Solving the Case Together: The Challenge of Net-based Interdisciplinary Collaboration.

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Abstract Process and outcome of a net-based collaboration between experts from different fields (advanced medical and psychology students) were analyzed. Confronted with a psychiatric case study, dyads were asked to jointly formulate a therapy plan using their complementary expertise. The goal of the study was to investigate the effects of technical realizations of a net-based collaboration on the collaborative processes and their efficiency. Two net-based settings were compared: (1) a high-end videoconferencing system with a shared text-editor and (2) a more "conservative" system, including e-mail, personal text-editors, and an audio connection (via telephone). In both settings scripted was compared to unscripted collaboration. With regard to the quality of the joint solution, participants in the condition with telephone and e-mail significantly outperformed their counterparts using the videoconferencing system. A more detailed analysis revealed that the coordination of the collaboration was central for the quality of the problem-solving process and its outcome. Participants in the condition with telephone and e-mail managed to coordinate their collaboration very well, combining individual, discipline-based working phases with phases of interdisciplinary collaborative work. On the other hand, the videoconferencing system, providing a better environment for collaborative activities, seems to have inveigled participants to work jointly all the time. The relevance of the coordination is corroborated by the effect of the induced script: participants with scripted collaboration produced better solutions than without.

Keywords computer-mediated communication, interdisciplinary collaboration, coordination of collaborative work, CSCL

Introduction

In many domains the enormous and rapid growth of domain-knowledge, in combination with an ever increasing specialization of this knowledge, results in a growing need for interdisciplinary collaboration. Experts from different fields of expertise are challenged to work together in order to succeed in solving the tasks at hand. As a result of this development, the investigation of collaboration between spatially distributed experts from different fields, as well as the possible promotion of such collaboration, move in the focus of research activities. In addition, the dynamically evolving technological solutions for net-based (computer-mediated) communication further the possibility of a collaboration across barriers of distance and time. In principle, the promotion of net-based collaboration can take two directions: an improvement of the collaborative setting and, on the other hand, a furtherance of the competence of the people involved.

Collaborative Problem-solving and Learning

The pooling of *shared* (information, common to all members of the group) as well as *unshared* (accessible only to individual members of the group) information is one of the crucial aspects of successful collaborative problem-solving and decision-making. However, groups often tend to rest their decision on the already shared portion of the knowledge, while neglecting those parts uniquely held by members of the group (Stasser & Titus, 1985; Larson, Christensen, Franz & Abbott, 1998). Thereby groups often miss the opportunity to make a more informed decision than possible for the individual member.

The failure of collaborating partners to pool their unshared knowledge resources is even more devastating given a situation where the individual group members are mutually dependent on each others knowledge in order to be able to successfully complete the group task (Johnson & Johnson, 1992). Such a situation is, for example, given in the case of "complementary expertise" as will be described later. Meta-knowledge about the own expert status and mutual recognition of expertise, as well as explicit assignment of expert roles at

the onset of the collaboration have shown beneficial effects on the pooling of unshared information, and in consequence on the quality of the results of the collaboration (Stasser, Stewart & Wittenbaum, 1995).
Learning and knowledge acquisition in collaborative problem-solving settings have shown to bear on two components: (1) the mutual transmission and pooling of knowledge, and (2) the joint elaboration of knowledge (Kneser, Fehse & Hermann, 2000). Given that the previous knowledge of the partners is sufficiently divergent (unshared), the collaborative setting offers an excellent opportunity to learn from one another. While the collaborating partners expound their opinions to each other, for one, they exchange knowledge. Furthermore, the necessity to make it explicit, leads to a constant elaboration of the knowledge during the interaction. Roschelle (1996) has described the processes of learning during collaboration as a cycle of ”convergent conceptual change”: the partners exchange ideas, evaluate them in discourse, make corrections and finally establish convergence.

Net-based Collaborative Problem-solving

For many years, research in group-collaboration as well as social construction of knowledge has concentrated on face-to-face interaction. However, in the nineties net-based (computer-mediated, computer-supported) collaboration has increasingly attracted attention.
In the discussion about net-based collaboration, realizations of ”net-based” have been distinguished on several dimensions, like ”communication channels” (e.g. text-based, audio, audio-video), ”time” (synchronous vs. asynchronous), ”access” (open vs. closed), and ”group size” (point-to-point vs. multi-point).
Text-based settings enable the partners to communicate only in writing. Such collaboration may be realized in a synchronous (all members of the collaboration are present online at the same time, e.g. chat-rooms, shared text-editors) or asynchronous (e.g. e-mail) manner. A central problem of solely text-based settings is the increased expenditure of the collaboration, due to the lack of nonverbal and paraverbal clues in such settings (Gräsel, Fischer, Bruhn & Mandl, 1997, Hiltz, Johnson & Turoff, 1986) and the increased communication costs (Clark & Brennan, 1991). Affected are, for example, turntaking during the communication, giving of feedback about reciprocal understanding, and social *grounding* processes (Baker, Hansen, Joinier & Traum, 1999; Hesse, Garsoffky & Hron, 1995).
In the course of recent technological developments, a second group of net-based collaborative scenarios has gained in importance: desktop videoconferencing systems, providing video- and audio-connection. Naturally, such systems support a synchronous form of communication and collaboration. Despite considerable technological improvements, also in videoconferencing systems the expenditure of collaborative activities is still increased. Delays in the transmission of sound and picture over the audio-video-connection, may cause breaks or overlaps in the structure of the communication Further, the exchange of nonverbal and paraverbal clues remains impeded (O’Connaill & Whittaker, 1997).
However, findings suggest that people participating in net-based collaborations tend to employ effective strategies to compensate for the increased expenditure of the interaction (Black, Levin, Mehan & Quinn, 1983; Gräsel et al., 1997). Further, net-based collaborative problem-solving and learning can efficiently be supported externally. For example, it was demonstrated that strategies known to be effective in facilitating face-to-face collaboration (Cohen, 1994; Dansereau, 1988), can be similarly suitable for net-based settings. Structuring the cooperation externally (scripted cooperation), Hron, Hesse, Reinhard & Picard (1997) found a decrease in the expenditure of the collaboration, resulting in more effective dialog as well as an improvement in the joint problem-solving and knowledge acquisition. Other possibilities for external support lie in the design of the collaborative environment (e.g. interactive graphic tools).
In sum, the difficulties of net-based collaboration should not lead to disregard the potential of such environments. As one of their most salient features, they enable people to communicate and collaborate across barriers of distance and time. Specifically in regard to the aforementioned trend towards collaboration among spatially distributed experts, this appears to be a great advantage of net-based collaborative settings. As Dede describes, ”Most people prefer face-to-face interaction, but find the convenience of just-in-time, anyplace access to others often outweighs the disadvantages of distributed sharing of ideas, experiences and support ” (Dede, 1996). Furthermore, it has to be recognized that, regardless of the difficulties arising in such environments, net-based technologies are increasingly employed for communication and collaboration in many areas from educational to corporate settings. Especially with

regard to the future of university education, emerging net-technologies will rapidly change the face of learning and instruction .

Interdisciplinary Collaboration on the Basis of ”Complementary Expertise”

Interdisciplinary collaboration (collaboration between people from different fields of expertise) is considered to be the key to a successful exploration of complex phenomena, where taking into account only one perspective falls short (Gibbons, Limoges, Nowotny, Schwartzman, Scott & Trow, 1994). However, at the same time interdisciplinary collaboration is not an easy undertaking. Problems known to be symptomatic for collaborative learning and problem-solving in general (e.g. instantiating and sustaining ”convergence” (Roschelle, 1996), coordinating the collaboration, and the pooling of unshared knowledge) apply to a great extent similarly to interdisciplinary collaboration (Thompson, Klein & Porter, 1990; Weingart, 1997). Bromme and his co-workers have presented several studies dealing with the communication between experts from different domains and the difficulties arising in such collaboration (for examples see Bromme, 1997; Bromme & Nückles, 1998, about the communication between medical doctors and nurses in oncology).

Interdisciplinary collaboration given a situation of ”complementary expertise” can be characterized as follows: the partners of the collaboration complement one another in that each of them possesses a relevant part of the unshared knowledge. In other words, each of the partners is a ”novice” in the other’s domain, at the same time being ”expert” in his own. This is an interesting basis for knowledge communication from the perspective of computer-supported problem-based learning (Koschman, Kelson, Feltovich & Barrows, 1996), because each party in the collaboration becomes to be ”teacher” and ”learner” at the same time. Teacher, in that he contributes to solving the case from his area of expertise, and learner in trying to understand the propositions made by the other expert. It can be concluded that complementary expertise offers a prolific and promising ground not only for problem-solving, but also for collaborative learning.

To ensure efficient work under such circumstances, it is crucial to coordinate the collaborative process. Hereby, coordination has to serve several goals: to specify the objectives of the work, to arrange the division of tasks between the partners, and to manage interdependencies of activities as well as their chronological order and their temporal synchronization (Malone & Crowston, 1990). Central goal of the coordination is to ensure the consistency of the work product which means to integrate partial solutions of the partners.

To what extent collaborating partners meet these demands is influenced by features of the tools for communication and collaboration. The expenditure of the communication (Clark & Brennan, 1991) the support of specific collaborative task activities by the system (e.g. by providing joint editing in a shared text-editor), and in general, the difficulty of system usage might foster certain work-activities while restraining others and therefore lead to different collaboration structures.

Experiment

The goal of the present study was to investigate the effects of different technical realizations of the net-based setting on the collaborative processes and their efficiency. Two different settings were compared: (1) a high-end videoconferencing-system, providing an audio-video- connection, a personal text-editor for each partner, and a shared text-editor. (2) a more “conservative” system, including e-mail, two personal text-editors, and an audio connection (via telephone). While the first setting was designed to provide participants with a maximum of communicative possibilities and collaborative powers, the second scenario was considered to be closer to what is common in today’s every-day interactions, at the same time trying to avoid at least some of the difficulties described for solely text-based settings by providing an audio-connection. On the one hand, it was expected that the efficiency of the collaboration is increased by using a shared application and a videoconferencing system, because these tools support joint activities like discussion and joint writing. However, the facilitation of the collaborative work could also affect the coordination of the collaboration negatively: less task division and individual work could result.

As collaborative task, the solution of a psychiatric case study by advanced students of psychology and medical science was chosen. The main coordination demands of this task are to identify and sequentiate different types of activities (i.e. content-related discussion and decisions, writing text) to identify which

parts of the task have to be solved together and which can be dealt with individually. Furthermore, it is relevant to find a good sequence for the different activities and to manage time constraints.

Method

32 dyads of paid volunteers (45 female, 19 male), all students at the University of Freiburg (Germany) participated in the study. The median age was 25. Each dyad comprised a medical student who had already attended psychiatric courses and a student of psychology who had taken courses in clinical psychology. The partners of each dyad met each other during an initial welcoming phase but stayed in different rooms during all following phases of the experiment. Participants were given a technical instruction including exercises for the use of all the relevant features of the communication and editing tools. Next, they had 10 minutes to gain an overview of the task material. With regard to the collaborative phase, participants were instructed to finish their work after about 110 minutes. However, this was not treated as a strict time limit. After finishing the collaborative task, the participants were asked to complete a short questionnaire.

Task and Material

The collaborative task was to work out a therapy plan for a patient suffering from major depression. The dyads of participants were instructed to develop a joint solution and to formulate a therapy plan in written form giving explications and arguments.

The description of the psychiatric case included information about current physical and psychological symptoms, the present living situation as well as details on the personal and medical history. Psychological and psychopharmacological treatments already prescribed were indicated. As an orientation for what should be covered by the joint solution, participants were given several questions concerning the therapy to be planned. They were also offered instructional texts about psychological and psychopharmacological treatments.

Treatment

A 2 x 2 design with eight dyads of participants in each cell was used varying the following factors: (1) Two net-based collaborative settings with different communication channels were compared and (2) A condition with prescribed collaboration phases (scripted collaboration) was compared with an unscripted condition. The effects of the different net-based settings were of special interest in this unscripted collaborative condition.

Two net-based collaborative settings. As mentioned before, the two net-based settings realized in this experiment were: (1) Telephone and e-mail: the first environment consisted of a telephone with a hands-free speaking system and a text-editor system which comprised a file-exchange device (similar to e-mail). (2) Videoconferencing system and shared text-editor: the desktop videoconferencing system provided a video window displaying the partner's face and an audio channel. In addition to the file exchange device described above, in this condition a shared text-editor presented the joint file to both partners and allowed on-line simultaneous editing.

Scripted and unscripted collaboration. In the scripted condition, specific phases were prescribed for the collaboration, with the goal to foster an optimal coordination of the collaborative work: (1) First, the two partners were instructed to individually produce a preliminary version of those parts of the therapy plan, that pertained to their field of expertise. For example, the medical student had to sketch a preliminary solution of the psychopharmacological treatment and related topics, while the student of psychology had to work mainly on the plan for the psychotherapy. (2) In a second phase, the partners were instructed to exchange their preliminary solutions and to analyze their partners' proposals. Subsequently, they were given a set of questions, asking them for their opinion on their partners' proposals (e.g. whether they were in line with their own suggestions). The answers to these questions were also exchanged in order to encourage content-related discussion. (3). In a third phase, the partners were asked to discuss their suggestions and to agree upon a joint plan. (4) A fourth phase was designated for individual work on the final text. (5) In the final phase, the partners were supposed to work collaboratively to integrate the individual parts of the text into a complete and well explicated solution. This scripted collaboration was compared to an unscripted one.

Table 2. Quality of Final Solutions

	telephone, e-mail, and personal text-editors	videoconferencing, e-mail, and shared text-editor
unscriped	.40	.34
scripted	.46	.39

Notes. Mean percentages of criteria met.

Dependent Variables

Quality of the final solution. To measure the quality of the solution with regard to content, two experts on depression-therapy developed a system of criteria for the case study. This system included 50 items covering medical and psychotherapeutic aspects of the therapy plan (e.g. type, focus, and sequence of treatments, objectives of the therapy).

The collaborative process: Pattern and sequence of individual and joint phases of work. To gain information about the collaborative process, videotapes and log-files were analyzed. Minute by minute it was recorded, whether the partners talked with each other, whether they used the personal or shared text-editors, whether text was typed, and whether e-mails were exchanged. In order to identify different phases in the collaboration, for each dyad of participants these data were depicted in a diagram showing the sequence of activities over time. Table 1 shows the results for one of the dyads with unscripted collaboration in the condition with telephone and e-mail.

Time. It was recorded how long each dyad worked on the case study.

Results and Discussion

Quality of the final solution. The scores for the quality of the final solution (c.f. table 2) showed significant differences: the solutions in the telephone and e-mail conditions turned out to be significantly better (M = 43 percent of criteria met) than solutions produced using the videoconferencing system and the shared text-editor, M = 36%; $F(1,28) = 5.71$, $p = .02$. Furthermore, the dyads produced better solutions if the collaboration was scripted (M = 42%) as compared to the conditions without cooperation script, M = 37%; $F(1,28) = 3.79$, $p = .06$. For the quality of the final solution no interaction was found between net-based settings and scripted collaboration.

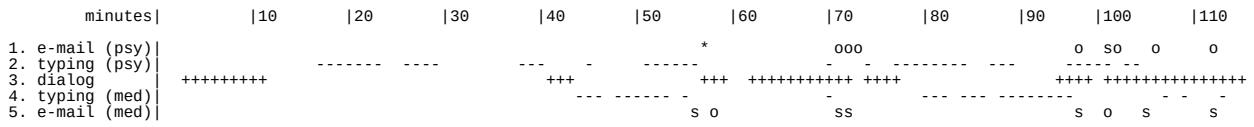
The advantage of the condition with scripted collaboration can be explained by the explicit task division and seperation of activities which resulted in an optimal sequence of individual and joint working phases. Also the elaboration of the partner's preliminary proposals might have increased the quality of discussion. At least in the unscripted conditions the differences between the two net-based settings can also be illuminated by looking at the collaborative process itself.

The collaborative process: Pattern of sequence of individual and joint phases of work. In the conditions with unscripted collaboration some dyads showed clearly seperated phases of discussion, individual work, and collaborative writing or editing of texts, while other dyads of participants worked together all the time. The work patterns were classified into two types: (1) Patterns showing long-lasting phases of parallel individual work without dialog as well as extended phases of dialog activity (Table 1 shows an example of this type of collaboration). (2) Patterns showing dialog activity over the entire collaboration and no parallel individual work with text-editors.

In the condition with telephone and e-mail and with unscripted collaboration, all of the eight work patterns were classified as type 1. In contrast, only four of the dyads of participants using the videoconferencing system and the shared text-editor were categorized as type 1, the other four as type 2. This difference in frequencies was significant, $\chi^2(1, N = 16) = 5.33$, $p = .02$.

These results indicate that dyads in the condition with telephone and e-mail tended to work collaboratively and individually, whereas only some dyads did so in the condition with the videoconferencing system and shared text-editor. The strong support of joint activities in this condition obviously kept some dyads from

Table 1. Diagram of Activities During Collaboration for Dyad 19



Notes. Dyad 19 collaborated unscripted in the condition with telephone, personal text-editors and e-mail. For each minute of the collaboration the diagram indicates, which activities took place. The upper two lines display the activities of the student of psychology (line 1: sending and opening e-mails, line 2: typing). The bottom two lines display the activities of the medical student (line 4: typing; line 5: sending and opening e-mails). Line 3 shows the dialog between the two partners. The following symbols were used to code activities:

+ dialog
- typing in an personal text-editor
s sending an e-mail to the partner
o opening an e-mail sent by the partner
* sending and opening of e-mails in the same minute

task division and working individually. This might be one of the reasons for the lower quality of final solutions in the videoconferencing condition: dyads that did not work individually at any time (Type 2) produced poorer solutions (M = 31 percent of criteria met) than dyads working both, jointly and individually (Type 1: M = 39%). This result is statistically significant, $t(16) = 1.89$, p = .04, one-tailed. It is in line with the result, that the scripted collaboration with phases of individual and joint work yielded better solutions. In both net-based settings with scripted collaboration similar patterns of individual and joint activities emerged. Except for one dyad of participants (condition: videoconference and shared text-editor) all patterns showed individual and collaborative work phases as prescribed by the instruction.

As already mentioned, we did not find an interaction effect between net-based settings and scripted collaboration on the quality of the solutions. This was unexpected, because we had hypothesized that the scripted collaboration should reduce the tendency to employ a suboptimal way of collaborating even in the condition with the videoconferencing system and shared text-editor. The time needed for the solution might be part of the answer.

Time. Participants using the videoconferencing system and the shared text-editor needed significantly less time to produce their final solution (M = 113 min) than participants using telephone and e-mail, M = 124 min; $F(1,28) = 10.08$, p = .00. The advantage of the videoconferencing condition can be attributed to the support of joint text editing using the shared text-editor. Dyads using this system had no difficulties to integrate parts of texts written individually. There was no significant difference between conditions with scripted collaboration (M = 117 min) and without (M = 120 min). Interestingly, least time (M = 109 min) was used in the combination scripted collaboration and videoconferencing system.

It is a central finding of this study, that the net-based setting providing a better environment for collaborative activities (videoconferencing system with shared text-editor) resulted—as expected—in shorter working time, but—at first sight surprisingly—in a lower quality of the problem solution. The shorter working time and the answers to the questionnaire which was completed by the participants at the end of the experimental session rule out the possibility that the richer setting was more difficult in usage: the difficulty to use the systems was judged nearly the same and the usefulness of the shared text-editor for writing the text of the final solution was mentioned several times.

The best explanation of this finding might be, that the richer setting inveigled some of the participants (at least in the unscripted conditions) to work jointly all the time and to neglect the necessity to coordinate individual working phases with phases of joint work. However, such coordination is of central importance for the quality of the problem solving process and its outcome. In particular, our task domain “clinical case studies” and similarly structured domains require to recall specific parts of the knowledge of the own discipline (individual, parallel working) and to apply it to the case in question (individual, parallel working) before integrating the discipline-based preliminary solutions into a joint interdisciplinary decision (joint work) and testing the joint solution with regard to consistency and possible side effects (individual or joint work).

Features of the net-based setting may promote or impede the coordination of this succession of phases. The relevance of this coordination is corroborated by the results on the effect of a cooperation script. However,

while a prescription of coordination might work in experimental settings it is not a very promising strategy in practice. Therefore, we currently pursue the goal to have experts acquire collaborative competence in a new project funded by the German Science Foundation as part of the priority program "Netbased Knowledge Communication in Groups". For example, this is done by providing them experience with ideal examples of dyads of complementary experts solving analogical cases.

Acknowledgements

This research was supported by grant from the German Science Foundation (DFG) to the first author within the Virtual Ph.D. Program (VGK) "Knowledge Acquisition and Knowledge Exchange with New Media", which is described in this volume (Plötzner et al. 2001), and to the third author within the priority program "Net-based Knowledge Communication in Groups". We thank Michael Fromme and Bernd Böker (Lehrgebiet Rechnernetze und Verteilte Systeme, University of Hannover), Oliver Müller and Michael Stumpf for the technical support.

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