Barriers and Biases in Computer-Mediated Knowledge Communication

COMPUTER-SUPPORTED COLLABORATIVE LEARNING

VOLUME 5

Series Editor:

Pierre Dillenbourg, *Swiss Federal Institute of Technology, Lausanne,* Switzerland

Editorial Board:

Michael Baker, *CNRS & Université Lumière Lyon,* France
Carl Bereiter, *Ontario Institute for Studies in Education,* Canada
Yrjö Engeström, *University of Helsinki,* Finland
Gerhard Fischer, *University of Colorado,* U.S.A.
H. Ulrich Hoppe, *University of Duisburg-Essen,* Germany
Timothy Koschmann, *Southern Illinois University,* U.S.A.
Naomi Miyake, *Chukyo University,* Japan
Claire O'Malley, *University of Nottingham,* U.K.
Roy Pea, *SRI International,* U.S.A.
Clotilde Pontecorovo, *University 'La Sapienza',* Italy
Jeremy Roschelle, *SRI International,* U.S.A.
Daniel Suthers, *University of Hawaii,* U.S.A.

The *Computer-Supported Collaborative Learning Book Series* is for people working in the CSCL field. The scope of the series extends to 'collaborative learning' in its broadest sense; the term is used for situations ranging from two individuals performing a task together, during a short period of time, to groups of 200 students following the same course and interacting via electronic mail. This variety also concerns the computational tools used in learning: elaborated graphical whiteboards support peer interaction, while more rudimentary text-based discussion forums are used for large group interaction. The series will integrate issues related to CSCL such as collaborative problem solving, collaborative learning without computers, negotiation patterns outside collaborative tasks, and many other relevant topics. It will also cover computational issues such as models, algorithms or architectures which support innovative functions relevant to CSCL systems.

The edited volumes and monographs to be published in this series offer authors who have carried out interesting research work the opportunity to integrate various pieces of their recent work into a larger framework.

The titles published in this series are listed at the end of this volume.

R. Bromme
F.W. Hesse
H. Spada
(Editors)

Barriers and Biases in Computer-Mediated Knowledge Communication

And How They May Be Overcome

Springer

Rainer Bromme, University of Münster, Germany
Friedrich W. Hesse, University of Tübingen, Germany
Hans Spada, University of Freiburg, Germany

Library of Congress Cataloging-in-Publication Data

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

ISBN 0-387-24317-8 e-ISBN 0-387-24319-4 Printed on acid-free paper.

© 2005 Springer Science+Business Media, Inc.
All rights reserved. This work may not be translated or copied in whole or in part without the written permission of the publisher (Springer Science+Business Media, Inc., 233 Spring Street, New York, NY 10013, USA), except for brief excerpts in connection with reviews or scholarly analysis. Use in connection with any form of information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now know or hereafter developed is forbidden.
The use in this publication of trade names, trademarks, service marks and similar terms, even if the are not identified as such, is not to be taken as an expression of opinion as to whether or not they are subject to proprietary rights.

Printed in the United States of America.

9 8 7 6 5 4 3 2 1 SPIN 11161530

springeronline.com

CONTENTS

RAINER BROMME, FRIEDRICH W. HESSE & HANS SPADA

BARRIERS, BIASES AND OPPORTUNITIES OF COMMUNICATION AND COOPERATION WITH COMPUTERS: INTRODUCTION AND OVERVIEW

1. WHY "COMMUNICATION AND COOPERATION WITH COMPUTERS"?

New innovative computer-mediated settings open a wide range of possibilities for cooperative learning and work across distance, domain, and level of expertise. Mechanical engineers discuss the repair of a complicated machine over a distance of thousands of miles. Medical specialists located at different hospitals advise a colleague how to treat a rare illness. Students of a distance learning institute learn cooperatively for their next examination taking advantage of computer-mediated communication. A senior citizen asks for help with a computer problem via hot-line. However, the successful use of such computer-mediated settings is not trivial. Cooperative learning and work itself requires special skills and strategies. Furthermore, the technical settings with sometimes restricted, sometimes new possibilities for communication add problems on top of the cooperation itself. As a consequence, computer mediated cooperation has moved not only into the focus of technological and organizational but also psychological and educational research. Relevant findings of this area of investigation are presented in this book. What are the barriers in computer-mediated communication for cooperative learning and work? Which are the most relevant biases in computer-mediated information processing? How is it possible to overcome these barriers and biases to fully gain advantage from the new opportunities?

2. WHY "BARRIERS"?

The term "barrier" comes from psychological research on problem solving and creativity. There it refers to the gap between an initial and an end state. In other words, barriers are challenges which have to be overcome in order to attain a goal. They could not have been avoided from the outset but are "natural" difficulties which – in the case of communication and cooperation with computers – can be traced back to features of the software and hardware used, and to the characteristics of the users and settings. Therefore, barriers will be discussed in all contributions to this book with regard to ways of overcoming them. The authors share the conviction that the technical side (hardware and software) is neither the sole cause of – nor the only solution to – the problems which occur with computer-mediated communication and cooperation. Many of these barriers are rather challenges which are present in all cooperation and communication scenarios. Some of these barriers are aggravated in computer-mediated settings, some are easier to overcome.

3. WHY "BIASES"?

This books deals with computer-mediated cooperation and communication scenarios in teaching and learning situations, leisure activities (e.g. laypersons looking for expert information on the internet), and net-based communication at work. Such scenarios will become increasingly important, because in future more people will spend more time in such scenarios. The CSCL (Computer Supported Cooperative Learning) and CSCW (Computer Supported Cooperative Work) research communities also hold this view. However, the computer environment is only part of people's normal environment. People are required to switch between the strategies and skills which they need for computer-based contexts and those (mostly longer-established and more basic ones) which they have acquired for use in other contexts. Working with computers as tools for communication and cooperation they have to acquire new knowledge and develop new skills. At best, a transfer of knowledge and skills takes place from the non-technical to the technical environment. These skills are then adapted to the altered conditions of communication and cooperation required when working with the computer. However, in the process, also weaknesses and errors in non-technical information processing and communication are transferred to the computer environment. Therefore, the question arises as to how a computer environment affects weaknesses and biases of this kind.

For example: the fundamental attribution error is a well-known bias of attribution judgments (Ross & Nisbett, 1991). Observers tend to over-emphasise dispositional factors of the actor, and under-emphasise situational factors. One of the reasons for this bias is that actors and observers often have different access to information about situational circumstances of the observed behavior. But what happens if the access to information about a remote partner's behavior is confined to what is available on the computer screen? Are people more aware about situational circumstances if the judged behavior is represented on a computer? Or is the fundamental attribution error even stronger due to the remoteness of the observed actor (Cramton, 2002)?

We therefore need to analyze both empirically and theoretically in what situations CSCL and CSCW environments provoke or augment biases of human information processing and action regulation and when they reduce them. A distinction needs to be made between evocation and augmentation of biases. In the first case errors are involved which are specifically caused by the technical environment and the characteristics of remote communication. In the second, more frequently occurring case, it is a bias which is present in our behavior anyway, but which is augmented in computer environments. Conversely, there is a need to distinguish between preventive and compensatory effects of technical environments on weaknesses and biases of information processing.

4. WHY "OPPORTUNITIES"?

Computer-mediated settings for remote cooperative learning and work help to overcome many traditional barriers of distance and time. While it is a challenge to use them in an optimal way, to ignore the new opportunities would mean to miss valuable chances. It would be a misunderstanding to see computer-mediated cooperation just as being inferior to face-to face interaction, because of its restricted possibilities for non-verbal communication, transfer of emotional signs, turn taking etc. Most computer mediated settings enable joint activities by means of application sharing technologies. Documents can be viewed simultaneously and jointly edited. Objects can be manipulated in a workspace that is visible and accessible for all participants. Functioning as an external memory shared workspaces can reduce cognitive load during interaction. Some of the chapters of this book show possibilities to represent the social structure of the interaction and to use this information to promote cooperation.

5. THE CONSTRUCTION AND USE OF TECHNICAL ARTIFACTS IS BASED ON PRESUMPTIONS OF BARRIERS AND HOW TO OVERCOME THEM

Every technical artifact is based on an assumption about the problems which ought to be solved by using the artifact. Thus, artifacts are based on a presumption about one or more causes of the barriers which precisely the artifact in question is intended to overcome. In the following we will refer to these assumptions as *barrier-presumptions*. They have a factual content but also contain a theoretical attribution of causality. Hence, as the following example should illustrate, they are not merely descriptive: a ladder serves as an artifact for overcoming differences in height by providing steps. Its construction is based on a barrier-presumption which is helpful for humans though not for dogs and hardly for fluids. In other words the barrier presumption is not only based on the notion of "height" but also on a certain supposition about the causes why humans have difficulties to overcome "height". For dogs a ramp would be a better proposition, and for fluids pipes and pumps are needed. It is, however, rarely as obvious as in this example what presumptions are made to overcome a barrier. While it is generally easy to formulate such barrier-presumptions for everyday artifacts they are not so straightforward in connection with technical environments for remote cooperative learning and problem solving. It is important to reconstruct theoretically which barrier-presumptions are underlying the construction of some specific environments. We will provide a short overview of such presumptions below. Then we will describe the contributions to this book, always asking what aim is to be achieved by means of the setting examined, and which barriers are intended to be overcome.

6. THREE BASIC BARRIER-PRESUMPTIONS RELATED TO PROBLEMS OF COMMUNICATION AND COOPERATION

6.1. The individual and mutual construction of "meaning" and the exchange of information in groups

Many contributions to this book deal with the construction of "meaning" when information is exchanged via computers. This holds true for learning scenarios as well as for workplace settings. When, for example, processing and use of the information presented by the teacher or fellow-students via the computer are discussed, the cooperative establishment of "meaning" is viewed as the central challenge. This we term the *meaning barrier.* The authors of this book are in agreement that in communication information is not simply transmitted from sender to receiver but that meaning is constructed mutually. Most of their contributions follow perspective-taking models: "Perspective-taking models of language use focus on the shared context that communicators must identify or create to produce and comprehend messages" (Krauss & Fussell, 1996, p. 674). This model also contains a more specific barrier presumption, namely the assumption that without adequate common ground, communication cannot succeed (*common ground barrier*). Also inherent in the perspective-taking model is a cooperative aspect, i.e. the proposition that both the producer and the recipient of an utterance are responsible for the communication being understandable.

However, some instructional contexts entail not only mutual generation of meaning but also acquisition of a meaning which is required as learning content. The learner tries to achieve this by means of an active construction. This barrier applies to a lack of knowledge and skill on part of the individual learner, not to a lack of shared meaning between the communication partners. This we term the *epistemic barrier.* Common ground barrier and epistemic barrier can be considered as more specific variants of the meaning barrier.

A group of people working on a problem has the potential advantage that the group as a whole is more knowledgeable than each of its members. However, this is only true if all the unshared knowledge is pooled which is often not the case (Stasser & Titus, 1985). We term this the *unshared knowledge barrier.* This barrier is relevant in the case of problems which have to be solved by experts from different fields, too.

6.2. The establishment and maintenance of structure in social interactions

Computer mediated communication and cooperation is social interaction. It is emphasized in many of the following chapters that social interaction needs structure. In traditional instruction with a teacher standing in front of the class, it is the task of the teacher to establish and maintain structured social procedures (who does when what?). In computer-mediated cooperation scenarios, too, a structure is necessary: we need to determine when the members of a team work on their own, when they exchange information, etc. Such structures can be provided (e.g., by scripts), they may evolve automatically during cooperation, or they can be established by technical means, if for example the members of a learning group are asked to contribute consecutively. Therefore, the construction of such environments is based on the assumption that a missing or inadequate structure of the interaction represents a barrier, which we term the *structure barrier.*

6.3. The establishment and maintenance of motivation to cooperate and communicate

The learning and cooperation scenarios addressed in this book are mainly concerned with complex learning goals or elaborate tasks that have to be worked on without a strong emphasis on external goal setting and control. Such tasks promote motivation and interest, which are, however, also assumed to be present. Some of the contributions, therefore, also ask what effects the computer environment might have on the users' motivation. They are concerned with overcoming motivational problems, in the following referred to as the *motivation barrier.*

7. WHAT IS THE IMPACT OF THE COMPUTER ENVIRONMENT ON THE MENTIONED BARRIERS?

Meaning and shared knowledge, interaction structure and motivation are critical *whenever* groups have to cooperate in work or learning contexts, not only in computer-mediated contexts. Nevertheless, problems related to the establishment of meaning, structure and motivation take a different form in computer-mediated contexts. An additional aspect has to be considered. Computers are universal tools. They are powerful tools for the representation and transfer of information, for social distribution (many receivers can be reached who in turn can easily switch from the recipient to the producer role), and for storage and relocation of information. This universality and power of the computer must be set against the everyday experience of many users who have to invest a lot of time and energy when working with computers which do not function in the way they ought to (e.g. programs crashing, incompatible transfer protocols, confusing user interfaces). Such experiences may lead to the impression that barriers in remote communication are mainly caused by the hardware and software, or that a lot of effort is needed to operate this "universal machine" at all adequately. Furthermore, users often think that they themselves are responsible for these barriers. Human information processing is flexible enough to work – within limits – with confused user interfaces, poor transmission rates etc., i.e. to function in spite of inadequate tools. On the other hand, empirical surveys show that quite frequently good features of hardware and software which would be capable of supporting users are not utilized (Aleven, Stahl, Schworm, Fischer, & Wallace, 2003).

We will in the following, when introducing the chapters, consider in each case which barrier-presumptions underlie the development or testing of the particular computer-mediated setting for remote communication. We will then outline the assumed impact of the computer environment on the emergence of barriers as well as ways of overcoming them. In order to highlight the authors' assumptions effectively, we will examine the localization assumptions, i.e. question where (with regard to the computer environments and with regard to the users' prior knowledge, skills, biases etc.) the authors of the individual chapters localize the sources of the barriers. To sum up, the cumulative effect of the chapters taken together is (a) to provide an overview of the types of problems for which computer environments for remote cooperation have been constructed and with which the user is confronted and (b) to present and evaluate measures to solve these problems.

8. THE CHAPTERS

Weinberger, Reiserer, Ertl, Fischer, and Mandl discuss the possible impact of scripts on collaborative learning. A script is a tool made for the facilitation of collaborative knowledge construction. The authors compare two kinds of scripts, one kind being the so-called epistemic script. Here questions about the learning task guide the learner to make relevant contributions and put them on the communication platform. A second kind of script is the social cooperation script. Here the script allocates certain roles to learners, e.g. the role of a tutor. The implementation of the epistemic scripts is based on a *meaning barrier* presumption (more specifically the *epistemic barrier*). The implementation of the social cooperation script is based on an interaction *structure barrier* presumption.

How do Weinberger et al. see the impact of computer environments on the meaning and structure barrier? The starting point of their chapter is the observation that learners in CSCL scenarios are quite often overtaxed. They have to fulfill too many demands which distract them from actual work on the learning material. They have to adjust to the learning environment, which delays the system's reactions. Weinberger et al. localize some causes for barriers in the differences between face-to-face interaction and computer-mediated interaction. They argue that computer-mediated interaction generates problems due to a reduction of information which does not occur in face-to-face interaction. In addition, Weinberger et al. suggest a further localization assumption which also can be found in other chapters of this book: learners in their settings under study have little experience and practice with computer-supported cooperative learning. Such learners should be instructed clearly what their role is, when they should contribute, and how to indicate what they are referring to. These structure barriers are not only found with computer-mediated environments. Structures for social interactions have to be established anew in every (!) instruction scenario if and when new groups form. Thus the question arises whether the scripts being examined here will remain necessary when computer-mediated cooperative learning has become an everyday occurrence, like group work in the classroom.

Pfister too tests a special variant of scripts in a text-based learning environment. His technical environment is intended to be used when a group of learners discusses an external representation (a text, drawing or illustration) with the assistance of a tutor. Scripts (referred to as learning protocols) define the didactic functions of statements, i.e. every participant must classify his/her type of utterance as a question, answer etc. The software also makes it possible for participants to refer their contributions explicitly to earlier statements. Referencing new contributions to earlier information is made graphically visible. The empirical investigation examines the effect of three types of protocols which were designed to support coordination and formation of coherence: the explicit reference of contributions, their type classification, and deciding on an order in which learners have to contribute. Hence Pfister's learning protocols are seen as an appropriate measure to overcome the *structure barrier*. He links this *structure barrier* presumption with a *meaning barrier* presumption: only if participants understand how new contributions refer to the contributions made earlier common ground can be established.

How does Pfister perceive the impact of the computer environment on the meaning barrier and the structure barrier? Just as the aforementioned authors, he localizes the source of the difficulty in establishing common ground in the features which in asynchronous and text-based communication impede the rapid repair of misunderstandings. Co-presence, instantaneousness, and simultaneity are the missing elements. To this extent it is a computer-oriented localization: the specific features of the computer environment create common ground barriers. However, the reduction of communication in such settings is not only the source of problems. Pfister localizes the solution there, too. He maintains that it is the reduction in the degrees of freedom which helps to overcome the common ground and structure barriers. From this point of view the computer environment both creates and compensates for the barriers of meaning and structure.

Rummel and Spada deal with a computer mediated setting in which a complex task has to be solved cooperatively on the basis of complementary domain knowledge. The collaborating partners work in a synchronous cooperation environment and they are able to see and hear one another via an audio-video link and can use a shared text editor. Advanced students of psychology and medical students work together on a case that contains psychological as well as medical aspects. They have to contribute their complementary expertise and agree on joint problem-solving strategies. The central topic of this chapter is the acquisition of competence in interdisciplinary cooperation, the question of how one can best learn to cooperate: via observational learning (participants watch a video showing a best practice example of working on a task demanding knowledge from different domains), via a script (similar to but more detailed than the organizational script which Weinberger et al. use) or by means of trial and error (unscripted problem solving).

The authors discuss the *meaning barrier*, the *unshared knowledge barrier* as well as the *structure barrier*. The emphasis in the empirical analyses is on learning effects when confronted with problems of interaction structure: how do participants decide when to work on their own and when together? Learners in the script condition and learners in the observational learning condition receive assistance in order to overcome all three barriers. The instructions are expected to reduce the time and energy spent on coordination and consequently lower the structure barrier. Additionally, participants learn how to use their complementary levels of expertise in interdisciplinary work. The impact of the computer environment on the occurrence of such problems and coping with them is discussed in detail. Rummel and Spada emphasize that establishing common ground in interdisciplinary communication is difficult by definition. Hence they localize the source of the meaning barrier in the interdisciplinary collaboration and in its unfamiliarity for the learner (cf. Weinberger et al.). In addition, Rummel and Spada examine computer-based localizations: the video recording is not perfectly synchronous and the visual space is limited compared to what would be visible for participants in a face-to-face setting. It is also pointed out that the complexity of the task combined with the demands of computer-mediated communication cause intra- and inter-subject coordination problems and cognitive overload and consequently contributes to problems of establishing an interaction structure.

Bromme, Jucks, and Runde focus in their contribution on net-based health advice. In their scenarios medical experts reply to enquiries mainly received from laypersons. Due to the qualitatively different prior knowledge (medical expert knowledge vs. naive lay theory about medicine), communication requires exceptional efforts on the part of the expert to adapt to the level of the layperson. In this empirical study the authors also examine the influence of external representations. They ask whether the co-presence of an expert illustration possibly leads to an "illusion of evidence" on part of the experts, i.e. leads to the erroneous assumption that everything visible to everyone can also be understood by everyone.

Starting point of the project is the *common ground barrier* proposition. The authors examine whether heuristics which serve to establish common ground in face-to-face interaction still "work" when computer-mediated communication is involved. In this investigation the different prior knowledge of the communication partners (experts and laypersons) also is of great importance because it can contribute to the difficulties during the establishment of common ground. In this respect the localization assumptions are not concerned solely with the computer environment since communication between experts and laypersons is very difficult in face-to-face interactions, too. However, in this chapter it is also assumed that in text-based asynchronous communication barriers to establishing shared meaning are raised. Moreover, Bromme et al. argue that it is computer-mediated communication which makes the barriers they are examining relevant in the first place. Since computers have become widespread, and expert information has become readily available to non-experts on the internet, experts increasingly have to answer queries from laypersons they do not personally know, e.g. via hotlines. Without the internet this could hardly occur because laypersons normally would not consult doctors they are not known to as patients. We can say, therefore, that the spread of computers is, in a sense, responsible that the scenario under investigation can be found outside research settings. One could call this the "quantitative enabling effect" of technology. It is not the technical feature of a technology per se but its widespread use which makes such a barrier part of social reality though it would in principle also exist without computers.

Anderson, Mullin, McEwan, Bal, Caerletta, Grattan, and Brundell report on a series of field studies and laboratory experiments with regard to the effect of new communication technologies on cooperative work. They deal with the size of groups, access to interfaces, and the organizational status of the communication in question. In the first study three groups are compared, each of which has the task to work out a route which has been drawn in on the so called instructor's map but not on the other group members' maps. VMC (Video Mediated Communication) is compared between groups of different sizes and a face-to-face condition. The aim of the cooperation is to achieve optimal understanding. This is the case when the participants have worked out the exact "meaning" set by the instructor. This contribution is therefore concerned with *meaning* and *structure barriers*. Another field study analyzed the mediated communication between two firms, one being a supplier (of tires), the other a manufacturer of the product in question (cars). The third study compared a communication condition in which several persons on each side share communication facilities, with a situation where each person has a computer to him- or herself. The main concern is about *structure barriers* which could impede smooth turn taking. Compared with the contributions described earlier quite different localization assumptions are involved: the number of cooperation partners and their status (in terms of power and responsibility for success) in the cooperation are not cognitive but organizational causes of barriers, when establishing structure and shared meaning. Furthermore, this chapter opens up a new field of enquiry: in two studies, teams cooperating on a computer-mediated task consist, on each side of the remote connection, of groups which communicate with one another face to face. So these scenarios contain both mediated inter-group communication and non-mediated intra-group communication. Situations of this kind occur relatively often (e.g. in the classroom, when several pupils share a computer). However, there has been very little research so far in this area. It remains to be clarified in what way challenges of meaning and structure are met and overcome when mediated and face-to-face communication coincide.

Cress, Barquereo, Buder, and Hesse deal with conditions under which people are willing to put information into data banks. The scenario of their experiments is modeled on using databanks in a company. Participants are required to use data from a databank to complete their task, and put their results in the bank for other people's use. Research questions are asked relating to various payoff functions for putting data in the data bank. Therefore, the experiment is concerned with a *motivation barrier*. The authors examine for example whether the importance of the information, the amount of the reward, and the size of the group are relevant for the behavior observed. This is what is known as the "public good dilemma", a well-researched phenomenon in social psychology. Here computer mediation does not really represent a specific cause for the motivation barrier being investigated. Nevertheless, computer mediation is an indispensable precondition for the public good dilemma with data banks. Only since the spread of computer networks in the workplace has the emergence and use of such databanks become possible. On the other hand, there are also various factors (e.g. instant individual feedback) which only occur with computer systems. As with the computer hotlines for laypersons mentioned above, this could be called the quantitative enabling effect of computer technology. The problems of knowledge communication analyzed here are not limited to computer applications, but it is the computer which turns them into social reality. Furthermore, Cress et al. mention another indirect cause of the *motivation barrier*: when people use a data bank they first have to realize that a communication process is involved. This is an important point, which is also relevant for other environments. It is by no means a matter of course that computer-mediated interactions are perceived as inter-personal communication.

Kirschner and Kreijns describe in their introduction the *barriers* of *meaning*, of *structure* and of *motivation*. They suggest the term *affordances* sensu Gibson for the theoretical description of the impact of the computer environment on the barriers. They illustrate the effect of affordances by means of different technical artifacts. This contribution deals with scenarios of self-directed learning in school and university. Learners must be assisted with the development of a content structure and a social structure for the interactions. Since such cooperative forms of learning do not develop by themselves, even when not computer-mediated, here too the cause of barriers is not the technical environment but the unfamiliarity with the learning objectives. The authors call these barriers to cooperative and independent learning social and educational affordances. Kirschner and Kreijns also emphasize ergonomic aspects. The utilization of many computer environments is not a trivial task, and the interface may be more or less well suited to the various users. This is a further important computer-based localization of barriers but it is here discussed from a different point of view.

The authors introduce a group awareness widget, a tool which produces a graphic illustration of data obtained from the social interaction of the group members during their work. The goal of using this graphic representation is to overcome motivational and structure barriers. Particularly when the group has no prior history it is important that participants receive information about group processes. In this way, participants can be motivated to take part in group communication. It is hoped that the group awareness tool will compensate for missing personal proximity. Consequently Kirschner and Kreijns localize the cause of the motivation barrier in the computer environment. Due to the missing social presence of communication partners, motivation to take part is reduced, i.e. the remoteness is responsible for the barrier. The group awareness widget compensates for motivation and structure barriers by supplying adapted information which on the other hand could not be acquired (so easily) in face-to-face interactions.

Strube, Wittstruck, Thalemann, and Garg analyze communication in teams of heterogeneous expertise. Their analysis deals with the cooperation between different types of specialists producing web-page layouts. The cooperating participants with varying functions need to know how the relevant knowledge is distributed in the group. The experts involved make default assumptions, and there is in fact very little explicit communication about already existing common ground. Hence the authors assume a *meaning barrier* proposition. They localize potential communication problems in the false assumptions that partners make about the prior knowledge of the other participants. Finally, the authors outline possible kinds of technical support which might compensate for such false assumptions. Computer modeling of previous implicit assumptions about task-relevant parameters could help to correct false default assumptions. This is very much in line with the previous chapter with regard to compensating for barriers by improved awareness. However, in this case it is not the awareness of group processes, but the "objective" parameters of the joint task which is targeted by the authors when discussing tools which might improve collaborative work on web design tasks.

Fischer and Ostwald examine the utilization of computer environments for cooperative work and design problems. By "design" they mean all constructive problem solutions which are concerned with the planning of artifacts. Prototypical designers are town planners and architects but also software developers. The chapter offers a basis for the classification of barriers which occur in design work. The authors distinguish between spatial, temporal, and technical dimensions, thereby providing an interesting conceptual framework for distinguishing between different types of computer environments for net-based cooperation. The authors chiefly discuss expertise of communication partners as a precondition for constructive problem solving, but also as a potential cause of communication problems caused by the *unshared knowledge barrier* and the *common ground barrier* (cf. Rummel & Spada; Bromme, Jucks & Runde, and Strube, Wittstruck, Thalemann & Garg in their chapters). They distinguish between communities of practice (COP) and communities of interest (COI). COPs are groups of practicians with the same background of knowledge who work on the same problems. They meet at intervals and exchange relevant experiences. COIs are groups with heterogeneous expertise (laypersons and experts of different expertise domains) who have come together to solve specific problems. The authors presume there to be barriers of meaning particularly with the COIs but also deal with barriers of structure and motivation. Fischer and Ostwald see the causes of barriers in characteristics of computer environments and in heterogeneous nature of the expertise. As a solution for overcoming the barrier of meaning they suggest the concept of boundary objects. These are external representations serving as points of reference in order to enable reciprocal communication. Central to their case study are domain oriented design environments, i.e. integrated systems which support communities of practice working together on designs. Design environments make it possible to create boundary objects and contextualize information.

Dillenbourg's contribution deals with the localization of barriers in connection with the utilization of computer environments for communication and cooperation. He criticizes the assumption, widely held in the CSCL and CSCW community, that the greater the similarity of computer communication with face-to-face communication, the better computer environments can be utilized. He provides evidence that a reduction in transmitted information (in contrast to the abundance of information which can be transmitted face to face) can be very useful. He also claims that some characteristics of asynchronous and written communication offer advantages which cannot be provided by video-supported or "direct" communication. His examples refer to the *meaning*, the *structure* and the *motivation barriers*. From a research strategy point of view, he recommends investigating the enabling side of computer technology systematically. His examples are awareness tools similar to those introduced in Kirschner and Kreijns' contribution. The tools which he and his colleagues have developed allow graphic illustrations of social interaction and the linking of participants' arguments. The system supplies such illustrations continually during work in the collaboration environment and feeds them back to the participants. Such software is used to solve the problem of lack of participation and is, therefore, based on a *motivation barrier* presumption. However, the technical solution – as Dillenbourg points out quite clearly – does not answer the normative and psychological questions which have to be answered in practical terms when constructing and using such awareness tools. The question arises whether the reduction in the individual participants' privacy enhances their readiness to cooperate and if this is even desirable. Hence technology can help to make implicit normative standards explicit, e.g. with regard to balancing the contributions of the various group members. Thus Dillenbourg's chapter emphasizes the dependency of barrier solutions on those standards.

The contribution of **Koschmann, Zemel, Conlee-Stevens, Yound, Robbs, and Barnhart** also starts out from an assessment of present research activities with regard to computer-mediated learning. Koschmann et al. discuss and illustrate the usefulness of ethno-methodological approaches for the analysis of interaction in learning groups, concentrating on the *meaning barrier*. They examine problem-based discussions in small-group tutorials held during medical training. They compare two discussions, one face-to-face and one via CSCW-software. The authors claim that the main problems which emerge from an ethno-methodological view are relatively independent of the medium employed. Considerable efforts are consistently required to make explicit the problems inherent in the subject that students are supposed to be learning. Above all, the process of transfer from an individual to a collective approach to a problem proves to be difficult. It also emerges that the methods which the participants apply in the computer-mediated environment are similar to those used in face-to-face situations. The methodological "message" of this contribution is that localization of the cause of meaning barriers can only be achieved by a detailed analysis of the constitution of meaning in the discussion process.

9. A MAP FOR THE LOCALIZATION OF BARRIERS, BIASES AND OPPORTUNITIES

It has become obvious that the causes of difficulties arising from computer use in remote communication and cooperation are manifold. Taken together, the contributions to this book provide a detailed map of the places where barriers and biases may have their source. It has also become apparent that the localization of difficulties invariably depends on theoretically based assumptions concerning the nature of barriers and biases. Working with new technologies is often difficult, simply because they are new, and because individual routines and social routines have to be established in using them. Additionally, the use of these technologies is difficult because they are not just alternative tools for dealing with old conventional problems but they are also expected to help with meeting new challenges, e.g. new forms of self-directed learning, a new way of participation by ordinary citizens, or new ways of interdisciplinary collaboration. That is why, in fact, most of the barriers and biases discussed in this book have multiple causes. Only knowing the "places" and causes of barriers and biases allows to develop successful strategies to overcome them and to gain advantage from the new technological possibilities.

Computer problems are commonplace for ordinary and expert users alike. There is at present no other technical domain in modern industrial societies where errors and problems play so large a role in the public mind as computers. Older readers of this introduction will remember that a few decades ago it was similarly commonplace for users of the technical system "car" to have an understanding of its technical problems and to be able to do some small repairs themselves, probably carrying a nylon stocking in the boot in case the V-belt needed replacing. Nowadays anybody using a computer could tell a lot of stories about problems concerning his/her experience with computer related problems, has some "nylonbelts" at hand in order to fix some of these problems and of course has implicit theories about the reasons for the difficulties she/he is experiencing. The combination of rapidness of technological developments and the new challenges they offer, contribute to the fact that our experience and knowledge about the nature of barriers remain mostly implicit. However, it is equally important for users, designers, and researchers that assumptions about the nature of such difficulties and their sources are made explicit and discussed. This book is intended to contribute to the explicit discussion of such tacit assumptions and to shed light on reliable measures to promote effective computer-mediated cooperative learning and work. In case of the technical system "car" such problems were solved by means of technical solutions. Remote computer-mediated communication will also be improved by technical progress but psychological and educational research will have a major impact, too. The editors hope that the contributions to this book are giving evidence of this claim.

ACKNOWLEDGEMENTS

We are grateful to the editor of the CSCW book series, Pierre Dillenbourg (Lausanne), who supported the concept of this book from the beginning. We would like to give special thanks to two anonymous reviewers who have provided very helpful and detailed comments on all chapters. Many thanks also to Regina Jucks (Münster) for comments on a draft of this introductory chapter and to Katrin Sommer (Münster) for her support of the editorial work and for the final formatting of this book.

REFERENCES

Aleven, V., Stahl, E., Schworm, S., Fischer, F., & Wallace, R. (2003). Help seeking and help design in interactive learning environments. *Review of Educational Research, 73* (3), 277-320.

Cramton, C. D. (2002). Attribution in distributed work groups. In P. Hinds & S. Kiesler (Eds.), *Distributed work* (pp. 191-212). Cambridge, MA: MIT Press.

Krauss, R. M., & Fussell, S. R. (1996). Social psychological models of interpersonal communication. In E. T. Higgins & A. Kruglanski (Eds.), *Social psychology: Handbook of basic principles* (pp. 655-701). New York: Guilford Press.

Ross, L., & Nisbett, R. E. (1991). *The person and the situation.* New York: McGraw-Hill.

Stasser, G., & Titus, W. (1985). Pooling of unshared information in group decision making. Biased information sampling during group discussion. *Journal of Personality and Social Psychology, 48,* 1467-1478.

bromme@uni-muenster.de
friedrich.hesse@uni-tuebingen.de
spada@psychologie.uni-freiburg.de

ARMIN WEINBERGER, MARKUS REISERER, BERNHARD ERTL, FRANK FISCHER, & HEINZ MANDL

FACILITATING COLLABORATIVE KNOWLEDGE CONSTRUCTION IN COMPUTER-MEDIATED LEARNING ENVIRONMENTS WITH COOPERATION SCRIPTS

Abstract. Collaborative knowledge construction in computer-mediated learning environments poses difficulties regarding what tasks learners work on and how learners interact with each other. Learners who collaboratively construct knowledge in computer-mediated learning environments sometimes construct inadequate conceptions of a subject and rashly build consensus regarding these conceptions. Collaborative learning tasks can be structured through cooperation scripts. It is unclear, how cooperation scripts could be designed for different tasks and different technologies for computer-mediated communication. In this chapter, two studies with a 2×2-design will be reported that applied social and epistemic cooperation scripts in computer-mediated learning environments based on web-based discussion boards and videoconferencing technologies. Results show that social cooperation scripts substantially foster the processes of collaborative knowledge construction as well as learning outcomes. Epistemic cooperation scripts facilitate the processes of collaborative knowledge construction, but have no or negative effects on learning outcomes.

1. COLLABORATIVE KNOWLEDGE CONSTRUCTION

Current approaches of learning and instruction emphasize the relevance of collaborative learning environments (see Greeno, Collins, & Resnick, 1996). In these approaches collaborative learning is often both method and aim of instruction. First, collaborative learning can facilitate knowledge building processes by requesting students to engage in activities beneficial for learning when cooperatively solving a problem task or discussing and elaborating text material (see Slavin, 1995; Webb, 1989). Second, working in small groups should prepare learners for life-long learning activities, which are largely embedded in social contexts. In this way, collaborative learning should result in specific *learning outcomes* that are beyond what could be achieved in individual settings.

The socio-cognitive perspective is probably the most elaborated theoretical framework in order to highlight and explain the benefits of collaborative learning environments (see Slavin, 1996; Webb, 1989). According to this framework, when working in small groups, learners construct knowledge by actively participating in discussion and sharing knowledge with their learning partners. From this perspective, cooperative learning aims at fostering *processes* of what we call collaborative knowledge construction (Fischer, Bruhn, Gräsel, & Mandl, 2002). Students ideally actively engage in learning processes when jointly working on a learning task. This is done by mutually explaining the learning contents, giving feedback to contributions of their teammates, asking and answering questions etc. There is a broad understanding that the specific benefits of collaborative knowledge construction are strongly linked to these specific processes.

Numerous studies indicate, however, that learners do not spontaneously engage in productive processes of collaborative knowledge construction, and consequently, the desired effects often fail to emerge (see Cohen, 1994; Mandl, Gruber, & Renkl, 1996). These difficulties can be particularly found on two major process dimensions of collaborative knowledge construction. On one hand, learners' difficulties in collaborative knowledge construction can be related to a *social process dimension*. A social process dimension of collaborative knowledge construction refers to the interactions of learners with their learning partners. Social interactions may be sub-optimal with respect to the goal of knowledge acquisition. For instance, discussions remain at a superficial level (Coleman, 1995; Linn & Burbules, 1993), and learners may try to quickly come to a consensus rather than critically refer to each others' contributions (Teasley, 1997). On the other hand, problems can be linked to an *epistemic process dimension*. An epistemic dimension refers to the tasks learners are confronted with, e.g., categorizing or defining new concepts (Fischer et al., 2002). That means, that learners appear to have difficulties in dealing with the learning task. They may disregard important aspects of the learning material and try to make sense on grounds of their prior knowledge only, instead of applying new concepts to the problem task (Hogan, Nastasi, & Pressley, 2000; Salomon & Globerson, 1989). Based on Vygotsky's (1978) perspective of collaborative knowledge construction as an internalization of processes on a social level, the epistemic activities during the social processes may have effects on how knowledge is acquired collaboratively. Both social and epistemic process dimensions need to be considered in order to analyze and facilitate collaborative knowledge construction.

2. COMPUTER-MEDIATED LEARNING ENVIRONMENTS

Distant learners work together on tasks and communicate through computer-based media in order to individually acquire knowledge. For instance, learners are expected to contribute their individual perspectives and resources, as well as to comment on each others' perspectives in a shared workspace, which they can access via the internet. In computer-mediated learning environments ideas and questions of learners can be represented in a central database (Scardamalia & Bereiter, 1996).

Computer-based media may therefore build a specific context for collaborative knowledge construction. Computers provide different communication modes with various technical and non-technical delays (Weinberger & Mandl, 2003). Information may be conveyed as text or as picture, for instance. Some computer-based media can be categorized as text-based (e.g., email, chat), whereas others are audio-visual (e.g., videoconferencing).

Messages in computer-mediated communication can be recorded and stored for later retrieval. Therefore, some forms of computer-mediated communication enable so called *asynchronous* communication. The discussants are not expected to interact at the same time, but a non-technical delay between the individual discourse activities may take place. This means that discussants receive and record messages, and respond to them at a later, more convenient time. Computer-mediated communication nowadays suffers only little technical delay. Messages are sent off and are almost at the same time received. This enables a discourse, which has been described as *synchronous.*, i.e. the communicants are supposed to participate in text-based or audio-visual computer-mediated communication at the same time.

In this chapter, we will present studies that aim to analyze and facilitate asynchronous, text-based communication built on web-based discussion boards as well as synchronous, audio-visual communication built on videoconferencing in computer-mediated learning environments. On one hand we aim to overcome specific barriers of computer-mediated communication for collaborative knowledge construction. The barriers we focus on are the reduction of exchanged information and the increase of coordination demands in computer-mediated communication in comparison to face-to-face communication. Therefore, learners may aim to reach consensus more quickly in computer-mediated communication than in face-to-face communication and only superficially deal with the learning tasks. On the other hand, we aim to exploit the potentials of different computer-based media to support processes of collaborative knowledge construction. Specific features of computer-mediated communication may foster the quality of collaborative knowledge construction. In particular, learners may have the chance to participate more actively and better reflect upon text-based communication than may be possible in face-to-face classroom talk (Scardamalia & Bereiter, 1996).

In order to appropriately use these potentials, we will systematically consider both social and epistemic process dimensions of collaborative knowledge construction in the context of different computer-mediated learning environments.

3. FACILITATING COLLABORATIVE KNOWLEDGE CONSTRUCTION

Dillenbourg (2002) distinguishes two different ways to facilitate collaborative learning. Taking a *condition-oriented approach*, teachers can indirectly influence the effectiveness of collaboration by arranging basic conditions like the group size, the group task or the communication media. In contrast, *process-oriented* approaches aim at directly influencing the interactions of group members by giving appropriate instructions.

There are a number of *disadvantages of condition-oriented approaches* compared to process-oriented approaches.

First of all, condition-oriented approaches may be *more difficult to design.* Condition-oriented approaches aim to facilitate the processes of collaborative knowledge construction indirectly. The rationale of this approach is, that when the basic conditions are set, the relevant processes of collaborative knowledge construction will emerge. The number of basic conditions relevant to collaborative knowledge construction, however, may be high, and mutual dependencies between these conditions are complex (cf. Dillenbourg, 1999). For instance, the effects of incentive structures on collaborative knowledge construction particularly depend on the complexity of the learning task, with the complexity of the learning task influencing what kind of processes are beneficial to knowledge construction (cf. Cohen, 1994). Therefore, it may be complicated to arrange all the conditions optimally to foster collaborative knowledge construction.

Second, condition-oriented approaches may be *more costly*. For instance, prior knowledge and experience in collaboration has been identified as a central basic condition of collaborative knowledge construction and thus, has been subject to cooperation training. Some of these training programs, however, take more time than the actual collaboration of learners (cf., Weinberger & Mandl, 2003). These costs may make the application of condition-oriented approaches less likely and less useful in educational practice.

Furthermore, some basic conditions of collaborative knowledge construction *cannot be arranged at all*. Mandl and colleagues (1996) note, for instance, that examination regulations typically disregard knowledge and competencies particularly fostered by collaborative knowledge construction. Typically, students need to memorize theoretical concepts in order to pass exams rather than to reflect and defend multiple perspectives on a complex subject matter. Consequently, students aim to avoid the costs of collaborative knowledge construction since its specific benefits are not requested in conventional examinations.

Therefore, *process-oriented alternatives* to facilitate collaborative knowledge construction may need to be considered. Process-oriented approaches may be more feasible, because they apply *during* the collaborative processes and because they can aim to *directly facilitate specific* activities and interactions of learners. Still little is known with respect to how process-oriented facilitation can be applied. Some process-oriented approaches, e.g., moderation of collaborative processes, may require complex skills and their success depends highly on the quality of the individual facilitator (cf. Clark, Weinberger, Jucks, Spitulnik, & Wallace, 2003). *Cooperation scripts*, however, have been regarded as a qualitatively consistent possibility to directly facilitate collaborative learning activities (cf. O'Donnell, 1999). Cooperation scripts aim at facilitating processes of collaborative knowledge construction by suggesting a structure to learners' collaboration. Cooperation scripts specify, sequence, and assign activities to collaborative learners. *Specifying activities* should help learners to produce activities which are beneficial to collaborative knowledge construction and to avoid activities which may be detrimental. Typically, a teacher specifies activities, which are believed to facilitate knowledge construction, prior to a collaborative phase of learners. For instance, teachers introduce students to the collaborative learning strategy of question asking. Subsequently, learners are expected to engage in the specified activities in the collaborative phase. Furthermore, *sequencing of activities* supports students in engaging in the specified activities. The specified activities may be beneficial for collaborative knowledge construction only when they are applied at specified times. In this way, interactions of learners may be organized to build sensible discourse structures. For instance, after question asking, the sequence of a script may suggest to answer questions as the next step. Therefore, sequencing may support learners to better relate to each other and support critical discourse. *Assigning activities* aims to warrant that the specified activities are carried out by all learners. This typically includes that learners are expected not only to engage in one specific activity, but to take turns in assuming responsibility for various specified activities. For instance, one learner may be assigned the activity to ask questions regarding one specific problem and another learner may be expected to answer those questions. Then, these learners may switch their roles to work on a subsequent problem.

Cooperation scripts have been studied extensively in face-to-face contexts. Recently, cooperation scripts have gained more and more importance for the design of computer-mediated learning environments, for which the disadvantages of condition-oriented approaches particularly apply. The computer-mediated learning environment builds a specific context in which distant learners cannot easily be prepared for online collaboration without giving up the idea of online and distance learning.

This contribution highlights central assumptions and empirical findings of this field of research in educational psychology in order to utilize these findings for computer-mediated learning environments. Moreover, we will describe two studies we recently conducted in order to analyze the effects of social and epistemic cooperation scripts in different computer-mediated learning environments.

3.1 Facilitating Social and Epistemic Activities with Scripts

Cooperation scripts are instructional approaches that aim at facilitating the processes of collaborative knowledge construction (O'Donnell & Dansereau, 1992). Despite this common goal, cooperation scripts can be designed in very different ways, based on various approaches, and aim at various process dimensions. Typically, cooperation scripts focus on several different process dimensions at the same time. Apart from social and epistemic activities, prototypical scripts aim, for example, to facilitate affective, elaborative, as well as meta-cognitive activities. Early attempts to disentangle the confounding of several dimensions of collaborative knowledge construction have been made with varying outcomes (Larson et al., 1985; see also O'Donnell, Dansereau, Hall, & Rocklin, 1987). Larson et al. (1985) compared effects of an elaborative and a meta-cognitive cooperation script on the quality of processes and results of collaborative knowledge construction. This comparison showed diverging effects on processes and outcomes of collaborative knowledge construction. The meta-cognitive cooperation script of this study produced a positive effect on processes, but was detrimental for individual outcomes of collaborative knowledge construction. The elaborative cooperation script, in contrast, only facilitated outcomes, but impeded processes of collaborative knowledge construction.

Various studies indicate that social and epistemic processes are particularly important for specific aspects of collaborative knowledge construction (Fischer et al., 2002; O'Donnell, 1999). As outlined above, specific difficulties regarding social and epistemic dimensions of collaborative knowledge construction have been discovered. Learners appear to have problems regarding the learning task as well as regarding productive social interactions. Starting from these specific difficulties, cooperation scripts can be designed that facilitate the social and epistemic processes.