Chapter 3
A Reader's Guide to the Productive Multivocality Project

Daniel D. Suthers, Carolyn Penstein Rosé, Kristine Lund, and Chris Teplovs

This chapter serves as a guide to a book reporting on a 5-year collaboration among researchers exploring the basis for productive dialogue between multiple theoretical and methodological traditions in the analysis of group interaction. Following a description of the overall format of the book, several reading strategies are described, and the chapters are outlined with annotations to help the reader implement these strategies.

Organization

The seven sections of this book include the present introductory section, five sections focused on case studies in which multiple analysts analyze the same data, and a final section summarizing lessons learned and implications. The case study

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sections each has the same internal structure. They each begins with a chapter written by the persons providing the data that describes the setting in which the data was gathered and the nature of the data. Several chapters providing alternative analyses of the data follow this data description chapter. Some of these analyses were iterated after being influenced by other analyses in the sections, resulting in some cross talk between analysis chapters, but the bulk of the discussion of productive multivocality issues is in the final chapter of each section, the discussant chapter. Depending on what was most salient for the given case study, the discussant chapters identify challenges that came up in achieving productive multivocality and how they were addressed, compare the results obtained, and summarize theoretical and methodological issues that were exposed.

Reading Strategies

Any reading of this book should begin with Chap. 1, to understand the key motivations and insights of the project. Then various reading strategies are envisioned, according to the reader's goals. Of course, one strategy is to simply read the entire book in sequence, and with this in mind the book is organized to provide a comprehensive survey of diverse analytic approaches as applied to equally diverse interactional settings, age levels, and topics in five case studies, culminating in what we learned from the entire enterprise. Each of the five case study sections ends with a discussion of issues in and strategies for achieving productive multivocality that are illustrated by the section. The final section of the book aggregates and abstracts these issues and lessons from the case studies. If for whatever reason the reader cannot or need not read the entire book, then one of the following strategies may apply according to the reader's goal.

Reading Goal: Understanding Productive Multivocality

Chapter 31 (Suthers, Lund, Rosé, & Teplovs, this volume) was written to stand alone as a summary of the productive multivocality project and its lessons and implications. It can be used, for example, as an executive summary for those who can read only one chapter or as an introductory reading in a graduate seminar. Readers who wish to go into more depth concerning what we have learned about productive multivocality and implications for a research field might skim the final discussion chapter of each of the five case study sections (Chaps. 8, 13, 19, 24, and 30) to first encounter the issues and lessons in context and then concentrate on the final section of the book where we discuss various aspects of productive multivocality that could apply to other fields of inquiry. References to the case studies in the case study discussions and final reflection chapters might inform such readers where to dive into the case studies for informative examples.

Reading Goal: Figuring Out How to Approach One's Own Data

Some readers may be faced with a dataset similar to one of ours and want to learn about different analytic approaches and what they have to offer, possibly with the intention of using multiple methods. Such a reader may begin with the guide to chapters that follows below to identify the case study that is closest to their interests according to their interactional setting, grade/age level, and topic, and then read the corresponding section in detail. Chapter 31 and the Methods for Multivocality chapter (Rosé & Lund, Chap. 32, this volume) also provide some practical pointers for thinking about how to approach the task.

Reading Goal: Learning About the Range of Analytic Approaches Available

Other readers may also be interested in learning about analytic approaches but not with any particular data in mind. Students and researchers who have been trained in one tradition may want to broaden their perspective, or early career readers may want to explore alternative traditions to pursue. The book can also support a graduate methods course through this strategy. These readers should begin with the description of dimensions along which analytic methods may be described in Chap. 2 (Lund & Suthers, this volume) and then use the guide to chapters that follows to either identify case studies that bring together the methods they want to explore or to construct their own reading trajectory that follows particular methods of interest (e.g., ethnomethodological, network analysis, statistical discourse analysis (SDA)) threaded through the case studies. Chapter 32 compares the experience of the expert analysts whose work is represented in this book with the experiences of graduate students just learning about multivocal analysis and therefore may provide some useful guidance for newcomers.

Reading Goal: Identifying Results for Research and Practice in Application Areas

Since this book includes various specific studies by reputable researchers, each with their own results and insights, this book can also serve as a resource for researchers or practitioners who are not interested in methodological issues but rather are most interested in research questions or issues of practice in one or more of the particular settings we studied. For example, a researcher may be interested in software agents in an intelligent tutoring system context, or a mathematics educator may want to examine a case study of how conceptual issues in mathematics may be

addressed with group exercises using simple tools such as paper and a blackboard. Again, such a reader can use the remainder of this chapter to identify the case study that is closest to their interests according to their interactional setting, grade/age level, and topic.

Data Section 1: Pivotal Moments in Origami Fractions

Section Editor: Kristine Lund CNRS

In this section, learning fractions in a 6th-grade Japanese classroom provide the focus for three analytical approaches, each identifying "pivotal moments" within the interaction. The data consists of an English-subtitled video in Japanese of six students folding origami paper and of one teacher monitoring their progress on the blackboard and an accompanying transcription of their talk and gestures. One analyst (Shirouzu, Chap. 5, this volume) sought to identify where the personal foci of learners originate; what happens in the interaction once a learner focuses on, for example, shapes or production methods; and how learner outcomes are related to such foci. Another analyst (Trausan-Matu, Chap. 6, this volume) identified the semantic content of "voices" and their interanimation patterns in a polyphony framework. A third analyst (Chiu, Chap. 7, this volume-a) applied SDA to the dataset in order to see whether recent sequences of utterances affected the likelihood of creating utterances categorized as new ideas, correct ideas, micro-creativity, or justifications. As a consequence of our multivocal approach, all three analysts revisited their methods and modified them in light of discussion with the others. An analysis of the methodological dimensions (cf. Lund & Suthers, Chap. 2) across the three researchers is presented, and lessons learned are summarized in the discussant chapter (Lund, Chap. 8, this volume).

Chapter 4 (Data): Learning Fractions Through Folding in an Elementary Face-to-Face Classroom

Hajime Shirouzu

Shirouzu introduces the fractions dataset in Chap. 4, entitled "Learning Fractions Through Folding in an Elementary Face-to-Face Classroom," a dataset he collected while visiting and teaching students twice in a remote area in Japan. In his chapter, he clarifies the rationale behind his data selection, the design principles of the class he taught, and the learning task he presented to the students as well as its objectives.

Chapter 5 (Analysis): Focus-Based Constructive Interaction

Hajime Shirouzu

If we can analyze the diversity of both the paths learners take and the goals that they reach in a collaborative situation, we will be able to utilize such diversity for further enriching learning. This chapter proposes the model of "focus-based constructive interaction," which hypothesizes that the intramental interaction of each individual creates a personal focus affecting how he verbalizes and acts in collaborative moments and that the verbalization leads to his learning outcome. By applying this model to the origami fraction data, the chapter demonstrates that, even in a shared situation involving the six children, each child deepened his or her own understanding by asking his or her own questions and searching the external world for answers along his or her own focus, which remained relevant for several months. It also shows that the difference in foci produced different interpretations and promoted social interactions among them. The analytic devices of focus and role were discussed and contrasted with individual attributes for explaining individuals' diverse progressions through social interaction.

Chapter 6 (Analysis): Collaborative and Differential Utterances, Pivotal Moments, and Polyphony

Stefan Trausan-Matu

This chapter presents a multivocal analysis method of collaborative learning and its application on the origami fractions dataset, considering several dimensions: spoken dialogue, body language, the visual dimension, internal dialogue (at an intramental level), and echoes. The analysis is performed starting from the polyphonic model, which was previously used for instant messenger conversations and discussion forums and was extended for the face-to-face (F2F) classroom interactions in this dataset. The analysis includes the identification of the voices, in an extended sense, interanimation patterns among them, collaborative and differential utterances, changes in the rhythm (chronotopes), and pivotal moments of the interactions.

Chapter 7 (Analysis): Social Metacognition, Micro-Creativity, and Justifications: Statistical Discourse Analysis of a Mathematics Classroom Conversation

Ming Ming Chiu

This analysis shows how SDA can identify the locations and consequences of pivotal moments and how characteristics of recent turns of talk such as questions and evaluations (social metacognition) are linked to characteristics of subsequent

turns of talk, such as correct ideas, new ideas, or justifications. Along with the other studies in this unit, this analysis shows how multivocality can suggest cycles of analyses and help develop further statistical methods.

Chapter 8 (Discussion): A Multivocal Analysis of Pivotal Moments for Learning Fractions in a 6th-Grade Classroom in Japan

Kristine Lund

This chapter compares the pivotal moments each analyst described using the five methodological dimensions discussed in Chap. 2 (Lund & Suthers, this volume): theoretical assumptions, purpose of analysis, unit of analysis/unit of interaction, data representations, and manipulation of data representations. Conclusions are drawn on how redefining the unit of analysis and the unit of interaction in light of other researchers' analyses, interpreting other researchers' pivotal moments in one's own framework, and comparing the semantics of and the relations between analytical concepts all contribute to helping an analyst surpass the limits of a particular method.

Data Section 2: Peer-Led Team Learning for Chemistry

Section Editor: Carolyn P. Rosé

In this section, we use a multivocal leadership construct as a lens for viewing and comparing the dynamics of two different peer-led teams as they solve a chemistry problem related to de Broglie's equation. Four different analysts offer their interpretation of the data, resulting in three analysis chapters: one providing an ethnographic analysis (Sawyer, Frey, & Brown, Chap. 10, this volume); another comparing and contrasting two multidimensional coding and counting approaches, each including a cognitive, relational, and motivational dimension (Howley, Mayfield, Rosé, & Strijbos, Chap. 11, this volume); and finally, a content-focused network analysis chapter (Oshima, Matsuzawa, Oshima, & Niihara, Chap. 12, this volume). Chapter 13 (Carolyn P. Rosé, this volume) discusses how the juxtaposition of the three distinct lenses reveals new insights into the intricate nature of complex constructs like leadership that argue strongly that a multivocal analysis is more than the sum of its parts.

Chapter 9 (Data): Peer-Led Team Learning in General Chemistry

Keith Sawyer, Regina Frey, and Patrick Brown

Peer-led team learning (PLTL) is a collaborative learning technique that has been used on many college campuses, particularly in large lecture classes in departments of chemistry. Several studies have shown that PLTL results in improved learning.

However, researchers have not investigated the discourse practices used by peer leaders and students, and among students themselves, that give rise to this enhanced understanding of chemistry content. To better understand the interactional mechanisms that make PLTL effective, three PLTL sessions for each of 15 veteran peer leaders were videotaped over the course of one semester. The dataset presented here contains transcripts of two PLTL groups as they solved the same problem.

Chapter 10 (Analysis): Knowledge Building Discourse in Peer-Led Team Learning Groups in First-Year General Chemistry

Keith Sawyer, Regina Frey, and Patrick Brown

To better understand the interactional mechanisms that make PLTL effective, we closely examined videotapes of two PLTL groups as they both solved the same chemistry problem. In one group, students engaged in group knowledge building: intellectual conversations where they asked each other questions, provided procedural and conceptual explanations, and closely monitored each others' understanding of the problem. This led to an increasingly accurate understanding of the problem. In the contrasting group, their conversations focused on rote application of formulas as they worked to calculate a "correct" solution. Our analyses help us to understand what effective collaborative discourse looks like and have practical implications for how peer leaders are trained and how peer groups are organized.

Chapter 11 (Analysis): A Multivocal Process Analysis of Social Positioning in Study Groups

Iris K. Howley, Elijah Mayfield, Carolyn P. Rosé, and Jan-Willem Strijbos

This chapter compares two multidimensional analyses of the PLTL chemistry dataset, which each includes a cognitive, relational, and motivational dimension. These multidimensional analyses serve to highlight the ways in which the complementary perspectives on collaborative processes offered by each dimension can be integrated in a way that offers deep insights into social positioning within collaborative groups. Differences revealed particularly along the relational and motivational dimensions raise important questions regarding the operationalization of interaction style as displayed through language and highlight the value of multivocality for the purpose of refining important constructs in ways that work towards theory building through integration of findings across research groups that employ different analytic frameworks coming from a common theoretical foundation.

Chapter 12 (Analysis): Application of Network Analysis to Collaborative Problem Solving Discourse: An Attempt to Capture Dynamics of Collective Knowledge Advancement

Jun Oshima, Yoshiaki Matsuzawa, Ritsuko Oshima, and Yusuke Niihara

This chapter presents an analysis of collaborative knowledge building in the PLTL corpus using a social network analysis approach. The goal is to present an analysis of collective knowledge advancement that goes beyond what has been accomplished using existing methods and offers a unique bird's eye view of how knowledge advancement proceeds over time.

Chapter 13 (Discussion): A Multivocal Analysis of the Emergence of Leadership in Chemistry Study Groups

Carolyn P. Rosé

This chapter reflects on the three analysis chapters describing the PLTL chemistry dataset in two different stages. The first stage focuses on the concept of leadership and contrasts the three quantitative analyses presented by Oshima, Rosé, and Strijbos at the workshop on Multivocality at ICLS 2010. Based on these reflections, a multi-faceted image of ideal leadership emerges that would not be visible in any single one of the frameworks investigated. This chapter integrates the perspectives discussed within these three chapters, illustrating how this multivocal separation between different leadership constructs allows us to view how it is possible to present one's views as standing on their own without denying others the right to have their own voice. Following up on this integration, a second wave of reflection focuses on the subsequent, more detailed written analyses, including a new qualitative analysis by Sawyer and colleagues, that enables a more in-depth comparison across analytic approaches at both the individual level and the group level. Questions are raised related to assessment of collaborative problem solving that must be addressed in future work.

Data Section 3: Multimodality in Learning About Electricity with Diagrammatic and Manipulative Resources

Section Editor: Daniel D. Suthers

The data for this section is from an innovative primary school science classroom in Singapore (Chen & Looi, Chap. 14, this volume). Group Scribbles collaborative sketching software (Brecht et al., 2006) is used in conjunction with physical

manipulatives (batteries, light bulbs, and wires) in an exercise to understand how basic electric circuits work. The corpus was analyzed by Looi, Song, Wen, and Chen (Chap. 15, this volume) using uptake and content analysis guided by a theory of progressive inquiry; Medina (Chap. 16) using uptake analysis with an ethnomethodological orientation towards unpacking group accomplishments; Lund and Bécu-Robinault (Chap. 17) focusing on coherence and conceptual change in translations between media and modes motivated by a theory of semiotic bundles; and Jeong (Chap. 18) using content analysis under her conception of "group understanding." The discussion chapter by Suthers (Chap. 19, this volume) identifies two major themes across the analyses: what evidences understanding and practices of multimodal interaction across various media. Suthers describes a related Group Scribbles case study that preceded the present one, discusses pragmatic issues concerning transcript sharing, and then compares the analyses in various ways summarized in his abstract below.

Chapter 14 (Data): Group Scribbles-Supported Collaborative Learning in Primary Grade 5 Science Class

Wenli Chen and Chee Kit Looi

This chapter describes the setting and context of a group of primary grade 5 (about age 11) students doing a collaborative learning activity in a science class. Data from this setting are analyzed in subsequent chapters in this book section. Students, in groups of four, used a networked technology called Group Scribbles (GS) to jointly complete a learning task—how to connect a circuit with batteries, wire, and a light bulb so that the bulb would light up. They shared information, negotiated meaning, and constructed knowledge through both GS interaction and F2F discussion. The lesson designers attempted to optimize the use of GS and F2F interaction in real classrooms to support students' collaborative learning, with the aim of harnessing the specific features of each medium.

Chapter 15 (Analysis): Identifying Pivotal Contributions for Group Progressive Inquiry in a Multimodal Interaction Environment

Chee Kit Looi, Yanjie Song, Yun Wen, and Wenli Chen

This chapter adopts an interaction analysis method using the notion of uptake to investigate the development of progressive inquiry learning in a classroom setting using GS. In progressive inquiry learning, students work together on elaborating a shared object such as a research problem, products in a shared digital space like GS,

or experimental practices to be reflected on and transformed. An uptake analytical framework is applied to code different facets of interactions in a small group, comprising verbal interactions (utterances and gestures), artifacts created in GS, and hands-on experimental practices into events as coordination acts and to identify uptakes and pivotal contributions (a contribution that plays the role of shifting the direction of the subsequent events seamlessly or abruptly) from such interactions. The analysis illuminates how the pivotal contributions influenced the direction of the group progressive inquiry and led the group to developing progressive understanding of the science concepts.

Chapter 16 (Analysis): Cascading Inscriptions and Practices: Diagramming and Experimentation in the Group Scribbles Classroom

Richard Medina

The analysis discussed in this chapter draws attention to the interactional and inscriptional practices observed in Group Scribbles science classroom. The critical finding is the identification of a pivotal sequence of interaction occurring in the later half of the activity in which one member of the group proposes an innovation for illuminating two light bulbs in a single circuit. The proposal and its subsequent endorsement by the other members are contingent on an immediately prior interaction in which the group appropriates another group's circuit diagram. Together, this pair of adjacent sequential structures exposes multiple instances of uptake between participants. These uptake relations are realized through an ensemble of contingencies consisting of persistent diagrams, tabletop materials, and a locally situated interactional practice.

Chapter 17 (Analysis): Sustainable Coherency of Concepts Across Modes of Interaction

Kristine Lund and Karine Bécu-Robinault

Our analyses illustrate nine instances of what we call multimodal and multimedial reformulations of content beginning either with drawings of physics experiments and going to the manipulation of the physics experiments themselves or beginning with the experiments and going to the drawings. We postulated that each time one of these reformulations occurred, it was a potential (yet rare) pivotal moment for conceptual change because content was being transformed across modes and media. Within the nine instances of reformulation, we found two types of pivotal moments (three instances in all). The first type was changing one's conception from an intuitive

everyday view on physics to a canonical view of physics. The second was maintaining a canonical view of physics while also integrating more complexity in terms of experiments constructed, drawings made, or concepts talked about. In addition, the notion of the semantic bundle enabled us to show how the ongoing interaction supplied building blocks that illustrated either sustained conceptual change coherent with canonical physics or difficulties that students faced.

Chapter 18 (Analysis): Development of Group Understanding via the Construction of Physical and Technological Artifacts

Heisawn Jeong

The analyses reported in this chapter analyzed the development of group understanding along the dimensions of domain understanding and intersubjectivity based on the artifacts that a student group constructed during learning. In terms of the domain knowledge development, the analyses identified a progression of four circuit understandings, showing that the group's understanding of electrical circuits became more sophisticated over time as the group considered additional ways to light the bulb(s). The four group understandings also differed in terms of the extent to which they were interactively constructed so that some were constructed mainly by pooling individual ideas while others were more or less co-constructed in the process of collaborative artifact construction.

Chapter 19 (Discussion): Agency and Modalities in Multimediated Interaction

Daniel D. Suthers

As reported in previous chapters, four teams each analyzed traces of a group of students in a Singapore primary school science classroom, interacting F2F and with the aid of a shared whiteboard (Group Scribbles) while manipulating electrical circuits. The four analyses, undertaken from various theoretical and methodological traditions, identified pivotal events that changed the direction of the group's activity, gave accounts of how activity in multiple modes was coordinated simultaneously to enact innovations, examined how translations between different media evidenced changes in conceptual understanding, and characterized the group's understanding through the artifacts they produced. The present chapter summarizes the origins of this work in a prior analysis of Group Scribbles, discusses challenges encountered in producing shared transcripts or otherwise bringing our analytic artifacts into alignment for purposes of comparison, discusses analytic conflicts that led to synthetic agreement in one case and agreement to disagree in another, and characterizes

how the analytic approaches expose different theoretical conceptions of the distribution of agency across individuals and of activity across modalities. The chapter concludes with advice for future efforts at productive multivocality.

Data Section 4: Knowledge Building Through Asynchronous Online Discourse

Section Editor: Chris Teplovs

In this section we investigate data from an online graduate level course in education that used Knowledge Forum (Scardamalia, 2004) as its principal communication medium. Three analyses seek to identify and explore "pivotal moments" in the context of a broader analysis of the dynamics of group processes that support knowledge building and investigate the potential of automated analyses for use by learners, teachers, and researchers. The chapters highlight different approaches to analysis of asynchronous discourse data. Teplovs and Fujita (Chap. 21, this volume) analyze social and semantic networks derived from the discussions; Chiu (Chap. 23, this volume-b) applies SDA to analyze how prior messages influence a given message; and Law and Wong (Chap. 22, this volume) explore simple visualizations of student activity that may be usable by teachers managing knowledge-building classrooms. The section closes with a critical reflection on some of the advantages and problems of multivocal analyses and presents a model of iterative design-based research (DBR) that capitalizes on some of the unique affordances of multivocality (Fujita, Chap. 24, this volume).

Chapter 20 (Data): Online Graduate Education Course Using Knowledge Forum

Nobuko Fujita

Progressive discourse is a kind of collaborative discourse for inquiry in which participants share, question, and revise their ideas to deepen understanding and build knowledge. Although progressive discourse is central to knowledge building pedagogy, it is not known whether it is possible to detect its emergence in the participation patterns in asynchronous conferencing environments or what kinds of instructional interventions are most effective to support its development. To characterize episodes of discourse in which participants honor the commitments for progressive discourse and to refine designs of peer and software-based scaffolding, the data used in this section was collected in the context of a study that examined student interactions on the asynchronous online discussion platform, Knowledge Forum®, in an online graduate educational technology course.

Chapter 21 (Analysis): Sociodynamic Latent Semantic Learner Models

Chris Teplovs and Nobuko Fujita

In this chapter we present a framework for learner modelling that combines latent semantic analysis and social network analysis of online discourse. The framework is supported by newly developed software, known as the Knowledge, Interaction, and Social Student Modelling Explorer (KISSME), that employs highly interactive visualizations of interactions and semantic similarity among learners. Our goal is to develop, use, and refine KISSME to generate and test predictive models of learner interactions to optimize learning.

Chapter 22 (Analysis): Exploring Pivotal Moments in Students' Knowledge Building Progress Using Participation and Discourse Marker Indicators as Heuristic Guides

Nancy Law and On-Wing Wong

This chapter sets out to identify pivotal moments in students' knowledge building progress for an online asynchronous corpus generated by a class of master's-level students in the context of a totally online course. The main motivation for this study is to develop a methodology that can be effectively automated to aid teachers and/or researchers to quickly gain a good overview of students' progress in understanding at an overall class level from a very large, semantically rich, and complex discourse corpus. The methodology incorporates the use of participation and discourse marker indicators to provide an overview of the nature and depth of students' engagement in relation to key concepts targeted for student learning and to support the heuristic selection of a small sample of notes for use by the teacher and/or researcher for further in-depth qualitative analysis. This methodology has the potential of being developed into a teacher's pedagogical aid to more effectively facilitate students' collaborative inquiry and knowledge building. As a researcher's productivity tool in understanding students' developmental trajectory in learning through discourse, it offers a distinct possibility for developing and validating knowledge building theory on the basis of empirical discourse analysis of large sets of corpus.

Chapter 23 (Analysis): Statistical Discourse Analysis of an Online Discussion: Cognition and Social Metacognition

Ming Ming Chiu

This study revised a statistical method (SDA) designed for linear sequences of turns of talk to apply to branches of messages in asynchronous online discussions. The revised

SDA was used to test for cognitive and social metacognitive relationships among 17 students' 1,330 asynchronous messages during a 13-week online graduate educational technology course. Multivocality benefits included enhancing a statistical method to expand its scope, exposure to other analytic methods' simpler user-interfaces, and potential integration of multiple methods into a computer program capable of semiautomatic analyses.

Chapter 24 (Discussion): Critical Reflections on Multivocal Analysis and Implications for Design-Based Research

Nobuko Fujita

This chapter presents critical reflections on the multivocal analyses presented in the preceding chapters in this volume by Teplovs and Fujita, Law and Wong, and Chiu on the asynchronous discussion data collected in an online graduate education course using Knowledge Forum. The multivocal analyses are discussed along five dimensions: theoretical assumptions, purpose of analysis, unit of analysis/unit of interaction, data representations, and manipulations on data representations. The diverse interpretations and findings of pivotal moments are explicated in light of broader dynamic group processes that support knowledge building in online graduate course contexts. The implications of multivocal analysis for DBR are discussed.

Data Section 5: A Data-Driven Design Cycle for 9th-Grade Biology

Section Editor: Carolyn P. Rosé

The unique focus of this section is on using multivocality to enhance a data-driven design process by offering a multifaceted understanding of how interventions under development interact with group functioning. Four analysts offer their interpretation of what went right and what went wrong in a pilot evaluation of a new form of software agent-based support for scientific discovery learning in 9th-grade biology (Dyke, Howley, Kumar, & Rosé, Chap. 25, this volume). The four distinct analytic approaches include ethnographic analysis (Cress & Kimmerle, Chap. 27), ethnomethodological interaction analysis (Stahl, Chap. 28), network analysis (Goggins & Dyke, Chap. 29), and linguistic analysis from a systemic functional linguistic perspective (Howley, Kumar, Mayfield, Dyke, & Rosé, Chap. 26). Each methodological lens identifies unique opportunities to refine and improve the intervention, which illustrates how a multivocal iterative development process enables each design iteration to suggest a wider breadth of opportunities for improvement in DBR (Hmelo-Silver, Chap. 30).

Chapter 25 (Data): Towards Academically Productive Talk Supported by Conversational Agents

Gregory Dyke, Iris K. Howley, David Adamson, Rohit Kumar, and Carolyn P. Rosé

In the past 6 years, technology for dynamic support for collaborative learning has matured in terms of its ability both to monitor online interaction through automatic collaborative learning process analysis as well as to offer context-appropriate support for effective participation in groups, such as using conversational agent technology. In recent years, we have been exploring an approach called academically productive talk (APT) as scaffolding for online collaborative learning discussions. In this form of agent-based support, the computer agent poses as an APT facilitator who asks questions that call for a relatively elaborated response (e.g., both a solution and a reason for the solution) and then presses the group to build on or challenge these ideas, with the purpose of keeping student reasoning at center stage and increasing student ownership of ideas. This study reports on an iterative design process for developing the concept of APT agents for supporting online collaborative learning. This effort extended over 2 years during which we have conducted two complete cycles of design development, deployment, and analysis, with the second-year design drawing on lessons learnt from the multivocal analyses presented in the chapters within this section, which were conducted after the first-year study.

Chapter 26 (Analysis): Gaining Insights from Sociolinguistic Style Analysis for Redesign of Conversational Agent-Based Support for Collaborative Learning

Iris K. Howley, Rohit Kumar, Elijah Mayfield, Gregory Dyke, and Carolyn P. Rosé

Data from an early stage of development of conversational agent-based support for collaborative learning provides an ideal resource for demonstrating the value of sociolinguistic style analysis paired with time series visualizations as part of an iterative design process. The method illustrated in this chapter was introduced in earlier publications focusing separately on the sociolinguistic style analysis and the time series visualization using the Tatiana tool. However this chapter is unique in its application to data that is at such an early stage in a development process. The data is admittedly raw and contains many examples of interaction gone awry. Nevertheless, the value in this analysis is in a demonstration of what insights can be gained through detailed stylistic analysis of conversational behavior that informs the next steps of intervention development.

Chapter 27 (Analysis): Successful Knowledge Building Needs Group Awareness: Interaction Analysis of a 9th-Grade CSCL Biology Lesson

Ulrike Cress and Joachim Kimmerle

This chapter presents an analysis of chat protocols from four 9th-grade biology classrooms with 50 students at a public school in Pittsburgh, PA. Particular aspects of knowledge building processes in small computer-supported groups are described and explained. We provide examples from the chat protocols that hint at successful knowledge building and from which we can learn something about how the development of knowledge takes place. Moreover, we provide examples that illustrate why four types of group awareness (social, action, activity, and knowledge awareness) are crucial for collaboration, why a lack of group awareness may be detrimental to CSCL, and which strategies students will apply in order to establish group awareness and common ground. Concluding, we point to implications for future design processes of CSCL scenarios.

Chapter 28 (Analysis): Interaction Analysis of a Biology Chat

Gerry Stahl

This is an analysis of data from initial attempts to combine (a) technology from the Virtual Math Teams (VMT) Project, (b) helping agents, (c) collaborative small groups, and (d) accountable-talk prompting in order to scaffold biology student online chats about videotaped results of a biology experiment. Analysis of the response structure of the chat log of a student group reveals characteristics of their interactions in terms of building collaborative knowledge. In particular, the mediation by the VMT technology, helping agents, and accountable-talk training is analyzed to determine their influences in promoting productive learning-oriented interaction. A DBR analytic perspective provides suggestions for redesign of the socio-technical approach based on the findings from the interaction analysis. Redesign in response to the analysis results in clear improvement, as seen in analysis of the response structure of a chat log from a second test cycle.

Chapter 29 (Analysis): Network Analytic Techniques for Online Chat

Sean P. Goggins and Gregory Dyke

Multivocal analysis applies two or more research methods to the same dataset and then applies reflexivity in a joint analysis to achieve greater insights than would be possible with a single method. In this pilot study, we demonstrate how

the application of specific methods is influenced by the ordering of the methods and present a guideline for future multivocal analysis of online chat data using network analytic techniques. We do this in two phases. First, we use Stahl's ethnomethodological analysis of one session of biology chat discourse to inform decisions about how to identify and weight implicit connections between participants. Implicit connections are useful because they can be easily automated and presented in real time. We then contrast Stahl's analysis with the networks we derive from those implicit connections, showing some similarities. Second, we use Tatiana to construct ethnomethodologically informed networks for the full corpora and perform network analysis on the resulting explicit connections. The results are not aligned with our first-phase analysis of network position and roles for members. Further inquiry illustrates that the session chosen for ethnomethodological analysis by Stahl has different characteristics than the other six sessions, drawing our use of that analysis for building implicit connections in the corpora into question. We conclude with a clear vision for applying the group informatics methodological approach to corpora prior to the performance of time-consuming qualitative methods like ethnomethodologically informed analysis. Weaving methods together in the right order, we argue, will lead to more rapid and deeper insight.

Chapter 30 (Discussion): Multivocality as a Tool for Design-Based Research

Cindy E. Hmelo-Silver

This chapter provides an integrated perspective of the discussions and analyses related to the DBR process enacted in a multivocal way in this 9th-Grade Biology section of the book. The focus of the work is iterative development of what are referred to as accountable-talk agents to support collaborative learning in an urban high school science laboratory. This discussant chapter provides an interpretation of the multivocal process, how it sometimes worked and sometimes didn't, and what lessons were learned along the way. This early stage in a DBR program is timely for understanding how a complex socio-technical intervention affected collaboration.

Reflections

The final section steps back from the specific data corpora and their attendant issues to return to the question of when and how productive multivocality can be achieved. Chapter 31 (Suthers et al., this volume) summarizes the entire project and the major lessons learned, and can be used as a self-contained reading. Chapter 32 (Carolyn

Penstein Rosé & Lund, this volume) uses a conceptual model of how multivocality relates to methodological traditions to consider pathways for approaching multivocality and possible pitfalls. They compare our experience in this project with the experience of a class of graduate students in their attempt at productive multivocality. Chapter 33 (Dyke, Lund, Suthers, & Teplovs, this volume) examines how data and analytic representations are used and given meaning in analysis, with examples derived from the case studies of this volume, and discusses the implications of representational affordances for multivocality. It concludes with strategies for effective use of representations in support of productive multivocality. Chapter 34 (Lund, Rosé, Suthers, & Baker, this volume) examines what happened when different epistemologies encountered each other in the case studies and discusses what could or should have happened (e.g., when the epistemologies did not engage with each other, or the engagement was not productive). The chapter shows how epistemological encounters can help to bridge between isolated traditions that work on similar objects of study. Chapter 35 (Law & Laferriere, this volume) takes a critical look at which aspects of this project may have meaningful implications for educational practitioners such as teachers. While some of our work may only be of interest to researchers, the authors find types of relevance to practice: informing immediate pedagogical decision-making and providing more general insight and understanding to the processes and outcomes of learning and knowledge building in collaborative contexts. Finally, in Chap. 36 (Koschmann & O'Malley, this volume), two prominent researchers from different methodological traditions who were not involved in the project discuss the implications of this research collaboration and the relation of multivocality to other literatures. Their chapter takes the form of a dialogue, constituting their own productive multivocality.

Chapter 31: Achieving Productive Multivocality in the Analysis of Group Interactions

Daniel D. Suthers, Kristine Lund, Carolyn P. Rosé, and Chris Teplovs

This chapter reports on the productive multivocality project, a 5-year collaboration among researchers exploring the basis for productive dialogue between multiple analytic traditions in the analysis of group interaction, focusing on educational settings. The project was motivated by the need to bring cohesion to multidisciplinary fields such as the learning sciences in a manner that respects and leverages their diversity. Five data corpora were each analyzed by several analyst teams representing various theoretical and methodological traditions, and we explored strategies for engaging these teams in productive dialogue. This chapter offers a self-contained summary of the project and its major insights and lessons and can serve as a starting point for further reading. After briefly reviewing the motivations and history of the project, we then summarize the five data corpora, the analyses done on them, and

the challenges for productive multivocality that we encountered and what we learned from these case studies. The chapter concludes with a discussion of strategies for productive multivocality.

Chapter 32: Methodological Pathways for Avoiding Pitfalls in Multivocality

Carolyn Penstein Rosé and Kristine Lund

This chapter explores multivocality from a methodological perspective. A conceptual model is presented for thinking about multivocality and how it relates to methodological traditions. We reflect back on what we have learned through experimentation with multivocality through the five data sections of the book and draw principles for best practices that we offer to the broader research community. As a running theme throughout the chapter and as an invitation to disseminate multivocality to the next generation of researchers in our field, we contrast the experience of expert analysts whose work is presented in the preceding data sections with the experience of students working in groups on their first discourse analysis project in the context of a computational models of discourse analysis (CMDA) class.

Chapter 33: Analytic Representations and Affordances for Productive Multivocality

Gregory Dyke, Kristine Lund, Daniel D. Suthers, and Chris Teplovs

This chapter describes and reflects upon the analytic representations used in the analyses presented in this book and the roles they played in multivocal analysis. As shown in other chapters, multivocality across analyses based on shared datasets can be productive in a variety of ways and for a variety of reasons. From a pragmatic perspective this productivity is also dependent on the ability of analysts to share datasets, perform analyses, inscribe new analytic knowledge into representations, and use these representations as a basis for discussion. In this chapter, we examine how representations are used and given meaning in analysis. We catalogue the types of entities and attributes inscribed in representations, the notational systems by which they are encoded, and the kinds of moves that result in the creation of new representations. We then discuss the opportunities for multivocality afforded by the representations present in the different data sections and discuss the properties desirable in a framework for coordinating analytic representations. We describe instances of representation-based productive multivocality found in this volume, presenting nine strategies for researchers seeking to engage in productive multivocality. This chapter will be of interest to tool designers but also provides guidance to researchers in reflectively choosing representations (and their affordances for interpretation and manipulation) so as to maximize their ability to engage in productive multivocality.

Chapter 34: Epistemological Encounters in Multivocal Settings

Kristine Lund, Carolyn Rosé, Daniel D. Suthers, and Michael Baker

Researchers usually work and evolve in the scientific frameworks in which they were trained, without questioning their epistemological foundations. However, this may be required when researchers coming from different disciplines and paradigms try to work together on the same object of study. This chapter reflects on epistemological encounters in a 5-year project of multidisciplinary collaborations in the analysis of interaction. We argue for maintaining diversity of epistemological traditions while either achieving complementarity within explanatory frameworks on different levels or maintaining productive tension. We then present the extent to which researchers in our project and a similar project encountered each other's epistemologies when they compared their analyses of shared corpora. The majority of comparisons in various contexts led to engagement between epistemologies, and some of these epistemological encounters were productive and glitch free, others had difficulties, but still led to productivity, while still others led to missed opportunities and in one case to radicalizing incommensurable stances. A minority of comparisons in other contexts did not lead to engagement but could either still be fruitful or not productive at all. In conclusion, we summarize the consequences of engaging with epistemologies through the comparisons researchers make of their analyses in multivocal contexts, showing how epistemological encounters can help to bridge between isolated traditions that work on similar objects of study.

Chapter 35: Implications for Practice

Nancy Law and Therese Laferriere

While the focus of this book is generally to explore whether multivocal analysis of the same dataset can lead to productive interactions among researchers and possible theoretical and/or methodological developments that this may bring about, this chapter explores whether such multivocality would have meaningful implications for practice. Our analysis demonstrates that irrespective of the analysts' theoretical or methodological constructs, whether the work has pedagogical relevance depends largely on the purpose and focus of the analysis. A meaningful analysis from the practice perspective can be made by researchers who do not themselves generate the data and using analytical methods that are grounded on theoretical frameworks different from the ones underpinning the pedagogical practice contexts from which the data were collected. Pivotal moments that are directly linked to the subject matter domain being studied are likely to be easily appreciated by teachers as relevant to their practice. However, not all pivotal moments have direct relevance to pedagogical practice. Further, this preliminary study provides substantial evidence that the

multivocality in interaction analysis can be productive in providing valuable insight and pedagogical support to teachers interested in implementing collaborative learning in their everyday practice. Overall, we find that multivocal interaction analysis can contribute to two types of relevance to practice: those that can inform more immediate pedagogical decision-making and those that provide more general insight and understanding to the processes and outcomes of learning and knowledge building in collaborative contexts.

Chapter 36: A Dialog on "Productive Multivocality"

Timothy Koschmann and Claire O'Malley

This chapter presents a reflection on the whole productive multivocality project in the form of a dialogue between two researchers in the CSCL field who come from different analytic perspectives. The reflections include comparisons of the project with other attempts to bring to bear different analytic methods on common data as well as other attempts to aggregate findings over multiple datasets. The chapter also reflects upon the successes and challenges of the productive multivocality project as measured against the five overarching questions that they set themselves at the outset of the project.

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