantage of the considerable amount of work, over some decades, that researchers of several disciplines have put into the development of methods for analysing interaction. There is no virtue in re-inventing wheels, or in ignoring the methodological problems with which others have grappled.

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