2\textsuperscript{nd} Documentation on the Special Priority Program (SPP) “Net-based Knowledge Communication in Groups”

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Overview

It is a widely held view that net-based communication technologies will fundamentally transform the way we live and work. Knowledge has become the most important resource in an ‘information society’. And, as it is often stressed in this context, it is one of the few resources that do not decrease when shared. That’s fine and good. But: What does actually happen when knowledge is shared via net-based media? From a scientific point of view, the processes that occur in such situations are only partially explored. In 2000, DFG’s Special Priority Program (SPP) “Net-based knowledge communication in groups” set out to overcome this lack of insight. Its aim is to understand the generic qualities of computer-mediated knowledge communication by performing research of both a social science and technical nature.

Scope of research

Three aspects define the field of research addressed by the Special Priority Program. First, the program concentrates on knowledge communication, i.e. communication episodes related to knowledge building or modification. This applies above all to situations where people learn or work together. Second, the program centers on communication in groups. It examines bi-directional, interactive communication settings. This excludes mass media and mass communication formats. And third, the Special Priority Program is conducting research on net-based communication. What is of interest is thus not the mere use of computers, but that of computer networking technologies.
Within this framework, a broad range of specific research issues is being tackled. The Special Priority Program is comprised of 15 projects concerned with different priorities. These encompass issues as diverse as the role of heuristics in net-based communication, motivational factors influencing knowledge disclosure, the importance of non-verbal cues or cognitive load. Among the scenarios investigated are decision-making, the communication of expert knowledge and several learning tasks. From a technical perspective, various settings are being explored, ranging from rather indirect forms of communicating knowledge (such as databases) and asynchronous and synchronous text-based messaging to the use of annotated multimedia materials, shared workspaces, videoconferences or avatars.

The section following this overview contains a work report from each project and will present their research in detail.

Goals
The program’s 15 projects are not only pursuing an in-depth investigation of their specific concern. Being part of a research network, they are also engaged in the collaborative endeavour of solving the jigsaw puzzle presented by their single findings, locating missing links and outlining a research agenda on the basis of these insights. In this manner, the members of the Special Priority Program are jointly delineating the features of net-based knowledge communication as a research field in its own right. Reflection on theoretical implications of the empirical research performed within the SPP is a major concern of the program as a whole. Its aim is not only to integrate the results yielded by the participating projects, but also to relate them to mainstream concepts of the relevant disciplines. Thus, the Special Priority Program makes an attempt to bridge the gap between media and technology-focused studies on the one hand and classic research on learning and communication on the other. Creating an integrative theoretical framework for the research field of net-based knowledge communication is a long-term goal of the program.
**Approach**

Such a framework can only be comprehensive if different disciplinary perspectives are being considered. The Special Priority Program approaches its multi-faceted research object by involving researchers with backgrounds as diverse as cognitive science, social psychology, education, and computer science. This collaboration allows for the equal consideration of both technical features and human abilities. Moreover, it enables not only the examination of existing tools with respect to the basic underlying factors of human interaction with technology, but also the development of new ones better adapted to human demands and limitations. Thus, the basic research performed within the program complements with aspects of application.

Regular meetings and a continued exchange via an online forum ensure communication and collaboration within the research program. The projects are divided between two teams according to their research focus, which allows for a concentration on certain overarching issues. Besides, many project-to-project co-operations have formed. The following section called “Networking Activities” will provide more information about these ‘networks within the network’ and, furthermore, present the links the program has established with the international research community.
Networking Activities

This section presents the factors that make the Special Priority Program a research network, i.e., its structures of internal cooperation, as well as the ties that link it to the international research community. A short description of the network’s public relations work will conclude this overview.

Coordinated activities within the Special Priority Program

To enhance fluid cooperation in a larger group of people, a balance between spontaneous self-organization and coordinated action must be reached. In the Special Priority Program, the task of ensuring communication between the projects, fostering cooperation, and supporting the establishment of joint products is assigned to the Coordination Project. One of the means used to fulfill this assignment is the organization of regular face-to-face meetings. These meetings give the program members the opportunity to inform one another about the ongoing project work, to identify common interests, to discuss theoretical implications, and to plan joint activities. In the past two years, two such general assemblies were held, focusing on the following priorities:

- The Tübingen meeting on April 7th and 8th, 2003, concentrated on integrating new members into the program. As a consequence, the team structure was reorganized. The three teams of the first funding period were replaced by two new ones: research team one focuses on structuring net-based knowledge communication via scripts and comparable elements, while team two addresses topics like information pooling, transactive memory and presence in computer-mediated communication.

- The Freudenstadt meeting on January 15th and 16th, 2004, served to provide orientation before the beginning of the third and final funding phase. Discussions focused both on practical matters like the organization of a concluding event at the end of the third funding period and on theoretical issues, such as the integration of the individual projects’ findings.
To enable a continued exchange beyond those face-to-face meetings, the Coordination Project set up two electronic communication devices: A password-secured BSCW workspace (basic support for collaborative work) serves as a shared repository for documents on the Internet and several mailing lists facilitate e-mail exchange within the program. One of these mailing lists enables contact with all the program members, whereas the other two correspond to the research teams.

These teams play an important role in organizing the program’s work. Just like the program as a whole, they, too, hold regular face-to-face team meetings that foster a further concentration on special issues and help members enter a deeper dimension of interaction. Moreover, the teams advance joint projects. Each team is currently working on a joint publication.

**Project-to-project cooperation**

In addition to the ‘top-down’ actions initiated by the research teams or the Coordination Project, many ‘bottom-up’ collaborations involving individual projects have emerged as the Special Priority Program continues to evolve over time. These collaborative efforts take on various forms. Joint publications are common and discussions on theoretical issues initiated during program or team meetings are often continued in greater depth at a small-group level. There is substantial exchange on methodological questions, as well, as illustrated by the shared interest of Mandl, Spada, Piontkowski, and others in the analysis of collaborative processes.

However, collaboration is not limited to exchanging views; research instruments are shared, as well. In the case of the cooperation between Münzer and Piontkowski/Keil, for instance, the same experimental information-pooling task is applied, but each time with a different focus of interest. In other cases, technical tools developed within the program are shared. Here, the fruitful interplay between tool-centered and social science research is perhaps most manifest. Tools are applied and tested by other program members in the lab, as well as in the field of teaching, as demonstrated by the collaboration of Bromme/Jucks with both Hoppe and Ottmann. Often, such applications entail an adaptation of the tools employed. This spurs further development, not only in the sense of improving existing features, but also of adding new ones. For example, in a series
of experiments conducted by Bente and Krämer, Hoppe’s shared-workspace software ‘Cool Modes’ was complemented by a channel for avatar-based audiovisual communication. Or, to name another example, plans are being made to integrate scripts used for collaborative learning in the Mandl/Fischer project into the Annotation Web Service system developed by Ottmann.

A detailed account of these and other project-to-project collaborations can be found in the corresponding projects’ work reports.

**International contacts and partnerships**

One of the goals of the Special Priority Program is to actively participate in the relevant international research community and to initiate concrete partnerships with research groups sharing similar interests. During the past few years, three main areas of activity have emerged, namely collaborative associations with colleagues from the U.S., Japan and within the European Union.

With regards to the Special Priority Program’s partnership with researchers from the American National Science Foundation’s ROLE program (Research on Learning and Education), the Early Career Exchange realized in 2001/2002 is now being followed by another joint workshop series, this time dedicated to the “Creation of an American-German Research Network in the Field of Technology-Supported Education”. Its aim is to bring together American and German researchers, to develop a joint agenda of research questions to be pursued collaboratively, and to design projects that capitalize on the strengths of complementary approaches. In addition, participants were invited to take part in the workshop activities as teams comprised of researchers at different career stages. This mentor-mentee structure adds a strong early-career support perspective to the aforementioned goals of the event. A kick-off workshop was held in Tübingen on November 12th-14th, 2003; a second event will follow at Stanford University on June 17th-19th, 2004 – both co-funded by NSF and Deutsche Forschungsgemeinschaft DFG.

Contacts with researchers from the Japanese Society for Information and Systems in Education (JSISE) were established during a conference held in Berlin in September 2003 on “cognition and learning via media-communication”. This event was well-attended by scientists from Japan and the German-speaking countries, including seven
teams belonging to the Special Priority Program. A follow-up workshop in Japan is envisaged for 2005/2006, again with substantial participation from the SPP.

Finally, the start of a European Union-funded Network of Excellence called “Kaleidoscope: Concepts and methods for exploring the future of learning with digital technologies” in January 2004 has opened up a European perspective for future cooperation. The network is comprised of over 800 European researchers. Some members of the Special Priority Program are already involved in Kaleidoscope’s activities. A presentation of the SPP at the European network’s general assembly in Duisburg, June 2005, is meant to pave the way for further collaboration.

Going public

In real life, the last networking activity that will be described here is actually the very first: Making oneself known to others is the basis and beginning of all further cooperative action. Therefore, one objective of the Special Priority Program is to develop a public voice. Presentations at relevant conferences, such as CSCL, ICLS and, on a national level, the conference of the German Society for Psychology (DGPs) and its subsections on Media and Educational Psychology, are important means of fulfilling this objective.

Joint publications also play a role in disseminating the Special Priority Program’s research. A good example is the book “Barriers and biases in computer-mediated knowledge communication – and how they may be overcome”, edited by Bromme, Hesse and Spada, which will soon appear in the CSCL series published by Kluwer. Comprehensive and up-to-date information about the Special Priority Program’s publications can be obtained on our website, which is, of course, itself a powerful instrument for reaching a wider audience. Apart from a list of our publications, this Internet site gives details about the program’s research topic, approach, projects, and events in German and English. The pages can be found at http://www.wissenskommunikation.de and are highly recommended to anyone who wants to learn more about the SPP’s current activities.
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Responsible for content are the project members who provided the text.
Team 1:  

**Structuring Net-based Knowledge Communication**

Overview

The common theme of the eight projects that are part of this team is the investigation of barriers to successful computer-mediated communication and collaboration, and the development of appropriate support methods to overcome these barriers – with a focus on measures that help structure the net-based interaction.

The project by Bromme and Jucks focuses on net-based communication between experts and laypersons and the specific problems arising from the adaptation of the expert’s explanations to the layperson’s level of understanding. Then, Nückles and Renkl investigate tools that facilitate such communication by providing the expert with information about the layperson’s level of knowledge. Along similar lines, Strube, as well as Spada and Caspar, investigate collaborations among persons from different areas of expertise. In the Strube project, the focus is on analyzing knowledge communication in interdisciplinary web design teams with the goal to develop a support system for such interactions. Spada and Caspar develop and test instructional support methods that promote a well-structured collaboration of medical doctors and psychologists working together on psychiatric cases that require expertise from both domains. The three projects by Fischer and Mandl, Mandl, and Pfister and Haake implement cooperation scripts to structure and promote collaborative learning in different computer-mediated settings. Finally, Ottmann investigates the potential of an interactive annotation system to support net-based teaching and learning.

Within the overarching common theme, a variety of collaborative net-based scenarios are analyzed. The *computer-mediated scenarios* implemented in the eight projects range from text-based asynchronous (Bromme and Jucks, Nückles and Renkl) and synchronous (Fischer and Mandl, Pfister and Haake, Strube) communication, to a desktop videoconference setting with application sharing (Mandl, Spada and Caspar),
and a multimedia lecture setting (Ottmann). The *collaborative activities* under investigation include collaborative learning at the college level (Fischer and Mandl, Mandl, Pfister and Haake, Ottmann), collaborative work and problem solving by experts (Spada and Caspar, Strube), and knowledge communication between experts and laypersons (Bromme and Jucks, Nückles and Renkl).

During the second phase of the SPP, the focus of the publication activities in the individual projects was on extending the scope to the international, English-speaking research community. A second important goal was to present the project work to the public by publishing articles in university research journals, in the local newspaper or even presenting a project report on television.

**Team Activities**

The common interest outlined above resulted in several collaborative activities within this team:

First, in June 2002, an international workshop on “Barriers and Biases in Net-Based Knowledge Communication – And How They May Be Overcome” was held in Münster. In addition to members of the team, well-known researchers in the field of net-based knowledge communication (Anne Anderson, Pierre Dillenbourg, Gerhard Fischer, Paul Kirschner, Tim Koschman, Richard Moreland) participated in this workshop. The framework of a comparably small group of people and a constructive atmosphere made intensive and fruitful discussions of research possible. Building on this foundation, a book with the same title was initiated by Rainer Bromme, Friedrich Hesse and Hans Spada, which is currently under final editorial revision by its publisher Kluwer. Beyond the Münster workshop, the members of team 1 came together in two meetings: in July 2003 at the Institute of Psychology in Freiburg; and again in January 2004 during the annual meeting of the SPP in Freudenstadt. These meetings were used to discuss the project work, including extensive discussions of methodological questions concerning collaborative process analyses. Furthermore, joint activities were planned; for example, joint symposia for conferences were organized (EARLI 2003, PAEPS 2003, ICLS 2004, DGPs 2004) and a second book project was launched:
Frank Fischer, Heinz Mandl, Jörg Haake, and Ingo Kollar have initiated a book on “Scripting Computer-Supported Communication of Knowledge – Cognitive, Computational, and Educational Perspectives”, which will include contributions of team members as well as of several international experts in the area.

As a means to foster the early career and intermediate level career researchers, Armin Weinberger and Matthias Nückles will take the lead in writing a review article on structuring net-based knowledge communication together with some other early and intermediate career researchers (PhD students and post docs) from the team. Alexander Renkl and Heinz Mandl will coach this article project.

The book and article projects reflect the projects’ common interest and the team’s interdisciplinarity. But they also go beyond the scope of SPP and take a step into the international research community.

International networking activities also include: participation of several team members in the German-American exchange program on “Technologies in Education”, co-funded by NSF and DFG, as well as participation in the “KaleidoScope” Network of Excellence funded by the European Union; moreover, some team members are involved in supporting the merger of the CSCL community with the International Society of the Learning Sciences (ISLS).

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Recipient Design in Net-based Written Communication among Experts and Laypersons

Goals

The goal of our research program is twofold. First, on a theoretical level, we are interested in the impact of the participants’ differences in knowledge on mutual understanding in computer-mediated settings. We begin by taking Herbert Clark’s psycholinguistic theory as our basis (for an overview, see Clark, 1996), in order to conceptualize the relationship between knowledge (of experts and laypersons) and communication. Clark’s theory was developed as a model to apply to face-to-face communication in everyday contexts. Its transferability to computer-mediated communication is, therefore, a question that has to be answered empirically. Our results shall contribute to current debates (e.g. Barr & Keysar, 2002) about this theory. Second, on an application level, we investigate the conditions that enhance or restrict mutual understanding in written, online communication among experts and laypersons in the domain of health-related knowledge.

Background

Our research starts out from a psycholinguistic assumption (Clark, 1996): Usually, speakers more or less adjust all verbal utterances to their listeners’ communicational needs. This principle of recipient design is regarded as fundamental for successful communication. Several heuristics help speakers to adjust their utterances (Clark & Marshall, 1982): the community membership heuristic, the physical co-presence heuristic and the linguistic co-presence heuristic. The heuristics guide assumptions about what information can be taken for granted as so-called “common ground” and what has to be made explicit by the speaker. In asynchronous email-communication, the possibilities to control mutual understanding are rather limited (in comparison with face-to-face interaction) and, therefore, such heuristics might be of particular importance. These heuristics are the focus of our experiments, because it is still an unanswered question
as to whether they are used in net-based online counseling. Experts in particular often seem to have problems in flexibly adapting to a lay audience (Hinds, 1999). One can suspect that their own extensive and highly integrated domain-specific knowledge makes it particularly difficult to anticipate the qualitatively completely different perspective of a layperson. We assume that in this case, the use of the above-mentioned heuristics may be misleading.

**Project Work**

In our experiments, a net-based hotline scenario is modeled. Health experts (pharmacists and medical doctors) respond to fictitious laypersons’ requests via email or chat while having only minimal information about the knowledge of their recipient(s) available. Within the first funding phase, we concentrated on the *physical co-presence* and on the *community membership heuristics*. In net-based communication, ‘physical’ refers to shared *graphical representations*, i.e. in our scenarios, to diagrams of body functions. We asked if such graphical representations produce an *illusion of evidence* on the experts’ side: Do experts assume that a diagram is part of the common ground just because it is shared, even if its understanding requires profound domain expertise by the recipient? This line of research on the impact of *graphical representations* is continued in the second phase of funding, now with a focus on possible positive effects of external representations on online counseling.

The last of the above-mentioned heuristics, the *linguistic co-presence heuristic*, is the main topic of the second phase of funding. This heuristic is important for the establishment of a shared language among interlocutors. Again, such standardization of lexical encoding is a well-researched issue in face-to-face interactions and in everyday contexts, but it is not known whether the linguistic co-presence heuristic is also used in the scenarios of interest to us. As experts often tend to stick to their specialist language, they might not respond to differences in word use among laypersons. And if they do respond, it is still not understood what triggers adaptation.

At first, we did a descriptive field study on a large sample of German health-related Internet sites. In the study, we analyzed contingencies between patients’ and medical
doctors’ lexical encoding. Then, we started a series of experiments (still ongoing), in
which our research subjects (medical experts) received fictitious queries that varied with
regard to the choice of words used to express the laypersons’ concerns. Additionally – in
forthcoming experiments – medical doctors will be provided with further information
on the patients’ knowledge level. At present, we have analyzed the explanations of the
first experiment \((n = 46)\) with respect to the experts’ adoption of medical terms and fur-
ther variables of the experts’ recipient design.

Like this study, all our studies use text analysis in order to measure the degree of
the experts’ recipient design. Furthermore, surveys with samples of ‘real’ laypersons
provide information about the comprehensibility of experts’ explanations from the
vantage point of laypersons. Ancillary to the main line of experiments, we run a study
in a setting of online financial investment advice, in order to test the robustness of our
findings across different domains.

**Results**

We have found clear evidence for the use of the *community membership heuristics*. The
illusion of evidence hypothesis, which was related to the *physical co-presence heuristic*,
was partly confirmed. Texts that had been produced when a shared representation was
available were rated as being less simple and clear than the texts written under other
conditions. In addition, we observed the huge impact graphical representations have on
the content of written explanations, even if only the writer, not the recipient, has access
to them. This is similar to the representational guidance effect found in instructional
settings (Suthers, 2002). Based on our findings, we designed a further experiment that
tests the possibility to support experts in focusing on conceptual explanations in medi-
cal online counseling.

Our studies on the application of the *linguistic co-presence heuristic* show
that experts do adopt the lexical encoding used by their communication partner.
The field study on German Internet sites revealed clear contingencies between
medical experts’ use of technical medical terms and the preceding use of ter-
minology by laypersons. The first experiment confirmed the field observations.
Since, in this experiment, no other information on the laypersons’ level of medical
knowledge was given, it is remarkable that even slight differences in the laypersons’ wording can have such an effect. Additionally, we found relationships between standardization of common language and further variables of recipient design.

**Future Research**

In the next experiments on the establishment of a shared language between experts and laypersons, we will ask how explicit information provided by laypersons about their pre-knowledge interferes with the way the query is formulated. This will reveal why and when experts adapt to laypersons. Furthermore, the impact of other features of laypersons’ requests (for example ‘hedges’, i.e. linguistic means to emphasize the borrowed meaning of words) will be analyzed. Finally, we shall strive to develop research-based tools to support experts’ capacities to adapt and – as a result – to improve their explanations to laypersons.

**Funding period**

November 2002 – October 2004

Documentation for April 2002 – February 2004

**Cooperations with other SPP project partners**

In addition to the exchange of experiences and discussions with conceptually related projects, especially in AG 1, a shared workspace environment (Cool Modes) developed by Hoppe et al. (Duisburg) was used in the above-mentioned chat experiment. In our university teaching, we use and test OPAS (online peer assessment system) developed by Ottmann et al. (Freiburg).

**Research output**

**Publications:**


**Publications in preparation:**


**Conference contributions:**


**Forthcoming conference contributions:**

**Further activities**
Bromme and Jucks have taken part in the first NSF-DFG cooperation program (in 2001/2002) and are taking part in the current program (2003/2004) on educational technologies. In response to requests by pharmacy faculties and by pharmacy associations in Münster and Bonn, we are giving several lectures.

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Computer-supported Collaborative Learning: Facilitating Argumentative Knowledge Construction with Cooperation Scripts

Goals
In online learning environments, learners in groups often tend to discuss their tasks superficially and are oriented towards quick consensus; in peer discussions at the college level, students rarely refer to scientific concepts nor do they question or criticize the contributions of their peers appropriately. Asynchronous computer-supported learning environments hold the potential to foster argumentative knowledge construction, because learners are supposed to have sufficient time to analyze and construct arguments carefully, to apply given representations of scientific concepts, and to discuss divergent perspectives with peer learners. With asynchronous communication, learners can be instructionally supported according to their individual needs in the time frames between interactions. Thus far, there have been few systematic empirical studies on facilitating argumentative knowledge construction for collaborative learners in computer-supported environments. Furthermore, there is little knowledge concerning the interaction between collaborative knowledge construction and individual cognition in asynchronous computer-supported learning environments. Therefore, the main goals of this project are to investigate the effects of different forms of scripts that aim to facilitate the analysis and construction of arguments in computer-supported collaborative learning environments and to analyze the interaction between argumentative discourse quality and individual cognition in asynchronous, text-based computer-supported learning environments.

Background
Our approach to collaborative argumentative knowledge construction emphasizes the central roles of both collaboration and cognition in knowledge construction. In our framework, we conceptualize four major dimensions of argumentative discourse: the
argumentative microstructure (i.e., the structure of a single argument), the argumentative macrostructure (i.e., the sequence of arguments in a discussion), the content quality (i.e., the domain-dependent appropriateness of the argument), and the transactivity (i.e., the degree to which an argument refers to the argument of the learning partners). As outcomes of collaboration, we consider conceptual and application-oriented knowledge, both with respect to content and argumentation. Based on socio-cognitive approaches, the individual outcomes are related to the processes of collaborative knowledge construction. We chose scripted cooperation as an approach to foster collaborative learning. Cooperation scripts structure the interaction of learners by specifying, sequencing, and eventually assigning roles and activities within a group of learners. We see computer-supported collaborative learning environments as a promising context for structuring specific processes of collaborative knowledge construction. Cooperation scripts can be implemented into the interface of computer-supported learning environments, supporting individual learners to analyze and construct arguments. Scripts may have specific goal dimensions. So far, we have analyzed the effects of scripts that each aimed at a different one of the four major dimensions of argumentative discourse.

**Project work**

We developed a collaborative, case-based learning environment using Web-based discussion board technologies. Two main experiments and a number of further studies were conducted to analyze the effects of Web-based cooperation scripts with specific goal dimensions on argumentative discourse and individual cognition in text-based online learning environments. In the first experiment, we systematically varied the factor “content-oriented script” and the factor “transactive cooperation script” in a 2×2-design. 105 university students of Education Science participated and were randomly assigned to one of the four experimental conditions. In the second experiment, we systematically varied the factors “coordinative script”, “micro-script of argument construction”, and “macro-script of argumentation construction” in a 2×2×2-design with 240 university students of Education Science being randomly assigned to one of the eight experimental conditions. The students of both experiments were asked to solve three authentic problem cases in groups of three by applying Weiner’s
attributional theory. Pre- and post-tests were applied to measure individual acquisition of conceptual and application-oriented knowledge, both on content and on argumentation. Interactions on the Web-based discussion boards were recorded. Think-aloud protocols were taken in order to analyze individual cognition. Coding systems were developed to analyze argumentative discourse quality with respect to the dimensions of collaborative knowledge construction, and individual cognition with regard to elaboration activities, such as organizing, summarizing, and exemplifying the learning material within the computer-supported collaborative learning scenario. Results indicate that cooperation scripts facilitate on-task participation in computer-supported collaborative learning environments and foster their specific goal dimensions of argumentative discourse quality. Learners equipped with a content-oriented script produced better contributions with respect to content, learners supported with a micro-script for argument construction built better arguments, i.e. they warranted their statements more than learners without such a script, learners with a social script to foster transactivity referred more to the reasoning of their learning partners. Although the process of collaborative knowledge construction could be improved with respect to the particular dimension targeted by the scripts, not all of the scripts also facilitated individual knowledge acquisition and some even produced unwanted “side effects”. For instance, the content-related script impeded individual knowledge acquisition and the formal microstructure of argumentative discourse. In contrast to our expectations, collaborative knowledge construction processes are rather moderately correlated with individual knowledge acquisition. Scripts appear to be particularly effective with regard to supporting individual knowledge acquisition, when they not only foster the construction of arguments, but also the critical analysis of the contributions of the learning partners. The script components that were investigated so far, however, had stronger effects on the construction of one’s own argument than on the analysis of the learning partners’ arguments.

Cooperation within team 1 of the Special Priority Program comprises the ongoing edition of the volume “Scripting the computer-supported communication of knowledge – cognitive, computational and educational perspectives”. Closer cooperation with the project of Bromme/Jucks and the project of Spada/Rummel has been established with
regard to methodological questions on process analyses leading to a joint symposium at the International Conference of the Learning Sciences. In cooperation with computer scientists from the Ottmann project, we are aiming to technically formalize the scripted cooperation approach. The formalization of scripts could serve as the foundation for a scripting engine, which might help educational practitioners to implement scripts with or without computer tools.

Future Research

A consequential question is how active analysis of learning material and peer contributions can be fostered. In this context, the results show that especially the learners’ analysis of argumentation can be improved. We will work toward script components to make theoretical concepts and contributions of learners more salient inside Web-based learning environments and investigate how script components for the analysis of arguments interact with script components to foster the construction of arguments. Methodologically, we will complement our discourse analyses with think-aloud protocol analyses to gain better insight into the complex relationship between collaborative knowledge construction and individual cognition in text-based asynchronous learning environments.

Research output

Publications and Published Conference Proceedings (Selection):


Submitted Papers:


Kollar, I., Fischer, F. & Hesse, F. (subm.). Computer-supported cooperation scripts – A conceptual analysis.


Conference Contributions without Published Proceedings (Selection):

Theses (Selection out of 18 theses in total):
Other project members
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Kati Mäkitalo, Guest Scientist from the University of Jyväskylä, Finland
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Funding period
August 2000 – July 2004

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Collaborative Knowledge Construction in Desktop Videoconferencing: Effects of Domain-specific and Socio-cognitive Support

Goals

Research on collaborative learning in videoconferencing has become increasingly important for educational psychology, as videoconferencing enables synchronous forms of collaborative distance learning and complex interactions between learners. Furthermore, due to the feature of application sharing, learners can co-construct knowledge in a permanent and visible manner. This quality of application sharing can be a strong anchor for support. Our goal is to research different support measures for collaborative learning processes and outcomes in videoconferencing in order to attain a more comprehensive understanding of how to support collaborative learning in videoconferencing.

Background

In terms of collaborative learning research, there are at least two conceivable possibilities of fostering interaction processes in collaborative knowledge construction: (1) supporting learners with domain-specific structures, which can facilitate the construction of new knowledge and (2) providing socio-cognitive support in order to evoke conducive processes of collaborative knowledge construction.

**Featuring domain-specific support.** In order to foster domain-specific collaboration, learners are provided with an abstract visualization of relevant aspects of the content. This visualization takes place in the shared application, and is accessible for all learners. We have empirical findings, which indicate that domain-specific support can foster processes and outcomes of collaborative knowledge construction (cf. Ertl, Reiserer & Mandl, 2002; Fischer, Bruhn, Gräsel & Mandl, 2001). In collaborative settings, domain-specific structuring methods can facilitate interaction processes by supporting collaborating learners.
Providing socio-cognitive support. There are several approaches that aim at fostering collaborative knowledge construction by structuring interaction processes between the collaborating learners and their work on the task. The most well-known techniques are reciprocal teaching (Palincsar & Brown, 1984) and scripted cooperation (O’ Donnell, 1999). These techniques share a common feature in that they both specify different tasks, which involve social, cognitive and meta-cognitive learner activities.

Project Work

The aim of our studies is to investigate two different possibilities for facilitating collaborative knowledge construction in videoconferencing in order to gain deeper insight into the support of collaborative learning in videoconferencing. So far, we have arranged two learning scenarios: a peer teaching setting with two learners and a case-based learning environment for three learners. The variables that were varied in the experiments were (1) a content scheme as domain-specific support and (2) a collaboration script as socio-cognitive support. Our main research questions were:

1. How does domain-specific support influence learning processes and learning outcomes in videoconferencing?
2. How does socio-cognitive support influence learning processes and learning outcomes in videoconferencing?

Results

We found effects of domain-specific and socio-cognitive support in both studies. In study 1, the domain-specific support primarily influenced the collaborative learning outcome, while the socio-cognitive support produced/showed effects regarding individual learning outcome (cf. Ertl, Reiserer & Mandl, 2002). In study 2, the domain-specific support produced/showed effects in the collaborative, as well as the individual learning outcome. These effects could be further enhanced by socio-cognitive support (cf. Kopp, Ertl & Mandl, 2004). In both studies, as well as in our previous work, we found more supportive and less supportive characteristics associated with both support measures. Thus, for future research, we are looking forward to the completion of our model on the support for collaborative learning in videoconferencing.
Future Research

We are planning our future research in two directions. On the one hand, we aim to trigger socio-cognitive processes by task interdependence. The learners’ reciprocal interdependence will be a further enhancement of the socio-cognitive support. On the other hand, we plan to modify our content scheme for evoking more elaborative learner activities.

Cooperation

In past project work, we had cooperation projects with Fischer and Spada leading to joint journal publications and with the project by Weidenmann regarding the implementation of the learning scenario videoconference. Recently, we have begun cooperation projects with Spada and Piontkowski concerning the analysis of collaborative processes, with the project by Hoppe regarding the use of the Cool Modes tool, and with Diehl about the impact of distributed resources in the collaboration process.

Research Output

Dissertations (Ph.D. theses):

Publications:


Conference Contributions:


Qualifying Work:

Masters (M.A.) Theses regarding:

- Socio-cognitive processes of case-based learning in videoconferencing
- Epistemic processes of case-based learning in videoconferencing
- Information sharing processes of case-based learning in videoconferencing
- Motivational aspects of case-based learning in videoconferencing
- Collaborative use of shared external representations

Funding Period

I. August 2000 – July 2002
II. March 2003 – August 2004

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The Assessment Tool: A Method to Support Asynchronous Communication between Computer Experts and Laypersons

Goals

The proliferation of the Internet has opened new avenues of communication between laypersons and experts. E-consulting services, such as help desks for hardware and software, are a prominent example of this development. However, the constraints of asynchronous communication and the experts’ inclination to forget about the exclusiveness of their specialist knowledge may impair the advisory success. Therefore, in order to overcome these difficulties, we are developing methods that support asynchronous communication between experts and laypersons. The main goal of our project is to empirically test a so-called assessment tool. The assessment tool provides help desk experts with information about an inquirer’s knowledge level in order to facilitate the construction of a mental model of the client. We investigate the effects of the assessment tool both on the processes and the outcomes of asynchronous communication.

Background

To give effective advice to laypersons, experts need to be able to adapt their explanations to the layperson’s knowledge level. Both from an educational and a psycholinguistic perspective, adaptation to a communication partner’s background knowledge is regarded as fundamental for comprehension and learning. However, experts often fail to take into account the limited domain knowledge of a lay audience. Their extensive and highly interconnected domain-specific knowledge makes it difficult for them to anticipate the entirely different perspective of a layperson (Hinds, 1999). Clark and Brennan’s (1991) theoretical analysis of communication media further suggests that the establishment of a common ground is particularly aggravated in asynchronous communication. The lack of nonverbal feedback and the anonymity of the communication situation make it difficult to evaluate a communication partner’s knowledge and to
adjust one’s communication accordingly. Thus, providing experts with information about a layperson’s knowledge by means of an assessment tool could help to compen-
sate for these constraints and facilitate the experts’ task of adapting their communication to the layperson’s needs.

Project Work

The assessment tool approach

We conducted a series of experiments to test the effectiveness and efficiency of the assessment tool empirically and to investigate the underlying psychological mecha-
nisms. The assessment tool consists of a small Internet-based questionnaire, in which users who place a support inquiry are asked to provide the help desk expert with several self-assessments of their computer expertise. In the experiments, an asy-
chronous computer consulting situation was realized. Dyads of computer experts and laypersons communicated through a text-based interface. The clients placed a number of thematically distinct inquiries to the help desk and the expert’s task was to answer each inquiry. The clients could write back and ask as many questions as they needed. The availability of the assessment tool and the information displayed were manipulated. Outcome measures included communicative effectiveness, that is, the client’s increase in knowledge, and communicative efficiency, that is, the number of questions asked by the client in response to an expert’s explanation. We also conducted a linguistic analysis of the experts’ answers. For example, we analyzed their use of everyday examples and technical terms.

The effectiveness and efficiency of the assessment tool was demonstrated in a pilot experiment with 38 dyads of experts and clients. (Nückles & Stürz, in press). With the assessment tool, the clients wrote back half as often in response to the experts’ expla-
nations, while, at the same time, they acquired significantly more knowledge than the control group without the assessment tool. Evidently, the presentation of the clients’ self-assessments of their computer knowledge increased the effectiveness and efficiency of the experts’ counselling. Yet, it is an open question as to how accurate self-assess-
ments of one’s own computer knowledge generally are.
Study 1 ($N = 200$) examined the accuracy of people’s self-assessments. Research in metacognition suggests that self-assessments of one’s own knowledge are often biased. In particular, there is evidence that over- and underestimations of personal knowledge are correlated with gender in some domains (Beyer, 1999). To investigate the accuracy of students’ self-assessments of their Internet knowledge, a questionnaire and knowledge test was administered to 100 female and 100 male students. The students provided global self-ratings of their Internet expertise prior to the knowledge test and confidence judgments regarding their performance on each test item during the test. The self-assessments were compared to the students’ test performance.

Study 2 ($N = 80$ dyads of experts and clients) examined whether the validity of the information displayed is crucial for the effectiveness and efficiency of the assessment tool, or whether the assessment tool has a non-specific sensitizing impact on the expert, that is, the information displayed is of little surplus value. The experiment was conducted using four different conditions: (a) communication with an assessment tool displaying valid information about the client’s knowledge, (b) communication with an assessment tool displaying distorted information, (c) communication with an assessment tool displaying no information, and (d) communication without the assessment tool.

Study 3 ($N = 60$ dyads of experts and clients) investigated whether over- and underestimations of a layperson’s knowledge level influence the communication process and the outcomes differently. The experts had an assessment tool that displayed information representing (a) the client’s valid knowledge level, (b) a knowledge level being clearly higher, or (c) a knowledge level being clearly lower than the client’s real knowledge state.

The script approach
In addition to the project goals related to the assessment tool, we also took up a research interest shared by other project teams in fostering net-based communication and learning by cooperation scripts. Successful help desk communication not only depends on the expert’s ability to adapt to the layperson’s knowledge, but also on the layperson’s ability
to describe their problem in a concise and comprehensive manner. Since laypersons’ descriptions of their problems with the computer typically suffer from serious drawbacks, we developed a script that supports laypersons’ problem descriptions. Its rationale is based on the assumption, that in order to generate a problem representation, laypersons may draw upon so-called weak, domain-independent problem-solving strategies, such as means-ends analysis, which can be assumed to already be part of their everyday problem-solving competencies. Accordingly, the script prompted the layperson to describe (1) the aim of their interaction with the computer, (2) the steps they had undertaken thus far, and (3) a hypothesis as to why they had failed to reach the aim.

Study 4 (N = 54) compared different versions of the script (structured vs. semi-structured condition) with a control condition (descriptions without a script). Dependent variables were the representativeness of the client’s written problem descriptions and the ability of experts, who were blind to the client’s problem, to reconstruct the problem solely from the client’s description.

Results

The assessment tool approach

Study 1 revealed strong correlations between students’ self-assessments of their Internet knowledge and their subsequent performance on the knowledge test. There were no gender differences. Hence, students were able to evaluate their own knowledgeability in the Internet domain relative to the knowledge of peers with reasonable accuracy. A similar result was obtained with regard to the students’ confidence ratings. Generally, students’ confidence judgments reflected their actual test performance very accurately. These results underscore the conclusion that self-assessments are feasible indicators of an individual’s computer and Internet knowledge.

Study 2 successfully replicated the results of the pilot study (Nückles & Stürz, in press). Communication with the assessment tool was more effective and efficient than communication without the assessment tool. More importantly, however, the experiment allowed for conclusions about the mechanisms underlying the assessment tool effect. The clients acquired the most knowledge and asked the least questions when the computer expert was presented with valid data. By contrast, when the information
about the client’s knowledge was distorted, the clients asked the most questions and their knowledge acquisition was impaired. Hence, the validity of the information provided by the assessment tool is crucial. The assessment tool not only sensitized the experts in terms of the inquirers’ needs, but the information presented also allowed for specific adaptations to their individual knowledge levels.

*Study 3 (over- and underestimations):* The data collection is still ongoing.

*The script approach*

*Study 4* showed that providing laypersons with a script that prompts them as to how to describe their problem actually improved the quality of their problem descriptions. Laypersons in the structured prompting condition wrote descriptions that were more representative of the underlying computer problems compared to those in the semi-structured or control condition (no prompts). Computer experts, who were blind to the laypersons’ problems, were more successful in reconstructing the problem from descriptions, which had been written in the structured prompting condition compared with the other conditions.

**Future Research**

We intend to run a think-aloud study to analyse how the experts develop a qualitative representation of the client’s knowledge from the quantitative information provided by the assessment tool and how this qualitative representation is used to generate instructional explanations for the client. In addition, thinking-aloud protocols of the client’s comprehension processes could help to identify features of the expert’s explanations that make them well-adapted to a specific knowledge level. A third experiment will test the effectiveness of the script approach in a dialogue setting under ecologically valid communication conditions.
Research Output

Publications and Submitted Manuscripts:


Wittwer, J., Nückles, M. & Renkl, A. (submitted). Can experts benefit from information about a layperson’s knowledge for giving adaptive explanations?


Conference Contributions:


Two abstracts have been submitted as contributions at the DGPs Kongress, Göttingen 09/2004. A long paper has been submitted to the Annual Meeting of the Cognitive Science Society, Chicago, USA, 08/2004.
**Funding Period**
October 2002 – September 2004

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Annotation as an Instrument to Support Synchronous and Asynchronous Teaching and Learning Scenarios

Goals
The goal of this project is to develop manifold annotation facilities for the lecture recording system Authoring on the Fly (AOF). Learners will be able to personalize lecture recordings with graphical and textual annotations during a live session, where a lecture is recorded, as well as in a post-usage mode, where they learn with existing recorded lectures. Learners can post private, public or group annotations to an arbitrary place (both spatially and temporally) in a time-dependent lecture recording, where the annotations can serve as a starting point for ’anchored discussions’. These annotation possibilities also allow new means of assignments like peer assessment with recorded presentations of students.

The overall goal is to develop a new kind of collaborative learning environment for manifold types of annotations and group discussions. In terms of an „enabling technology“, this tool can serve as a basis for new research in the field of net-based knowledge communication in groups.

Background
Years of experience have shown that lecture recordings are well-accepted and used by students. However, the approach has mainly fostered individual work thus far and has neglected collaborative learning. A useful approach for stimulating network-based collaboration among learners is that of anchored discussion, where each contribution item is directly anchored in the content material. This particular approach has been implemented for static documents, but there have been no convincing approaches for time-dependent media, such as recorded lectures. Also, the contributions themselves have usually been restricted to typed text, whereas graphical, hand-written or even spoken annotations can be just as useful, especially when discussing multimedia documents.
In peer assessment scenarios, where learners discuss and evaluate their peers’ artefacts, continuous media have rarely been used. Our technology enables students to author their own multimedia mini-presentations as input for peer assessment.

**Project Work and Results**

1. Annotation of Time-dependent Media:
   a) Notes containing Text or URLs can be anchored both spatially and temporally in time-dependent multimedia documents. Also, notes can serve as anchors for other notes (thereby allowing “replies” to notes). The “PostIt” metaphor applied in the user interface (annotations are virtually “attached” to their context like sticky notes) provides an intuitive way of usage. An extension of the system to include graphical and free-hand annotations made directly on multimedia documents (such as highlighting, underlining, etc.) is the focus of current work.
   b) Notes can be published or shared within groups through a Web Service architecture: annotations are stored in an XML database on a server, and autonomous clients (in our case, a media player for viewing recorded lectures) connect to upload the notes created locally and to download and display the new annotations that are available. Alternative views of the notes allow threaded discussions about the material.

2. Multi-User Recording and Replay
   a) When lectures are recorded for later re-use by students, participants of the live event can receive the lecture materials via WLAN, annotate them live on their own computer (creating an additional media stream) and capture these annotations.
   b) The private annotation streams can be added to and synchronized with the master recording of the lecture. They can also be shared with others for comparison.

3. Peer Assessment
   As an example for the use of different kinds of annotations, we have developed a flexible, net-based peer assessment system, which supports different learning phases – individual, as well as collaborative. A peer assessment process consists of at least three phases: Authoring and submission of an artefact, review of the submission on
the basis of a given set of criteria and feedback schema and discussion of a certain aspect exemplified by the artefacts and the reviews. Learners can submit static as well as time-dependent documents like recorded presentations. For the latter scenario, we have implemented a peer assessment module in the AOF replay software, which consumes peer assessment functions as WebServices from the net-based system.

4. Viewing multimedia lectures on handheld devices
Personal Digital Assistants (PDAs) seem to be highly suitable devices for the annotation and personalization of documents. On the other hand, the small displays and different modes of interaction make it difficult to watch recorded lectures on those devices. A viewer to replay lecture recordings was implemented for Pocket PCs. The major focus was on the readability of slide contents and comfortable fine-grained navigation.

Future Research
During the current phase, the Annotation Web Service system will be extended to support collaboration scripts that involve group discussion. Some existing scripts (e.g., those evaluated by Fischer, Mandl, Weinberger) will be implemented.

For the next planned phase of the project, we envision a further extension of the system to include a more generic “scripting engine”, which can handle a multitude of different collaboration scripts.

In cooperation with the project by Fischer, Weinberger, and Mandl, the formalization of collaboration scripts will be examined and driven forward.

Features for synchronous discourse around recorded multimedia lectures will be included in the system. Examples are “anchored chat” and a collaborative workspace for an easy, “drag & drop style” compilation of collaboration results.

Research Output


**Products**

aofJSync (Authoring-on-the-Fly Java Synchronizer): Player software for viewing recorded lectures. New features: full AWS client capability; synchronization of multiple streams recorded by different users during the same live event; improved used interface.

AWS (Annotation Web Service): Private, public, and group notes can be added to multimedia documents and shared between users, allowing threaded anchored discussions.

LARA (Learn AnywheRe Anytime): Pocket PC users can interactively watch multimedia lectures on their handheld devices.

OPAS (Online Peer Assessment System): A net-based peer assessment system allowing the definition of arbitrary criteria and scales, as well as annotation schemas for review. The peer review functions are available as WebServices.

**Funding Period**

July 2003 – December 2004

**Other Project Members**

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Knowledge Construction and Grounding Decisions in Net-based Cooperative Learning with Learning Protocols

**Goals**

The project aims at experimentally studying the requirements, the effectiveness, and the constraints of structured discourse in net-based learning environments. Learning protocols, defined as implemented and system-controlled cooperation scripts, are assumed to overcome some of the deficiencies of unstructured text-based computer-mediated learning discourses. Especially, we want to clarify the basic conditions under which Learning Protocols function, to define the knowledge domains for which Learning Protocols are appropriate, and to clarify the mechanisms of knowledge construction during cooperative learning with learning protocols, in particular, how common ground is established during learning discourses.

**Background**

Using text-based tools, such as chat, for online learning discourses has been shown to result in suboptimal learning outcomes, probably due to incoherent contributions and a lack of coordination among participants. We suggest that a specific variant of cooperation scripts, called Learning Protocols, is capable of overcoming some of these deficiencies and improving learning in synchronous text-based learning groups. A learning protocol is defined by four characteristics: (i) Typed contributions: Each contribution needs to be categorized by the participant by choosing from a menu of predefined types, such as ‘question’, ‘explanation’, or ‘comment’; (ii) Explicit references: The concept or contribution to which a participant refers needs to be explicitly indicated and visually depicted for all participants; (iii) Distinct roles: Each participant is assigned a role (e.g., tutor), which constrains the permitted contributions; (iv) Sequence: Order of participants’ turn-taking is controlled by predefined rules. From this definition, specific instantiations of learning protocols can be constructed by specifying the permissible
contribution types, reference objects, roles, and sequence rules. So far, three types of learning protocols have been conceptually defined, implemented as working learning environments, and experimentally tested: (i) the *explanation protocol*, which supports groups of up to four learners in discussing a special subject matter (with the help of a tutor) by asking questions, giving explanations, and providing comments to others’ contributions; (ii) the *text processing protocol*, which supports the cooperative construction of summaries by an ordered exchange of additions, corrections, and comments with respect to an incrementally constructed summary of a knowledge domain; (iii) the *argumentation protocol*, which guides the conversation about a controversial topic, such as genetic engineering, by supporting the learners in providing pro and con arguments with respect to that topic.

**Project Work**

During the first project period, the focus was on testing the basic assumption that learning protocols can be an effective means to enhance learning and on investigating the special conditions, which are beneficial or disadvantageous for the use of learning protocols. In a first series of experiments, the explanation protocol was used as the basic test environment to study the effects of various knowledge domains, of varying group sizes, and of the inclusion/exclusion of different features of learning protocols, such as the referencing function, always comparing the outcomes with a control group that worked with an unstructured chat tool. Performance was always assessed individually with a pre-/post-test design.

A second experiment aimed at testing the effects of the text processing protocol. Here, the distinction between a macro-protocol, guiding the participants across a succession of different phases of the learning process, such as summarizing a text, or commenting on a text, and a micro-protocol, which included the specific features, such as referencing and typing tailored to the task of summarizing a text, was introduced. Otherwise, the experimental strategy was analogous to the explanation protocol.

During the ongoing second project period, we investigated the question of whether learning protocols can be employed to reconstruct knowledge after a certain time interval. More specifically, the learning discourse was recorded, and after a time delay of
one week, participants could use a recorded version of their own previous discourse to ‘re-learn’ the knowledge they had discussed one week ago. The presentation format of the recorded discourse was varied: either participants were presented a sequential format, i.e., all contributions were listed in exactly the same order they were generated during the original discourse, or a structured format was provided, i.e., all contributions were arranged in a tree-like structure according to the references indicated during the learning session. Performance was assessed individually after the second session to test which presentation format was more helpful for knowledge reconstruction.

A further series of experiments, which is currently being carried out, combines all three protocols developed thus far with different types of knowledge domains to establish a correspondence between protocol type and adequate knowledge type.

**Results**

Results of the first project period confirm the basic hypothesis that learning protocols, particularly the explanation protocol, can be beneficial in increasing learning performance in cooperative net-based groups. Furthermore, the essential mechanism, which improves the learning discourse, is most likely the referencing function, i.e., the need for participants to explicitly indicate the referent of their current contribution. Experimental results suggest that the referencing function is not only necessary, but also sufficient to enhance learning. Also, the effectiveness of learning protocols increases with group size. However, learning protocols seem to be highly domain-specific, and are possibly appropriate mainly for scientific and factual domains.

Experimental results with respect to the text processing protocol are less encouraging. Generally, the findings of the explanation protocol could not be replicated. A more detailed analysis shows some evidence that, for simple facts, learning with the text processing protocol was helpful to some extent, but not for complex facts or for knowledge based on inferences from more basic facts. Since the text processing protocol was more difficult for participants to learn and to handle, one plausible account of these findings could involve cognitive load theory: if the design of the user interface demands too much cognitive capacity to manage, very little capacity remains for genuine learning processes.
Using recordings of learning discourses for knowledge reconstruction also yields unexpected results. It was hypothesized that a structured representation, which relates the participants’ contributions according to their referential structure, is more helpful for re-learning than a presentation of contributions based simply on their succession during the original discourse. However, results indicate that – contrary to this hypothesis – a structured representation is indeed detrimental and leads to a less successful reconstruction of previously learned knowledge. This could be due to reading habits, i.e., participants might need more time and experience to learn how to learn with structured representations.

**Future Research**

Currently, our research concentrates on the correspondence between different types of learning protocols (such as explanation or argumentation protocol) and different types of knowledge domains; we aim at establishing a set of empirically based correspondence rules to decide which protocol to use for which learning goal. Further research during the second project period will focus on so-called optional learning protocols, i.e., protocols, which do not oblige participants to use all protocol features, but give them a choice as to which feature they want to use. It is assumed that the decision to apply a protocol feature is a function of the learner’s grounding criterion, i.e., if a participant thinks that his or her contributions need to be well-grounded to establish common ground among the members of the learning group. Also, it is expected that optional learning protocols are more motivating for learners as components of integrated virtual learning environments.
Research Output

Journal Papers and Book Chapters:

Conference Contributions:
Diploma Theses:

Products / Software:
As part of the cooperation with Fraunhofer-IPSI, results of the project are partially incorporated into the Fraunhofer-IPSI ConcertSuite.

Funding Period
First project period: June 2001 – May 2003
Second project period: June 2003 – May 2005

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Goals

The central goal of this research project is to develop instructional measures for promoting collaborative, interdisciplinary problem solving in a computer-mediated setting.

The research is based on the following scenario: Individuals with expertise in different content domains collaborate on solving a complex problem. The solution of the problem requires knowledge from all involved disciplines. As the experts cannot meet in person, they make use of a modern remote communication system to collaborate. A setting and task with practical relevance and realistic complexity were chosen: the interdisciplinary collaboration of medical doctors and psychologists on the treatment of psychiatric cases.

Three specific goals for the conceptual and empirical work were formulated: The first goal is to contribute to a theory of what constitutes a successful computer-mediated interdisciplinary collaboration. The second goal is the development of efficient instructional methods (model learning, script learning) to improve the relevant competences and strategies to achieve such collaboration. The third goal is to develop and evaluate methods to analyze collaborative process and outcome in order to define characteristics of a good collaboration and assess the effects of the instructional measures.

Background

To meet the challenges encountered in computer-mediated collaboration settings, two instructional measures were developed to improve collaboration by promoting the collaborative skills and knowledge of the people involved in jointly working on a task: (1) In a “model condition”, people were provided with an elaborated, worked-out example of a good collaboration. The model consisted of recorded model dialog and animated text, which allowed the observers to follow the development of the model solution on
the shared text editor. (2) In a “script condition”, the collaborating partners were provided with a script guiding them step by step through their collaboration on a first task.

The main hypothesis was that the instruction provided by the model and the script would promote people’s capability to collaborate in a fruitful way in subsequent collaboration. To test this hypothesis, an experimental paradigm was developed consisting of two clearly separated phases: In the first phase (learning phase), the instructional treatments are implemented. The second phase (application phase) is the source for applying and testing the acquired skills. The partners collaborate freely on the second task. The quality of the collaborative process, the joint work product, and the results of an individual posttest on knowledge related to collaboration are analyzed.

**Project Work**

In a first experimental study, we investigated the effects of our instructional support measures (model and script). The two instructional conditions were compared with a third condition in which the partners collaborated freely (without instruction) during both phases, and a fourth (control) condition limited to the application phase (see Rummel & Spada, accepted). The computer-mediated scenario consisted of a desktop videoconference including audio and video connection, personal text-editors and a shared text-editor. The collaborative task was the interdisciplinary solution of psychiatric cases with combined psychological and physical pathology. 36 dyads of advanced medical and psychology students (9 dyads in each condition) were asked to jointly diagnose the patients described in the cases and to develop a suitable therapy plan making use of their complementary expertise.

As part of the data analysis, various methods to analyze collaborative process were developed (Rummel & Spada, in press). In our assessment of collaborative process, we distinguished between three levels of analysis: (1) a macro level, assessing the coordination of joint work, (2) a micro level, assessing the communication, and (3) the domain-related content and quality of the collaboration. To gain information about the collaborative process at these levels, we used different approaches: First, on the basis of log-files, the activity patterns of the collaboration were analyzed. This analysis provided
information about a central aspect of the coordination of the collaboration: the pattern of individual and joint phases of work. Secondly, video recordings and transcripts allowed an analysis of the dialogs at all three levels: coordination (macro), communication (micro) and the domain-related verbal interactions of the partners. The units of analysis were minutes (macro) and turns (micro). The focus of the domain-related analysis was on “topics” arising within the dialog and their attributes (relevance, depth of discussion, etc.).

In a second experimental study, the issue of elaboration support is addressed: the effects of a model and a script with elaboration support and without such support are compared to investigate the importance of guiding reflection on the instructional support measures. For this study, new instructional materials (model and script presentation) had to be developed. The data collection on this study has just been completed. The data analysis will be carried out in the next months.

**Results**

The results of the first experimental study show that both of the instructional methods developed have the capability to improve collaboration in the given scenario. Dyads who received instruction by observing the worked-out collaboration example during the learning phase (model condition), as well as dyads who were led through the collaboration in the learning phase step-by-step by a cooperation script (script condition), outperformed their counterparts in the unscripted and the control condition on many of the dependent variables assessed during the application phase. Firstly, they produced better joint solutions for the diagnosis and therapy plan. Furthermore, they showed better performance on both subscales of the individual posttest: subscale A, asking for knowledge on what makes a good collaboration in the given type of scenario at a more general level, and subscale B, asking participants to describe elements of a good therapy plan.

The analysis of the activity patterns gained from log-file data proved to be an efficient method to gain access to some aspects of the collaborative process, such as the amount of individual and joint work. The analysis revealed that dyads in the model and script condition adhered to the proportions of individual and joint work shown to them
during the learning phase. They showed a substantial amount of individual work, which proved to be an important predictor of their performance on the joint solution (Rummel & Spada, accepted). A similar result was already noted by Hermann, Rummel & Spada (2001). This is a very notable result given the typical lack of attention usually directed to individual phases of work in research on supporting collaborative work and learning. Individual work phases are crucial to allow each group member to pull back in order to consider aspects of the problem from the perspective of his or her expert domain. Joint work phases are necessary to share information and to update the meta-knowledge about the distribution of expertise in the group.

In discussing the results for the dialog analyses, methodological issues have to be considered. It is important to note that what was being assessed was the quantity – or intensity – of dialog activity with regard to several aspects. However, the relation of quantity, e.g. of coordinative dialog activity, and quality of the collaborative work is complicated. In the light of this criticism, it would be desirable to complement the assessment methods with a dialog analysis, allowing the quality of collaborative process to be evaluated more directly.

A promising approach has been taken by performing a multi-step analytic procedure built on the methodology put forward by Mayring (e.g. 2003) to identify process dimensions relevant for a successful collaboration. From this analysis, seven dimensions were identified to be constitutive for a good collaboration. Subsequently, the dimensions were applied as a frame of analysis to a new set of data with promising results: a substantial correlation between the seven dimensions and the quality of the joint solution was found. This analysis combines the potential of a qualitative holistic analysis in the development of the dimensions with the methodological rigor of a quantitative analysis in its application.

**Future Activities**

The latter method to analyze collaborative process has been very well received by other researchers in the area. Research on collaborative learning and problem solving in technology-supported settings increasingly focuses on understanding collaborative processes, in order to be able to promote collaboration in an informed way. It is our
goal to further evaluate our method in order to work towards bridging the gap between quantitative counting of instances and qualitative intuition and it will be applied to the data of our second experimental study. Subsequently, we want to make this method of analysis available for researchers investigating technology-supported collaboration in other content domains.

Prof. Frank Fischer, Prof. Heinz Mandl, Prof. Jörg Haake, and Ingo Kollar have initiated a book project on cognitive, computational, and educational perspectives of scripting in technology-supported settings. Our contribution to this book will focus on the after-effects of scripted collaboration in particular. The question being posed is whether people can learn computer-mediated collaboration by following a script.

A central goal for further research is the application and evaluation of our training methods (model and script) on persons with different levels of expertise in the same domain, and in other computer-mediated scenarios. Part of this research will be conducted in collaboration with researchers from the Open University of the Netherlands (Prof. Paul Kirschner and Prof. Els Boshuizen) who are experts on the development of expertise in different domains and have ample experience in administering online courses.

**Research Output**

**Publications**


**Conference Contributions**

*Papers were presented at the following conferences:*

- European Conference on Computer-Supported Collaborative Learning (E-CSCL), 2001
- International Conference on Computer Support for Collaborative Learning (CSCL), 2002, 2003
- International Conference of the Learning Sciences (ICLS), 2004: a symposium was organized and a paper will be presented (proposals accepted).
- Kongress der Deutschen Gesellschaft für Psychologie (DGPs), 2002; for 2004:
  - a paper proposal was submitted
- Symposium der Fachgruppe Klinische Psychologie und Psychotherapie der Deutschen Gesellschaft für Psychologie, 2002

**Funding Period**

September 2000 – August 2004

**Other Project Members**

- Dipl. Psych. Nikol Rummel, M. S. (UW-Madison)
  (Completed her doctoral thesis as part of the project)
- Jana Groß Ophoff, Stefanie Sosa y Fink, Katrin Schornstein
  (Completed their diploma theses as part of the project)
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WebShark: Web-based Sharing of Knowledge in Teams of Heterogeneous Experts

Goals

The focus of this project is on the emergence and the role of shared knowledge in collaborative problem solving. We have chosen the domain of web design, because it requires experts with heterogeneous background knowledge to cooperate and communicate via electronic media. Our goals are

• to build a model of the structure of web design, and analyze this complex task in terms of knowledge needs

• to analyze and model the knowledge communication process, and

• to develop a knowledge-based support system.

Background

Throughout literature, shared knowledge is supposed to be an important variable in determining how groups consisting of members with heterogeneous background knowledge (e.g., expert groups like our web design teams) function. Shared knowledge about the distribution of information within the group is also regarded as a major constituent of the group’s transactive memory system, which guides information encoding and retrieval on the group level (Wegner, 1987). Shared mental models comprising shared knowledge about task, team, equipment and situation have been found to be crucial for effective expert team decision-making, problem solving and co-ordination in complex dynamic environments (Cannon-Bowers, Salas & Converse, 1993). Furthermore, effective communication requires a common ground and shared vocabulary (Clark & Brennan, 1991).

As shown by this brief summary, the kind of shared knowledge required depends on the task and characteristics of the group. In addition, the policy of knowledge sharing and the amount of shared knowledge needed vary according to the individual scenario,
from sharing almost everything (in the combat teams studied by Cannon-Bowers et al.) to a division-of-labor scheme (in the domain under study in this project).

**Project Work**

1) Using knowledge engineering techniques (observation, interviews, document analysis), we established a model of the task of web design.

2) In order to analyze the process of knowledge communication, we conducted interviews and a quasi-experiment with three experts, as well as an experiment with 13 dyads of trained students in our laboratory.

3) We are currently conducting interviews with web designers to explore communication and coordination problems in more detail.

**Results**

Due to organizational difficulties, we started much later than planned and still have 10 months of project time left. Among our current results are the following:

1) A model of the task of web design. As further investigations have shown, the two top levels of this model constitute part of the shared knowledge possessed by team members.

2) Our analyses showed that members of web design teams mostly work in parallel and have a lot of expert knowledge that is not shared with other experts. In addition to this private knowledge, we found some form of shared knowledge: shared background knowledge about the top-level structure of the task, shared meta-knowledge about roles and responsibilities of the team members and shared knowledge about the design decisions that have to be communicated.

3) A schema model of knowledge distribution within design teams with a body representing the private expert knowledge and a header representing design decisions (shared knowledge).

4) Experimental results demonstrating the effect of shared knowledge in a similar task, from a doctoral dissertation project by S. Thalemann (advisor: G. Strube).
Future Research

1) In order to explore the specific knowledge communication and coordination problems in web design teams in more detail, we will continue our interviews at different companies.

2) On the basis of these results, we will develop a support system consisting of a workflow component and a knowledge-based component to control knowledge communication for completeness and design decisions for consistency.

Research Output


Funding period

October 2000 – September 2002 (prolonged so that 10 months of project time remain)

Other project members

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Team 2:

Mechanisms of Net-based Knowledge Communication

Overview

Success or failure of net-based communication scenarios depends on a number of cognitive, social, and technological boundary conditions. As part of the Special Priority Program, this research team investigates these boundary conditions of net-based knowledge communication by using a multidisciplinary approach that combines elements from cognitive psychology, social psychology, and computer science. Although practical implications for facilitating net-based communication are addressed by this team, its primary focus is on a deeper understanding of the psychological mechanisms that shape and constrain computer-supported collaborative learning and work.

Some team projects address fundamental aspects of net-based communication, i.e. they investigate very general psychological mechanisms that potentially play an important role in many, if not all forms of net-based scenarios. The project Hesse/Creß deals with the question of what actually motivates participants in a net-based scenario to cooperate at all. This project regards knowledge exchange as a social dilemma, with the conveyance of one’s personal knowledge as a potential loss of power, or at least as a sometimes expendable investment of effort. Their mathematical formalization of knowledge exchange describes how groups and organizations can escape the trap of non-cooperation.

The Münzer project links net-based communication to research on the general cognitive architecture, viz. to working memory capacity. This project investigates how various net-based design features impose cognitive load on learners. As a consequence from these fundamental aspects of human cognitive processing principles can be derived that reduce the extraneous load of net-based scenarios. Of particular interest to this project are interindividual differences in cognitive capacity, and the question of how to accommodate for these.
The project Bente/Krämer addresses the impact of non-verbal cues in net-based communication. Given that traditional forms of net-based communication were particularly impeded in transmitting those cues, this rather new line of research has put an emphasis on virtual environments. Project research is embedded in the general question of how much social presence (awareness of being engaged in communication with others) different forms of net-based scenarios can provide. By investigating several facets of social presence, this project sheds some light on the notoriously vague conceptualization of presence that currently is at the heart of research on virtual environments.

While the aforementioned projects focus on a particular construct (social dilemma, cognitive load, social presence) as it unfolds across various net-based scenarios, two other projects follow the opposite strategy of investigating how various psychological mechanisms influence collaborative behaviour in a given scenario of group decision making. Specifically, these two projects address the social psychological paradigm of pooled information sampling, which rests on the assumption that groups will benefit in their decision making from pooling the various informational resources of their members. The Piontkowski/Keil project embeds its research into a general framework that breaks down group decision making into various stages that can benefit from specific technological support features. Particularly, it investigates how features of participation management, turn-taking management, coherence management or social network characteristics can create or reduce coordination losses in a net-based decision making group.

A general finding from the literature on pooled information sampling holds that groups are often unable to pool their resources effectively, which leads to suboptimal group decisions. Using this experimental paradigm, the Diehl project investigates a number of cognitive biases that prevent groups from identifying the best decision alternative. Moreover, this project implements technological features that enforce or reduce existing biases (e.g. varying source credibility, filtering redundant contributions, sequencing discussion phases).
In addition to these five projects with their strong emphasis on psychological mechanisms, the team is comprised of a sixth project dealing with mechanisms of net-based knowledge communication from the perspective of computer science. One of the problems of psychological research in this area has to do with the fact that group processes are difficult to observe, or in the event that they are observable, they rely on techniques that require a lot of interpretation (e.g. content analysis). One of the goals of the Hoppe project is to address this issue by developing tools that make collaborative mechanisms visible. This project designs a variety of cognitive tools that not only provide information that serves as feedback for learners, but also facilitate the scientific analysis of collaboration by external observers.

**Team Activities**

This team was newly established during the second phase of the SPP. It is comprised of several projects from each branch of the original 3-team structure of the SPP and includes two projects that did not participate in the first phase of the program. Each project was involved in larger activities surrounding the SPP, e.g. in the cooperation activities with NSF’s ROLE program, or in the cooperation with the Japanese Society for Information and Systems in Education JSISE, or with various conferences held by the German Society for Psychology (DGPs) and its sub-sections on educational psychology and media psychology. However, combined activities of the team as a whole are comparably recent. An overall strategy for future research in this team was developed during the general SPP meetings in Tübingen (2003) and Freudenstadt (2004), as well on the dedicated team meeting held in Cologne (2003). One particular goal that was identified during these meetings is to develop a general framework of net-based communication that encompasses the various psychological and technological mechanisms that are addressed across research projects. The development of such a framework is underway, and results of this combined effort will be presented at the next conference of the DGPs in Göttingen 2004. Moreover, the team will publish its research results in a Special Issue of a leading journal in our field. At the time of writing this documentation, the team is in negotiation with several journals that are interested in editing such a Special Issue.
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Goals

Due to the increased need to overcome the physical distance between team members in modern companies, it is essential to gather fundamental knowledge about advantages and drawbacks concerning innovative net-based communication technologies. In this context, the enrichment of computer-mediated communication by the application of nonverbal aspects is considered a promising approach to achieve a more natural, efficient and satisfying knowledge exchange. Based on these considerations, several efforts have been made to extend text-based media like chat by means of nonverbal communication aspects (gesture, gaze direction, head and body movement). Besides common technology approaches like video conference systems, VR-based technologies like avatar-based communication platforms provide completely new possibilities for structuring the communication setting. The word avatar refers to a computer-animated figure, which is used as a virtual representation for dialogue partners within a computer-mediated communication. The dynamic behaviour of the user can be transferred to the avatar directly in real time by using capture devices (data gloves, trackers, head-mounted display). Thereby, the nonverbal behaviour of the person can be displayed by the avatar without revealing the actual appearance of the communication partner (gender, ethnic group, etc.). By separating dynamic and static aspects and the possibility to systematically vary which channels are displayed, a new methodological approach for systematic research on nonverbal behaviour and its meaning for the communication process is opened up.

Although avatar-based communication is obviously quite different from other mediated settings, there are still only a few studies, which pay attention to its cognitive, socio-emotional and motivational implications for the knowledge communication process. Therefore, this project focuses on the effects of this new form of computer-
mediated communication and its potential influence on different aspects of net-based communication. Here, a special focus lies on the concept of social presence. This knowledge will be used for further developments of avatar-based systems with regard to possible application settings. Furthermore, the project aims to achieve knowledge about fundamental social-psychological principles by using the new methodological possibilities of the avatar technology. In two experiments, the extent to which the usage of avatars stimulates the experience of “social presence”, as well as the performance of the users (against the background of ”social facilitation”), is analyzed.

**Theoretical Background**

One of the most intensely discussed concepts in net-based communication is social presence (Short, Williams & Christie, 1976). One of the project’s major research aims is to provide a multidimensional theoretical extension of the concept “social presence”, as well as a multidimensional methodological approach to measure it.

The assumptions made in this context are based on the theoretical considerations of Biocca et al. (2001). They define social presence as the moment-by-moment awareness of the co-presence of another sentient being accompanied by a sense of engagement with the other. The degree varies from the peripheral sense of spatial co-presence of the other to progressively higher levels of social presence. Those levels are characterized by a deeper sense of psychological involvement, access, and connection to the intentional, cognitive, and affective states of the other. Additionally, higher levels may include a sense of behavioural engagement that leads to actions that are perceived as linked, reactive, and interdependent.

The assumption of several levels allows for a more differentiated examination of the potential influence of the chosen media technology on the perceived social presence of the other. Thus, a communication technology is no longer evaluated by means of a total high or low social presence score, but rather by its “social presence pattern” (which levels of social presence are facilitated by the communication medium and which are not). This, for instance, can lead to more valid recommendations for a task-centred development process of computer-mediated communication technologies.
A conceptualisation of social presence as multidimensional also requires indicators and measures that meet the requirements of the theoretical scope. Therefore, in this project, different measures are taken into account:

- cognitive indicators (self-report scales, questionnaires)
- emotional indicators (physiological measurement) and
- behavioural indicators (measurement of nonverbal behaviour: gaze, head and body movement, gestures).

**Project Work (includes cooperation with other projects)**

**Methodological Development**

*The Virtual Communication Environment (VCE)*

Our Virtual Communication Environment (VCE) employs data gloves, head and body trackers, as well as gaze trackers (figure 1), to record the interaction behaviour of participants in net-based communications. The behavioural data are transmitted in real time via TCP-IP to the computer of the interaction partner and are re-synthesized into a real-time animated 3D avatar.

![Figure 1: Head and gaze tracker in interaction situation](image)
In addition, the recorded behavioural process data (gaze, head and body movement, gesture) are automatically stored for later analysis. The VCE allows for a virtual representation of the interaction partners by the means of different avatars: a reduced line model and a more elaborate full-body model (figure 2).

![Figure 2: Elaborate anthropomorphic and reduced line model](image)

Besides avatar-based communication, the platform also allows for synchronous computer-mediated communication by text, audio or video. Apart from this, the cooperative workspace tool “Cool Modes” was integrated during a cooperation with the project team Hoppe from the University of Duisburg. This tool allows participants to structure their work process by creating and writing on virtual cards by using a graphical input device. These cards can be put down onto a structured virtual desktop where the interaction partner can read them (figure 3).
Physiological Measurement
To get further access to physiological process data, we use a new measurement technology called SMARD-Watch® in our studies. SMARD-Watch® was developed by the “Department of Stress Research”, Berlin, and provides a non-invasive, simultaneous measurement of different psychophysiological responses like heart rate, pulse rate, electrodermal activity, skin conductance, and electromyogram. The necessary sensors are integrated into a small strap that participants can wear on the wrist or ankle. Further usability testing in our laboratory confirms that the device is easy to wear and does not interfere with the task in any way.

Social Presence Questionnaire
Based on the theoretical considerations, an initial set of 58 five-point Likert scale items was created and evaluated during a pilot criterion test in which 48 participants took part. The participants were randomly assigned to four different communication settings (text, audio, avatar, and FtF communication) with 12 participants (6 women/6 men) in each group and had to fill in the questionnaire after having interacted with a confederate. Analyses included correlation analyses, factor analyses and tests of internal consistency. Results show that factors largely resemble those found by Biocca, but that we were able to add an important new dimension termed “intimacy”.

Figure 3:
Cool Modes within a VCE interaction
Results
The assumption that the consideration of social presence as a multi-dimensional construct could be useful for further investigations was confirmed by variance analyses based on the data of the described study: The different communication groups varied with regard to the level of perceived social presence, showing a different pattern for each presence aspect and each setting. In comparison to the other groups, the findings did not confirm a general superiority of the avatar-based communication setting in facilitating the social presence experience of the participants. Only for the aspect of co-presence did the results meet the assumption that the usage of an avatar will stimulate the presence experience in a better way than text- or audio-based technologies. However, concerning the factors “intimacy” and “non-attentional engagement/comprehension”, telephone conversations, at least, proved to foster higher levels of social presence than avatar interactions. In general, the study may lead to the conclusion “it depends”, suggesting that in further studies we will have to take a closer look at precisely what it depends on. Certainly, the practice to examine only one aspect like co-presence as the only indicator of social presence cannot be the way for those who want to evaluate the potential of CMC technologies.

Future Research
Due to the fact that preliminary results did not generally show a superiority of avatar-based communication compared to audio or video interactions, we want to focus on the specific conditions under which avatar-based communication provides benefits. On the one hand, we will investigate if triads – due to increased coordination requirements – profit to a greater extent from the incorporation of nonverbal information. On the other hand, we will focus on the comparison of our desktop-based system with so-called immersive virtual reality technologies.
Research Output

Conference Contributions without Published Proceedings:

Funding Period
April 2003 – October 2004

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Computer-mediated Information Sampling in Small Groups

Goals

Within the scope of the special priority program „Net-based Knowledge Communication in Groups”, we investigate decision-making processes in small groups. Improving the process of exchanging and integrating the decision-relevant information by means of computer-mediated communication is the primary target of our work. In our opinion, net-based knowledge communication can be an effective tool for overcoming the shortcomings of decision-making processes in face-to-face groups.

Background

Previous research on group decision-making has found that groups do not make better decisions than individuals. The information sampling model (Stasser & Titus, 1985) suggests that the reason for this phenomenon is biased information sampling. Due to a smaller a-priori probability for communicating unshared compared to shared information, the shared information dominates group discussion. In cases in which the shared information leads to the consensual preference for a sub-optimal decision alternative, since the optimal decision alternative can only be detected if the unshared information is exchanged (=hidden profile), groups will fail to make a correct decision. Numerous empirical studies confirm these assumptions in face-to-face groups.

However, stochastic processes (=probability bias) may not be the only cause of a sampling bias in information pooling. There are several additional psychological processes that might impede the exchange of unshared information: (1) Since unshared information may inconsistent with one’s individually preferred alternative, group members might withhold unshared information (=confirmation bias). (2) Since shared information is mentioned more often than unshared information, the shared information will be more accessible in memory than the unshared information (=accessibility bias). (3) Since unshared information is mentioned only by individual group members, whereas
shared information is mentioned by all the group members, the shared information will appear to be more trustworthy than the unshared information (=consensus bias).

Introducing computer-mediated communication in decision-making groups should reduce these information sampling biases. In particular, the accessibility bias and the consensus bias should be eliminated by separating information exchange from group discussion and decision-making. Sending a group member’s information to a common information board before the group discussion avoids any public commitment to an individual decision and prevents consensus information about the knowledge and preferences of the other group members from being received. Such a process structuring should thus result in a nearly complete exchange of all the relevant information. This was precisely the case in our last study (cf. Möhle, Diehl & Zipfel, 2002) of the previous funding period (2000-2002). However, despite the optimal information exchange, most of the groups were not able to recognize the optimal decision alternative. Although sharing all relevant information is clearly a necessary precondition for making a good group decision, it evidently does not suffice. Therefore, we decided to concentrate our work in the current funding period (2002-2004) on the processes of information integration.

**Project Work**

The sub-optimal information integration observed in the last study of the previous funding period may be caused either by a peripheral, or by a central but biased, information processing. Whereas the first explanation is the subject of the project manager’s dissertational work, the latter was examined in three experiments. A fourth experiment is underway.

In our first experiment (cf. Möhle, Diehl & Willim, 2004), we tested the assumption that the failure to detect the best alternative by elaborating the (nearly) complete information presented on the common information board was due to a confirmation bias. We reasoned that this confirmation bias was so hard to overcome, because the pre-discussion information favouring the sub-optimal alternative was given by the experimenter – and thus a credible source – whereas the information favouring another alternative as the best choice came from the other group members and thus – due to
supposed personal interest – a less credible source. This hypothesis was tested in a 2x2 factorial design with the factors “credibility of the first source” and “credibility of the second source”.

In the second experiment, we tested both the accessibility bias hypothesis and the consensus bias hypothesis. Due to the fact that shared information appears repeatedly on the information board, it will be detected as shared (consensual) information and, in addition, will become more accessible in memory. Both effects might lead to more weight being given to shared compared to unshared information in the information integration process. In a one-factorial design with three experimental conditions and one control condition, the redundancy of the shared information was manipulated on a faked information board. The information board contained all the relevant shared and unshared information. In the condition with full redundancy, each item of the shared information appeared repeatedly on the information board, whereas, in the condition without redundancy, it appeared only once. The comparison of these two conditions allows for testing the accessibility bias hypothesis. In a third experimental condition, each item of the shared information also appeared only once, but, in addition, the number of group members who submitted each item to the information board was given in parenthesis. Thus, the shared information was presented as consensual information, allowing the consensus bias hypothesis to be tested. Since participants not only had to decide on the best alternative, but also had to read and evaluate each item before making a decision, a control condition was introduced for assessing the item evaluation in a non-decisional context.

In the third experiment, we tested the hypothesis of whether the high detection rate in the first and in the second experiment was due to elaborating (reading and evaluating) each item before making a decision. We reasoned that elaborating on the information contributed by the other group members is a necessary precondition for changing one’s initial preference for the sub-optimal alternative. Elaborating on the initial personal information should, however, strengthen the first decision, thus enhancing the confirmation bias. These hypotheses were tested in a 2 x 2 factorial design with group members being forced (vs. not being forced) to evaluate the initial personal information or the entire information.
Results

In the first experiment, we did not find support for our hypothesis that the best alternative could not be detected, because the initial information was attributed to a more credible source than the information brought up in the group discussion. There were no differences between the condition with a credible first and a less credible second source and those conditions in which both sources were of high or low credibility (The average detection rate for the best alternative was about 50%). Only in the condition with a first source of low and a second source of high reliability was a non-significant trend for a higher detection rate (70%) observed. Despite the non-significant effects of the experimentally manipulated reliability of the information sources, the perceived credibility of the information seems to affect the decision: Those participants who were able to detect the correct alternative rated the credibility of the information inconsistent with the prior preference significantly higher than those who stayed with their initial preference.

The second experiment revealed no differences between the three experimental conditions. That is, regardless of reading an item more than once on the information board or of being aware that a certain item was shared by other group members, about 54% of the participants were able to detect the correct alternative. Since there was no difference in the ratings of value, relevance and credibility between the three experimental conditions and the control condition, in which the items were not assigned to the different alternatives, we are led to the conclusion that no accessibility bias or consensus bias in information integration occurred. There was a high and significant correlation between the rated evaluation of the three alternatives and the evaluations calculated by Anderson’s information integration model. As in the first experiment, about half of the participants showed an unbiased information integration and thus detected the correct alternative. Correct and incorrect problem solvers differed in their evaluation of the new information, which was necessary to detect the correct alternative. Correct problem solvers evaluated new information as more relevant and trustworthy than previously known information, whereas incorrect problem solvers did not differ in their evaluation concerning trustworthiness and relevance of initial versus new information. However, incorrect problem solvers showed a confirmation bias in evaluating the trustworthiness
and relevance of information consistent with their initial preference as being higher than that of inconsistent information. Despite these biases, the incorrect problem solvers should have detected the correct alternative had they integrated the ‘biased’ information according to Anderson’s information integration model. The fact that they did not reveals an additional information integration bias.

In the third experiment, no differences were found with respect to preferences for one of the three alternatives due to having been instructed to read and evaluate each information item carefully. On the average, more than 58% of the participants were able to detect the correct alternative after being confronted with the information board. These findings led us to the conclusion that all the participants had elaborated the information thoroughly, whether being instructed to do so or not. This conclusion is supported by the finding that regardless of experimental condition, the participants were able to recall on average nearly one third of the existing information.

In summary, the fact that we found such high detection rates in a hidden profile task may be due to the fact that, in experiments 1-3, all the participants performed the task individually, i.e. without interacting with others, whereas the low detection rates in previous experiments were observed with interacting groups. Thus, in order to achieve high detection rates in a group context, the process of information integration should be structured in a way that reduces the differences between individual and group decision-making.

**Future Research**

In the third phase of our project, we plan to conduct studies in which the process of information integration is structured by means of our computer tool, so that group members can easily detect whether there is more information favouring another alternative than the one they initially preferred before exchanging information with the other group members. This could be done, for example, by evaluating information before it is attributed to one of the alternatives or by deciding within each of the alternatives, which information item is a pro argument and which one is a con argument.
Research Output

Conference Contributions:


Funding Period
October 2002 – September 2004

Other Project Members
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Knowledge Exchange with Shared Databases

Goals
The project investigates those processes, which influence knowledge exchange with shared databases. In the first two years of the project, we primarily focused on situational effects due to costs and benefits of knowledge exchange. In the third and forth year, we primarily focus on group factors stemming from the group and the way the members communicate.

Background
The decision whether to contribute knowledge to a shared database or to withhold it represents a public-goods dilemma: Each individual saves time and effort if s/he contributes nothing, but if all do so, no knowledge exchange takes place at all. Thus, the individually most effective strategy (to withhold information) leads to the worst result for the whole group. Specifically, a shared database constitutes a public good: the content is accessible to all users independently of whether they also contribute or not. This leads to strategies commonly known as free riding and social loafing.

Project Work
We developed an experimental setting where subjects in groups of 6 work in a knowledge-sharing dilemma. They have to calculate wages of hypothetical sales workers.

In a first phase of the experiment, each group member has to calculate as many base salaries as possible. For each result, s/he earns money and has to decide whether to contribute the result to the shared database, which costs time. In a second phase, each group member has to calculate total salaries. In order to do this, s/he needs the relating base salaries. If a participant did not calculate the base salary in the first phase, and if this value was not contributed to the database by at least one of the other group members, s/he has to calculate it in the second phase and will lose time.
In an experimental session, each participant is confronted three times with such a task. To control group effects, the individual worked independently of the others and the behavior of the other five group members was always faked.

With this experimental environment, we carried out a series of experiments, and tested the effect of the following factors:

- providing meta-knowledge about the importance of the information
- providing an input-related bonus to reward contributing
- providing a use-related bonus to reward contributing
- decreasing the contribution costs
- establishing prescriptive rules for the number of contributions
- providing feedback about the team-mates’ contribution behavior
- increasing the salience of the group
- reducing anonymity by providing photos of the group-mates
- providing information about the cooperativeness of each group member
  (identifying the behavior)
- providing heterogeneous resources
  (some people believe they have more knowledge than others)
- internal vs. external attribution of having more/less knowledge

Results

The experiments brought many detailed results according to the investigated factors. Here, we only summarize some of the most important findings across the experiments:

First: All experiments show that free riding is in fact a serious problem in knowledge exchange via shared databases. In all experiments, subjects calculated about 12 basic salaries in each trial and contributed about 30% – 50% of them. This means that they withheld the other 50% – 70% of their information.

In experiments where two different kinds of information were used (less and more important information), subjects contributed much more information of high importance than information of low importance. Thus, once a subject actually decided to contribute, s/he did this in a way that the others had the highest benefit. This shows that
subjects did not behave competitively with the motivation of maximizing the difference between their own and the others’ outcome. Instead, they selected their database contributions with a consideration of what the others need. This selection could be enhanced through a use-related bonus system. When costs are low, this selection is reduced, but only at the beginning of the experiment. When the subjects get more experienced, the selection increases.

Second: We observed that none of our manipulations was able to stop free riding completely. Neither a treatment which objectively reduced the dominance of withholding by providing a cost-compensating bonus, nor a cost-exceeding bonus, which objectively turned contribution into a dominant strategy, was able to reduce free riding fully. It seems that subjects subjectively have a bias to perceive such a situation as a dilemma, even if objectively, it is not. Thus, a bonus system cannot totally solve the dilemma. Instead, subjects assess the costs higher than the rewards they get through a bonus. This leads us to the third point:

Third: The possibility to influence subjects’ contribution behavior through a structural change of the dilemma (through reducing costs or providing bonuses) seems to be more limited than through social factors. Here, we have to consider a strong effect resulting from the feedback about the cooperativeness of the team-mates. Obviously, in the very anonymous situation of knowledge exchange via database, social cues become highly relevant.

Forth: External prescriptive rules influence the contribution behaviour even if subjects know that they will not be punished if they break the rule. Obviously, subjects use the rules as anchors if they have no further information concerning how others behave in the dilemma.

Fifth: Even with intensive treatments, it was not possible to induce a high level of group salience. The dilemma situation seems to always activate both the individual and the group identity. Without allowing more social contact among group members, it does not seem to be possible to enhance group identity.
Future Research

For future experiments, we plan to expand the experimental setting: instead of three trials, we will just examine one long trial. And instead of small groups of 6 persons, we will examine larger groups working asynchronously. We will focus our attention on the cooperation process: How does the group’s cooperation behavior develop over time? Which presentation-type feedback about the team-mates behavior do subjects prefer? And can different time-sensitive presentation types affect the cooperation rates?

Research Output

Publications


Creß, U. (sub.). The dilemma of knowledge exchange with shared databases: its formal structure and the possibility of a solution through a self-supporting bonus system.


Conference Contributions
Funding Period
January 2001 – December 2004

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Goals

This project aims at developing a general platform for shared workspace environments with semantically interpretable visual language plug-ins; implementing a variety of specialized languages and tools for different applications, which serve as “collaborative mind tools” and developing a spectrum of computerized methods to analyze collaborative interactions based on action histories and/or on the system state.

Whereas dialogue- or discourse-oriented analyses of collaboration have a longer history in CSCL research, action-based and state-based analysis techniques define a new line of research, which has a higher potential for problem-oriented feedback than linguistic approaches. While the first phase of the project focused on the collaboration platform and on basic analytic mechanisms, the second phase also investigates analysis-based feedback and intervention techniques. In the third phase, we will generalize the different analysis approaches, we will combine techniques for state-based and action-based analysis, and we will evaluate the previously implemented analysis and cooperation instruments in a study in cooperation with about 10 to 12 schools in Duisburg, which will subsequently use some of the results of this project in their lessons.

Background

Cooperative visual language environments implement the idea of combining collaboration support with cognitive mind tools in that they allow for constructing and sharing “computational objects to think with”. The term “computational object” indicates that the content is at least partially machine-readable and processable, so that the computational environments can “talk back” to the user(s) in problem-specific ways. Due to the generality of our collaboration framework, Cool Modes, which integrates visual languages from a great variety of domains, this “talk back” should not be generated.
by implementing an “intelligent” analysis tool for each visual language individually. Instead, we are searching for a way to limit usage low-level, domain-independent information and to produce a problem-specific output with it. We call this production of semantic feedback by using only syntactic pieces of information the “semantic illusion”. Given that our computational environment can partially interpret user actions, the problem of analyzing collaborative interactions can be redefined while avoiding or at least bypassing the known difficulties of linguistic interpretation. Process characteristics and models can be taken into account to interpret (and later scaffold) group collaboration.

**Project Work and Results**

*Analysis methods*

As a result of the first two periods of the work, we have developed a classification of analysis methods for collaborative activities. After developing a categorization for an analysis of collaboration activities in the first project phase and implementing methods for action-based analysis, the second project phase focused on state-based analysis techniques.

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<thead>
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<td>Summarical view of (domain-independent) activities</td>
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Based on our general shared workspace environment, Cool Modes, and exemplified by concrete applications, a spectrum of (non-linguistic) analytic techniques has been developed:

1. Action-based analysis (M. Muehlenbrock):
   Analyzing basic domain-independent operations (e.g. “create”, “modify” and “delete”) M. Muehlenbrock explored the ability to recognize higher-level collaboration activities. He describes more than 30 different group activities (e.g. cooperation and conflict phases) that can be recognized using this approach. This work was completed at the end of the first phase of the SPP.

2. State-based checking of models (K. Herrmann)
   Again using domain-independent information (e.g. orientation of nodes inside a model without using information about the function of the node), K. Herrmann implemented a checking system that “talks back” to the user and provides him with information about the properties of the model he built. Although it uses domain-independent data as its input, the system’s feedback “seems to have” domain knowledge. We call this the “semantic illusion”. The content checking module (CCM) was completely developed and implemented in the second phase of the SPP. It will be used in about 10 schools at Duisburg later this year for street security lessons.

3. Browsable collaboration reports (M. Roffmann)
   Collaborative modeling is a complex process with (potentially) parallel operations. To review the actions that take place in that process (beyond simple replay), a structural preparation of the logged data is needed. M. Roffmann developed XSL transformations that result in a browsable topic map that can be shown in the same environment, in which the modeling process took place. The participants of a collaborative modeling process can look at a filtered and structurally prepared version of their work without media breaks in the same environment, in which they previously worked. This mechanism was developed for the Petri Net visual language of Cool Modes during the second phase of the SPP.
Cooperation with other projects

During the second project phase, we focused on two cooperations with other SPP projects:

1. Cooperation with Prof. Bromme (Münster)
   We developed a visual language for Cool Modes for the group of Prof. Bromme, who researches communication between persons with different levels of knowledge. With this language, it is possible to show and annotate concept maps in Cool Modes. Additionally, we integrated a chat communication tool into Cool Modes. The experiments relating to this cooperation have been completed; we are now analyzing the data.

2. Cooperation with Prof. Bente (Köln)
   Our cooperation with the group of Prof. Bente (Köln) holds great promise for the future. We are currently integrating Cool Modes in this group’s Avatar Setting at the University of Köln. Together, we will explore the different communication channels’ impact on the process of forming an opinion. To do so, we are developing an adaptation of Cool Modes, including special features, e.g. for hand-written annotations, and for the synchronization of our tools with the software already installed in the laboratory at Köln.

Future Research

In the third project phase planned, we will, on the one hand, strengthen the theoretical background of our classification of analysis methods. A special emphasis will be placed on the further development of the Content Checking Module and its “semantic illusion” feature.

On the other hand, we will intensify our cooperation with Prof. Bente. We will explore the possibilities of combining different communication channels and types to enhance the efficiency of collaborative modeling.

A third area of interest will be the generalization of our collaboration report tool. We will expand this tool from the Petri Net domain to be able to automatically produce reports from models of any existing visual language for our Cool Modes environment.
Research Output

Articles

Products
CCM (Content Checking Module for Cool Modes): State analysis tool that produces domain-specific feedback by using only non-domain-specific information provided by Cool Modes.
Cool Modes (Environment): General platform for shared workspace environments with graphical representations. Features: heterogeneous visual languages, dynamic objects, context-dependent semantics, media integration.
Adaptations of our software tools for the cooperation with Prof. Bromme (Münster) and Prof. Bente (Köln).

Funding Period
November 2000 – October 2004

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Cognitive Load in Synchronous Knowledge Communication in Groups: Design Factors for Software Tools and Inter-individual Differences

Goals

The project investigates the role of cognitive load for individuals participating in net-based, synchronous knowledge communication in small groups. Cognitive load is viewed here as a mediating variable, which influences the processing of information during net-based communication. Both the design of (text-based) communication tools (i.e., chat tools), as well as the capabilities and skills of individuals, may determine cognitive load. The first goal of the project is to vary design factors of chat tools in order to reduce cognitive load. The second goal is to investigate the influence of inter-individual differences in working memory capacity as measured by the reading span test. Recommendations for the design of communication tools will be derived from the results of the experimental studies, which should especially be useful for individuals with lower working memory capacity.

Background

1) Cognitive load theory is an important approach in the area of man-machine communication, as well as in multi-media learning research. In those areas, the goal is to improve the user’s task performance by reducing the cognitive load produced by the tool and/or the form of instruction (e.g. the user interface or the specific arrangement of text and graphics). In the project, the design factors that influence the cognitive load produced by the communication tool are to be identified experimentally.

2) In order to measure cognitive load in synchronous communication directly, the dual task paradigm is applied.

3) The reading span test requires the simultaneous processing and storage of verbal information. It predicts inter-individual differences, especially in the area of verbal information processing tasks, e.g. text comprehension. The theoretical background
is a model of working memory that proposes inter-individual differences in the capacity for information processing under load. These models typically use the processing and storage span tasks (like reading span or operation span) to measure working memory capacity and predict performance in more complex tasks. It is hypothesized herein that reading span may predict the amount of verbal information that can be processed in a complex net-based communication situation using a text-based chat tool.

Project Work
The project started in November 2003. The status of the project work in March 2004 is described in the following paragraphs.

We analyzed design factors of chat software that may influence cognitive load. For instance, the possibility to produce messages in parallel, while the other participants cannot see the production of the message, typically results in many small messages in parallel threads. The speed of the incoming new messages might prevent individuals from engaging in careful inspection and information processing. In the first study, design factors, such as providing production awareness, prohibiting parallel writing, and reducing the length of the chat history list, are examined. After programming and testing the different chat tools, the first study is now in the phase of data collection.

Two pilot studies were conducted in order to pinpoint an appropriate secondary task by which cognitive load could be measured directly. First, an auditory secondary task was tested with simple reading and text comprehension as a primary task. This task required a 1-back comparison of auditory delivered consonants (go-no go). However, while this secondary task worked fine in the first pilot study, participant disengagement was observed in the second pilot study, in which the secondary task was combined with the primary task of chat conversation. Meanwhile, a modified secondary task is used, which requires concurrent visual monitoring of the color of a letter displayed in a separate window.

In order to measure the reading span, a computer software program was developed, which runs the test automatically and can be used to test subjects in parallel (in contrast to the original method, where it is necessary to have one protocol writer for each subject).
For the chat conversation, the “murderer game” material developed by the Piontkowski/Keil project is used. Therefore, results concerning the communication process and solving the information sampling problem can be compared with the outcomes of the Piontkowski/Keil project. In our project, a software program was developed to analyze and visualize aspects of information processing regarding the “murderer game”. This software program was also provided for the Piontkowski/Keil project.

We are working in close cooperation with the projects of Piontkowski/Keil and Pfister/Haake. The Pfister/Haake group uses ChatLine, a chat communication analysis tool developed at IPSI. The group is using it for the creation and visualization of restructured chat transcripts.

Results
In the first pilot study, we tested a reading span measurement program that worked fine. N = 19 subjects were tested. After a week, all subjects were tested a second time. Measured reading spans correlated significantly (r = .57), with a substantial training effect. Reading span also predicted text comprehension (i.e., it correlated negatively with the number of errors made in a recognition test), which was the primary task in the first pilot study. In the second pilot study, four different chat tools were examined: a free (standard) chat, a chat with a 30-second delay after sending a message, a chat with a speaker queue, and a so-called “bubble” chat tool, in which the production of a message can be viewed by all participants in a letter-by-letter fashion. Results from this pilot study show that the design of chat tools clearly influences the communication patterns. For instance, free chat generates the most message entries, but also the shortest messages with lowest efficiency (amount of words in relation to exchanged information) and often parallel writing activity.

In the project, a variety of secondary task software programs (which run independently of primary task software programs), 7 different chat tools, and software for analyzing coded chat transcripts according to the information sampling problem in the “murderer game” were developed on the basis of existing software previously developed at IPSI.
Future Research
The measurement of cognitive load by a secondary task might be “noisy” in the present study, since participants actively engage in the communication process. Deliberate decisions for active engagement, as well as motivational factors and the influence of other skills, such as experience with CMC and typing skills, may also play an important role in the information processing of an active participant. For the same reason, the reading span might not turn out to be a predictive measure. Therefore, all group communications are screen-recorded in the present data collection. A reading study is planned, in which participants follow the group communication without activity being engaged. The measurement of cognitive load and the influence of the reading span might be more reliable in a reading study, since the primary task of reading is less open to the various factors causing “noise” during active communication. Nevertheless, in the present study, the individuals’ processing of information, as well as their ability to recall information from the conversation after the group discussion, are closely examined, and the design factors of the software tools are analyzed with respect to the efficiency of information exchange and the communication patterns.

Research Output
Due to the short period of time this project has been running, there are no publications at this time.

Funding Period
November 2003-2005

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Process Gains and Process Losses for Knowledge Integration in Computer-mediated Groups

Goals
The scope of this project is to investigate the potentially facilitating effects of socio-technical devices on information sampling, knowledge integration and decision quality in computer-mediated groups. In contrast to the common approach in this field of research, which mainly aims at imitating face-to-face communication features when trying to support decision-making processes in CMC groups, we pursue a different approach: Relying on the specific task demands and the unique features of CMC, we develop and analyse socio-technical configurations, which particularly promote computer-mediated information pooling and decision making.

Background
The broader theoretical framework of this project encompasses process losses and gains in groups. We point out that the original concept of process losses (Steiner, 1972; Stroebe & Frey, 1982) needs to be differentiated with regard to process losses during knowledge integration. Precisely, three components of process losses – motivation losses, coordination losses, and information losses – need to distinguished. Information losses, the newly introduced component, are independent from motivation and coordination losses. That is, there might be groups, which are motivated and coordinated and still suffer from information losses, which might be due to e.g. group members’ limited memory capacities or time restrictions applied to the task at hand.

With regard to decision-making tasks, the separate conceptualisation of information losses is of major importance, since, in this scenario, information represents the key resource for successful task completion. Although group decisions should be superior to individual decisions, particularly when the group’s information pool is highly diverse and there is a high percentage of so-called unshared information (information that is known only by individual members), the so-called Information Sampling Bias in group
discussions – and consequently sub-optimal group decisions – has been amply demonstrated (e.g. Schittekatte & Van Hiel, 1996; Stasser & Titus, 1985, 1987; Stasser, Vaughan & Stewart, 2000; Winquist & Larson, 1998).

In numerous studies comparing the decision-making effectiveness of FtF and CMC groups, CMC groups proved to be inferior (for a recent meta-analysis, see Baltes et al. 2002), but it might be criticized that in these studies, imitating FtF conditions instead of explicitly building on the promising features of CMC is usually attempted. Building on the task-technology fit model (Dennis, Wixom, & Randenberg, 2001) and the Time-Interaction-Performance model (McGrath, 1991), Piontkowski (2002) proposes the task-interaction-requirement model, which elaborates the relationship between the task-oriented stages and the appropriate interaction processes. Thus, this model also provides guidelines for the development of specific technical configurations to diminish process losses in decision-making CMC groups (see below).

**Project Work**

In the first project phase, we dealt with information losses (see 1st documentation), whereas in the current phase, we primarily concentrate on different causes of coordination losses and interventions to accommodate these losses in CMC groups. Difficulties in turn-taking management, unequal participation of group members, structural communication patterns or lack of coherence in the discussion can all lead to coordination losses. We addressed each of these causes separately in four experimental studies. In all of the experiments, we applied a group decision task structured as a hidden profile. That is, each member’s information profile is not representative for the group’s total information profile. Only by thorough information exchange and sufficient consideration of unshared information can the optimal decision alternative be disclosed. In Experiment 4 (Experiments 1 – 3, see 1st documentation), different participation rates were induced by providing group members with different “accounts” of turns (equal accounts, unequal accounts, no accounts). This factor was crossed with the factor communication media (electronic chat, videoconference, face-to-face). In Experiment 5, we first varied the communication pattern. According to Leavitt (1951), the groups’ network was completely connected (decentralized) or communication paths of two members were
blocked; that is, these groups communicated via a central position. Second, the factor structuring aid was varied: Groups either had a whiteboard at hand for the purpose of highlighting the decision-relevant information or they did not have such a whiteboard at hand. As a third factor, communication media (electronic chat, face-to-face) was varied. In Experiment 6, different sequencing principles of message production and reception were investigated. Five levels of this single factor were operated by respective chat variants. In the so-called “floor-control” – condition, message production was controlled at the group level; that is, only one member at a time could “hold the floor” (i.e., type a message). If one member was typing, the other members were prevented from simultaneous production – they could only watch the emerging message and get the floor when the message was finished. In another condition, production and reception phases were switched at the group level. All at once, members could either only type or read. In a third condition, this sequencing principle was coupled with a request for the individual member to evaluate the other members’ messages after each production phase. In a fourth condition, the production and reception rhythm was adapted to the individual member: As long as he/she was typing, the entry for new messages were blocked. Not until he/she had finished typing did the messages written in between that phase appear. Finally, there was a control condition without any intervention. In Experiment 7 (about to start), coherence management will be varied with the aid of two chat tools. One tool asks group members to categorize their own messages as referring to one of eight predefined content classes before sending them. Another tool prompts the groups to establish their idiosyncratic coherence pattern in a tree structure.

Central dependent measures are information exchange (Which shared/ unshared information items are disseminated (and repeated) during discussion?) and knowledge integration (Which information is used to argue for the group decision after discussion?). Concerning the latter, information gain is of particular interest (To what extent do the members learn unshared items they had no access to prior to discussion?). Furthermore, recognition performance (Do the members recognize post hoc which items were discussed? And are they able to differentiate who (self or others) brought up which information?) and decision quality (correct consensus) are measured. At the present
time, Experiments 4 to 6 have been conducted and chat/discussion protocols completely coded. Data analysis is underway and a selection of results will be reported below. Experiment 7 is technically fully developed and data collection is about to start.

Results

Contrary to our hypothesis, participation (in)equality did not affect decision quality. Neither in the CMC groups nor in the FtF groups (videoconference or unmediated communication) did participation rates have an impact on finding the correct hidden profile solution. However, in accordance with another hypothesis, communication media significantly influenced decision quality: Videoconferencing and FtF groups (no difference between these media) were more successful than CMC groups.

With reference to Experiment 5, an interesting interaction effect turned up: In CMC – groups, a centralized communication pattern did promote the proportion of discussed unshared information (relative to the information discussed in total), whereas in FtF – groups, this proportion was better when they communicated in a decentralized way. A similar pattern of results was obtained for the absolute frequency of discussed unshared information; that is, information sampling was most successful in the centralized CMC groups. However, this advantage was not reflected in the group decisions. Decision quality was not affected by either communication pattern or communication media. The results of the subjective coordination losses strengthen the impression that centralizing communication is an appropriate means to facilitate coordinated information exchange in CMC –groups, but inappropriate for FtF groups. A possible explanation refers to a different handling with of the information load of the central persons in the two communication media. We got hints from the data that the central persons indeed struggled with more information load than the peripheral persons. We assume that the central CMC persons could handle this challenge better than the central FtF persons, since the latter had no external store for the discussed information.

In Experiment 6, significant differences with regard to the amount of discussed information were found: In the condition without any sequencing, more unshared and shared information were discussed than in the other conditions. However, obviously, the separation of production and reception at the group level represents a beneficial
condition for knowledge integration, precisely for information gain: Although less unshared information is exchanged in this condition than in the condition without any sequencing, more unshared information (originally not in the personal text profile) is utilized when arguing for the group decision.

**Future Research**

In the third research period of this project, the focus will be on cognitive-motivational factors that influence the readiness to incorporate new information, to re-evaluate information and to shift individual decision preferences. The interdependence structure (cooperative vs. mixed motive), the framing of the task (critical norm vs. consensus norm) and the initial preference constellation in the group (heterogenous wrong vs. homogenous wrong) are some of these factors. Furthermore, in subsequent experiments, we want to gather empirical evidence on how an optimal fit between the task-oriented stages and the technically supported interaction processes – according to the task-interaction-requirement model (Piontkowski, 2002) – can be achieved.

**Research Output**

**Publications**


Conference contributions

Funding period
November 2002 – October 2004

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