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THE ROLE OF EXPERT AND NOVICE TUTORS IN COMPUTER MEDIATED AND FACE-TO-FACE PROBLEM-BASED LEARNING

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This study investigates the role of tutors in face-to-face as well as computer-mediated problem-based learning. This study examined whether or not a tutor should use his or her expertise in facilitating small group problem discussion practiced in classroom or in synchronous computer-mediated communication. In one experimental condition, the tutor acted as a moderator providing no information regarding the presented problem. In the second condition, the tutor contributed his expertise, corrected wrong statements, or answered directly to questions. Results suggest that learners assessed the setting more positively and achieved higher scores in a final test when the tutor imparted his knowledge. After the sessions, learners were asked how confident they feel regarding their status of knowledge in the learning domain. Results showed that they were more confident in the moderated condition. The outcomes suggest that intensive tutoring can help to overcome several problems in computer-mediated distance education.

Keywords: Problem-based learning, tutoring, group facilitation, computer-mediated communication

1. Introduction

The current paper focuses on the role of tutors using small-group problem-based learning (PBL) in face-to-face as well as computer mediated communication. The basic principles of PBL—which has its origin in medical education at McMaster University in the early 1960s—can be summarized as follows (e.g., Barrows, 1985): learning in small-groups is reinforced through authentic and ill-structured problems. At the beginning of a PBL-unit, a problem is presented that is suited to initiate discussion among learners (e.g., Bannert, 1998; Schmidt & Moust, 2000). Learners discuss what they know about the problem and how to solve it. Students have to identify learning objectives and to bring together all the information they already have (Dolmans, Gijselaers, Schmidt, & van der Meer, 1993;

Dolmans, Schmidt, & Gijselaers, 1994). Meeting one another and discussing the problem always takes place in small-groups (Barrows, 1985; 1988; Barrows & Tamblyn, 1980). Providing a well-designed problem, the group members have to identify (1) which problems to address, (2) possible learning objectives, (3) how a problem can be solved, (4) distribution of single tasks among group members, and (5) the location of possible resources relevant for problem-solving. This collaborative task is a crucial phase in the whole process. Hence, it should be supported by a tutor supervising the learners' progress as well as the group functioning (e.g., Barrows, 1988).

After the initial discussion, students have to search for necessary information in order to reach the objectives. Collecting information usually takes place in an individual learning phase.

A PBL-unit ends with a final discussion about the problem, again facilitated by one or more tutors. At this point, results ought to be presented in a structured and organized way including a rationale. Each student is invited to present his or her own work concerning the learning objectives. Learners are also required to reflect critically on a) their own and others` contributions, b) the learning process, c) experiences during the problem-solving process, d) other possible solutions, and e) their learning progress (e.g., Schmidt, 1983; 1993).

If the task has not been solved, the whole cycle starts from the beginning until an acceptable solution has been reached. When one problem has been solved, the next one will be presented. If a course or a curriculum is designed according to the principles of PBL, almost all learning objectives will be accomplished by learners through solving problems presented within the syllabus (Engel, 1997; Ross, 1997).

Not all problem-based learning groups (or other task-oriented groups) are effective. But what factors determine successful and less successful learning groups? In his TIP-theory, McGrath (1991) suggested three major factors determining success besides many other propositions about the nature of task oriented groups: Groups have to fulfill synchronously functions of well-being, member support, and the production outcomes of the group process. Research on cooperative and collaborative learning has shown several benefits of cooperation on social and cognitive outcomes compared to individual or competitive learning (for an overview see Johnson & Johnson, 1996, 2004). But sometimes groups are not able to work in an effective manner (cf. Barron, 2003). Hirokawa (1983) presented a model of factors that have negative impact on effective group processing. These factors include misunderstanding of a problem situation, acceptance of wrong information, rejection of correct information, underestimation of negative consequences, and overestimation of positive consequences of group decisions etc. that lead to insufficient problem-solving strategies within groups. Furthermore, issues of gender can influence group climate (Kaplowitz & Block, 1998), group size can have an impact on learning strategies (e.g., Lohman & Finkelstein, 2000), and reward system can impact attribution style and learning outcomes (e.g., Slavin, 1995). Some of these factors can be influenced by instructional design, some of them not, especially in cases of ad-hoc groups. A human tutor can potentially mediate between disturbing factors and

their interactions and reduce negative impact on groups' problem solving capabilities and strategies.

Tutors in problem-based learning environments have to fulfill such mediation functions during small-group discussion, as well as other task-oriented functions (such as acting on metacognitive guides). Those other mediating functions refer to facilitating cooperation and collaboration amongst students. As PBL is a learner-centered approach, tutors are not and *should not* be like teachers in a traditional lecturing setting. Their primary function is to work as a didactic leader and to guide learners through their knowledge acquisition processes. Common possibilities to support students are, for example, to ask questions in order to stimulate discussion and elaboration, to organize group sessions, to provide learning resources etc. (some practical advice is provided e.g., by Fogarty, 1997, and Salmon, 2000). Beyond these basic assumptions, the question arises about what determines successful vs. less successful tutoring during small-group discussion.

2. Analyzing Tutor Characteristics During Problem-Based Learning

Obviously research about tutoring is not only related to problem-based learning. Chi, Siler, Jeong, Yamauchi, and Hausmann (2001) investigated the effectiveness of tutoring in dyadic settings. They tested three hypotheses which were all possible explanations for knowledge acquisition processes during tutorial facilitation: First, the *tutor-centered pedagogical hypothesis*, where the tutor's role is to monitor and control a session. In this scenario, the tutor primarily acts as an expert concerning the content that has to be learned. The tutor guides the student systematically by providing feedback about the learning content. Second, within the *student-centered constructive hypothesis*, focus is more on the learner. During a tutorial the learner is required to externalize his or her knowledge. By means of this, elaboration processes are enhanced. Third, the *interactive coordination hypothesis* states that there is a constant interaction between learners and tutor. The tutor's and students' contributions are regarded as speech acts that evoke each other: the tutor's comments are followed by an answer of the learner; answers of the learner are followed by answers, questions or comments of the tutor and vice versa. Such an interactive knowledge construction seems to be more effective than an individual externalization of knowledge such as during self-explanations (see also Constantino-Gonzales, Suthers, & Escamilla, 2003). Chi et al. (2001) found empirical evidence for all three hypotheses with all of the above mentioned processes occurring within a tutored session. Unfortunately, their findings are restricted to dyadic sessions although the transfer to group facilitation seems plausible. However, in order to investigate the role of a tutor during problem-based small-group facilitation, further findings have to be taken into account.

A major research focus about tutors during PBL has been on the role of their expertise with regard to facilitation as well as on the role of their expertise in the learning domain. According to Barrows and Tamblyn (1980), a tutor has to be knowledgeable in the field in order to guarantee effective supervision. They argued that only tutors with

expertise in the content domain are able to detect stagnation or wrong decisions within learning groups. Additionally, only a tutor knowledgeable in the learning domain would be able to redirect a group into a right direction. This will provide accomplishment of learning objectives of a course as well as possibilities of self-directed learning (similar to the tutor-centered pedagogical hypothesis of Chi et al., 2001). But content expertise is not enough as Barrows stated eight years later. He demanded additional competence of tutors (1988, p. 44): "There is no question that the ideal situation is for the tutor to be an expert both as tutor and in the discipline being studied by the students … if this is not possible, the next best tutor is the teacher who is good at being a tutor, as described here, though not an expert in the discipline being studied." A combination of both, competence in leading a learning group and content expertise, seems to be ideal. As this combination is not always available, Barrows (1988) suggested that if choice is necessary, moderation skills should be preferred over content-expertise. The most negative combination is in his opinion a person "who is an expert in the area of study, but a weak tutor" (p. 44). Interestingly, this approach is similar to McGrath's (1991) taxonomy of group functions: Tutors' interventions in small group learning should not only focus on the group function, but also on dimensions of group well-being and group's member support function. Thus, tutors do not only have to fulfill a cognitive but also a metacognitive (guiding students in their learning process and progress), motivational, and emotional function (cognitive and emotional member support and group well-being).

The considerations of Barrows found support in some research papers. Empirical research related to tutoring in PBL mostly compared tutors with different characteristics. Above all, such studies investigated influence of peer versus staff tutors as well as tutors with and without expertise in the learning domain. Schmidt (1977, cited in Schmidt & Moust, 2000) compared tutors with and without content expertise. He compared groups led by expert tutors with groups led by non-expert tutors with regard to learners' performance in their final exams. His analysis revealed no significant differences between both types of tutors. Learners that performed best were tutored by a person that was not an expert in the area of the learning domain (Schmidt & Moust, 2000). Similar results have been found by Regehr et al. (1995). Other studies found advantages of tutor expertise on students' knowledge acquisition. They also showed a direct connection between the tutors' knowledge of the discipline and the tutors' behavior: tutors with expertise asked more stimulating questions and gave more explanations, especially when a synthesis of different fields was required (De Volder & Schmidt, 1982, cited in Schmidt & Moust, 2000; Schmidt, Van der Arend, Moust, Kokx, & Bohn, 1993). Schmidt, Van der Arend, Kokx, and Bohn (1994) also analyzed the influence of tutors' characteristics on learners over several years. The highest impact has been found in the first year of (medical) education followed by a steady decrease of influence until the last year of education (a replication of these results is provided by Schmidt, 1994).

Other studies investigating the role of tutors in PBL examined the role of peer vs. staff tutors. Schmidt and Moust (2000) found slight advantages of staff in comparison with peer tutoring on learners' academic performance in final examinations. Furthermore,

Moust (1993, cited in Schmidt & Moust, 2000) showed that staff-tutored students spent more time with self-directed learning. Steele, Medder, and Turner (2000) found a preference for peer tutors over staff tutors among students in their final years. The peer-tutored groups also seemed to work more effectively on problems compared to staff-tutored groups.

Inspired by their own findings as well as the need for an integrated model of tutoring influence, Schmidt and Moust (1995) developed a theory of effective behavior in tutors. In their theory, they emphasize the tutor's ability to understand current processes of a group's knowledge construction (*cognitive congruence*), as well as the ability to understand group dynamics whilst taking into account learners' needs and dispositions (*social congruence*). They tested their theory using a structural equation approach and found that content expertise and social congruence were strong predictors of cognitive congruence. But social congruence also had a strong impact on group functioning, as well as group atmosphere: a more informal way of tutoring is beneficial for enhancing learners' motivation and reinforces their active participation within small-group discussions (see also Silver & Wilkerson, 1991). Schmidt and Moust (1995) also found a negative effect of high-content expertise on self-directed learning. A possible explanation therefore is that learners tutored by an expert are often treated similarly to students in traditional lecture-based learning. This is unbeneficial for processes of self-directed learning where tutor's role is mainly restricted to guidance of the collaborative process (cf. Constantino-Gonzales et al., 2003).

Taken together, the research outcomes are heterogeneous, although it seems that good tutors integrate both content expertise and tutoring competence (de Grave, Dolmans, & van der Vleuten, 1999; Maudsley, 1999). However, keeping the balance between group facilitation and lecturing is also very difficult as reported by Kaufman and Holmes (1998). They summarized "that tutors who are content-experts find it difficult to maintain the 'facilitator' role, but that those who maintain this role are more satisfied with PBL" (p. 255). However, the reported outcomes are all restricted to tutoring within traditional face-to-face settings. New approaches combining PBL with computer-mediated communication require other tutoring skills.

3. The Role of an E-Tutor

During the last two decades there have been some attempts to combine PBL with *computer-mediated communication* (*CMC*; e.g., Koschmann, Myers, Feltovich, & Barrows, 1994). While early attempts used local area networks, nowadays, Internet technology permits to take collaborative problem solving out of the classroom into the digital world. Meanwhile, there are several reports about synchronous as well as asynchronous *distributed PBL*-courses (*dPBL*) accessible on the Internet (e.g., Cameron, Barrows & Crooks, 1999; Strømsø, Grøttum & Lycke, 2007; Thomas, 2000; Valaitis, Sword, Jones & Hodges, 2005). Research revealed advantages as well disadvantages related to the use of CMC for distributed problem-based learning. Cameron et al. (1999) detected in their qualitative analysis of small group problem discussion via conferencing

software advantages of CMC regarding students' participation: CMC led to an equal distribution of comments among all participants. This is crucial because in face-to-face discussion many students remain passive or their participation is considerably lower than that of other more active students. Technology also enables each group member to provide an answer to each of the facilitator's questions in contrast to face-to-face sessions. In face-to-face sessions, mostly only one student is able to provide an answer before the next question will be posed. Furthermore, CMC provides an automatic storage of all students' and facilitators' contributions in problem discussion. This might enable new group members to build common ground related to the group more quickly.

There are also some major disadvantages of computer-mediated PBL due to the complexity of technology, learners' characteristics, and the interaction between them: Severe problems could derive from the human-computer-interface. Cameron et al. (1999) also reported learners' difficulties in navigation and scrolling in online discussion-boards or chat-texts. Obstacles like these can have a negative impact on students' concentration and/or their attention. Such problems as well as technical problems can reduce social awareness of collaborators and tutors. Thomas (2000) observed in his evaluation of an MBA-program using a dPBL course a drop-out rate of about 65% of students compared to a face-to-face course with a drop-out rate of only 10% (while the course was almost the same regarding objectives as well as material).

The exact causes for these problems reported by many collaborative online courses (not only dPB courses) remain hidden because many factors influence a learner's decision to leave or to stay in a course. One possible reason was provided by Dobson and McCracken (1997) who mentioned different problems that resulted from insufficient group facilitation. During CMC, the performance of online- or e-tutors in many cases do not meet the requirements of online-learners. Task-oriented groups (according to McGrath, 1991; see above) have to perform different tasks, functions, skills, and processes. In addition, they have to use specific knowledge in order to implement and maintain group cohesion and to reach the group goals. Most of the processes involved in each of these functions can be positively influenced by a tutor who is actively involved in the group process. However, due to the restrictions of CMC the requirements of *e-tutoring* are more complex than those of a face-to-face facilitator. Major limitations of typed text-based CMC compared to face-to-face discussion derive from media specific properties (for an overview see Olson & Olson, 2000; Romiszowsk & Mason, 2004). Deficit oriented CMC theories like channel reduction (e.g., Herrmann, 1991) or the cues filtered out approach (e.g., Kiesler, Sigel & McGuire, 1984) discuss such basic problems of text-based CMC like a lack of social presence (in face-to-face discussion usually generated by people filling a room) as well as difficulties related to *turn-taking* processes (cf. Herring, 1999). Obstacles to turn-taking, especially, are a major problem in CMC (also in distributed synchronous PBL, see Strømsø et al., 2007; Valaitiset al., 2005). Major burdens derive from difficulties on getting an overview about current topics and threads of discussion. Coherence building processes are much more difficult—especially in chat communication—because learners cannot recognize which thread of discussion is

currently focused on by a group, single (and possibly important) contributions elsewhere in a discussion are missed, or one's own contribution does not fit into a current thread or is not recognized by other learners, etc.

Taken together, the mentioned problems are obstacles to basic processes of *grounding* (cf. Clark, 1996). Learners in CMC-sessions are faced with difficulties building a common ground about all distributed participating learners within a group (on a cognitive level) as well as to establish a social grounding (cf. Clark & Brennan, 1991; Dillenbourg & Traum, 1996). E-tutoring can contribute to compensate or solve several of these problems.

Faced with such burdens, an e-tutor or e-moderator has to possess several qualities and characteristics. According to Rautenstrauch (2001), an *e-tutor* or *e-moderator* should be skilled on a face-to-face level, but in addition, has to meet the requirements of digital media. Taken together, tutors are required to be skilled in media competence, self-regulated learning, communication, collaborative learning, and instructional design. Similar requirements are reported by Salmon (2000): Tutors have to possess technical skills, understanding of online communication processes, online communication skills, (content-) expertise, and they should be able to understand learners' needs. In addition, Salmon (2000) emphasizes that technical issues and e-moderation are strongly connected with different levels of interactivity (starting with a basic access level and online socialization, continuing with information exchange about knowledge construction to further development of stable learning communities). Salmon's (2000) e-moderation model requires a large set of technical as well as interpersonal and instructional skills that altogether are quite challenging for an online tutor. Facilitation is necessary on all these levels in order to establish an appropriate group atmosphere and a meaningful knowledge communication (which is on an intervention level again similar to the concepts of group-well being and the production functions of groups according to McGrath, 1991). Furthermore, such behavior reflects the establishment of social and cognitive congruence according to Schmidt and Moust, 1995.

4. Research Questions

Taken together, the results from tutoring research as well as specific requirements of computer-mediated communication open a wide range of current and future research. In the present study we used a 2x2 factorial design, examining the role of tutors' knowledge as well as the role of the communication medium. Based on field research on expert versus peer tutoring, we investigated the influence of tutor characteristics (with and without expertise in the subject domain) in a controlled laboratory setting. We particularly examined cognitive and meta-cognitive outcomes as well as learners' subjective overall experience in problem-based small group learning. Which form of tutoring will have a positive influence on each of these outcomes?

Furthermore, we wanted to analyze the influence of computer-mediated communication on small-group learning outcomes compared to face-to-face learning, highlighting particularly the interaction of tutoring strategy and communication medium.

Which device would have a positive impact on cognition and social perception and which interaction would take place?

5. Method

5.1. *Participants*

The sample consisted of 48 participants, 34 psychology students and 14 participants from other courses of the University of Heidelberg. They were recruited by advertisement. As all majors of recruited students had traditional curricula, all participants had no experience in Problem-Based Learning. The mean age was 24.5 years (*SD* = 4.63). Three randomly selected participants formed a small-group, facilitated by one tutor. Participation was rewarded with 13 € or a study-relevant certificate stating participation in a psychological experiment of 2 ½ hours.

5.2. *Materials*

5.2.1. *The Communication Interface*

In this experiment, a major comparison was made between PBL using face-to-face (the face-to-face-condition) and computer-mediated communication for distributed Problem-Based Learning (the CMC-condition). For the CMC-condition we used the synchronous communication tool EasyDiscussing developed by the COLLIDE research group at the University of Duisburg (COLLIDE, 2003).

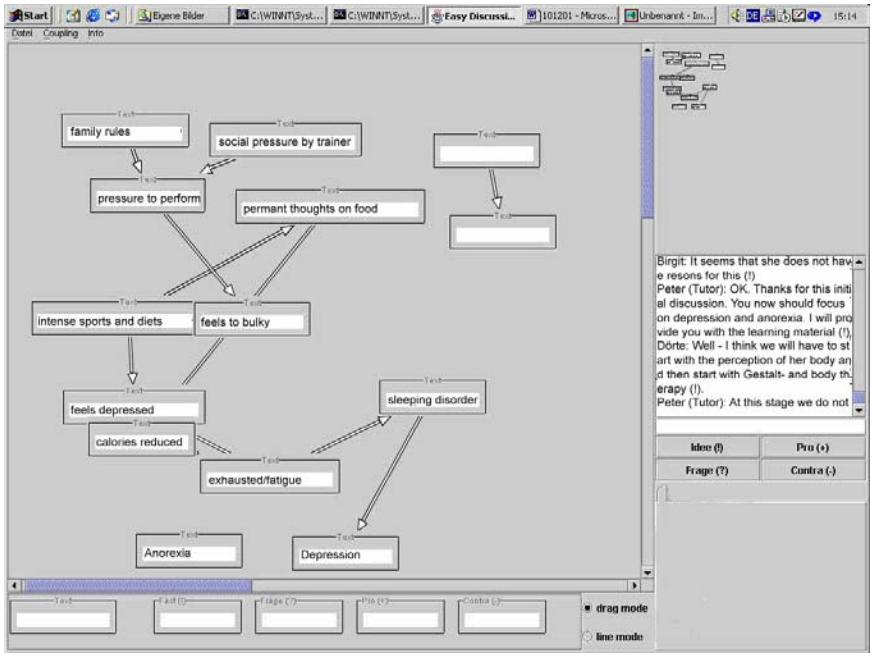

Figure 1: The communication platform *EasyDiscussing*

The JAVA-based tool enables synchronous collaboration by means of a shared workspace replicated via a central server. The interface of *EasyDiscussing* has different areas for different purposes. First, there is a chat tool on the right hand side of the screen. Second, there is an area on the left hand side that can be used as a shared whiteboard. Notes with text input can be dragged into that area and can be connected with arrows. Basic interactions like general discussions, decisions, or questions can be made either through the chat-tool or annotation notes in the shared workspace. The graphical representation within the shared workspace allows learners to make conceptual structures explicit and, thus, to support groups' collaborative learning process (cf. Suthers, Vatrapu, Medina, Joseph & Dwyer, 2007). In the CMC-condition, communication took place exclusively by application of this software. In the face-to-face condition, small group discussion was held in a traditional classroom using an "analogous" whiteboard with paper cards.

5.2.2. *Learning material*

The current investigation limits itself to the examination of a single problem scenario with the goal of analyzing the effects of the different treatment conditions. For this purpose, a problem from the field of clinical psychology was chosen. The problem itself was presented in text format on a computer screen:

> "Miss M., a single 23 year old woman is visiting your psychotherapy practice on a Monday morning. She looks desperate and has a petrified face. Her eyes are mostly looking to the floor. Miss M. is a college student in sport sciences graduating in the near future. Her study performance is between very good to excellent (her grades ranged from first class to upper second). Her main interest lies in rhythmic sport gymnastics, which she practiced since she was 5 years old. At that time, her mother had made her train in the local sports group. It was always important for her mother that all family members are active in sports. Miss M. always enjoyed doing rhythmic sport gymnastics. She also has participated at several contests where she has won several prices.
>
> At age 15, she started to work with a new trainer who said that Miss M. could be better if she would lose some pounds. This issue always has been a problem for Miss M. since she perceived herself as too fat. Her weight at that time was 58 kg, her height being 171 cm, which is considered to be normal. Driven by her trainer's remarks and her dissatisfaction, she started a strict diet and sports program. In addition to her daily training, she visited a daily course in aerobics five days a week. She banned sweets, snacks, fat meals and meat. Due to the intensive sports program, the relationships to her friends became more and more distant. During the last months she managed to reduce her weight to 44 kg but still perceived herself too fat. This made her very sad. For four weeks now she feels very depressed, worthless and unattractive. She has also lost her interest in all sports activities. The majority of the day, she is not doing anything. Her boyfriend – the relationship had lasted for two years- finished their relationship

> two months ago. He said that he could no longer stand seeing how she is mistreating and neglecting herself. Miss M. does not know what to do anymore. She feels so depressed that she is not able to concentrate on the final examination. Since she awakes several times at night, she is also very tired all day long. Life does "not make sense to her anymore". Her visit to your practice was finally initiated by her mother who told her that if she does not do anything, her examination and future career would be in danger."

Learning objectives with regard to this problem included knowledge about cause, diagnosis, development and therapy of depression and anorexia nervosa. Also, the learning goal was to establish connections between both disorders. The resources to solve the task consisted of passages of a study book for clinical psychology. These passages have been digitalized and were provided as an HTML-document (about 8,770 words).

5.3. *Data Acquisition*

In order to measure knowledge acquisition, a test with 25 items about depression, anorexia nervosa, and interrelations has been designed. 19 items of this test were presented in multiple-choice format; six items were open questions. The multiple choice questions were mainly designed in order to assess basic concepts of depression and anorexia as well as their interrelatedness. The open questions addressed issues of problem-solving by requiring participants to understand the interrelatedness of both disorders, the causes for the development of both disorders and implications on therapy. Thus, we addressed the nature of PBL by fostering problem-solving rather than teaching inert fact-based information.

In addition, a concept-mapping task was applied. In this task, the terms depression, cognitive therapy, pressure, negative thinking, symbolic loss, anorexia, depressive mood, wicked family relationships, lack of positive reinforcement, learned helplessness, lack of serotonin, distorted self perception, avoidance of calories, and MAO-blockers had to be connected with pointed arrows. Those arrows had to be labeled with "symptoms of the disorder", "therapy", "explanation for" and "causes". This test was designed to assess participants' structural knowledge in sense of a higher order thinking ability (Dansereau, Collins, Mc Donald, Holley, Garland, Diekhoff & Evans, 1979; Jonassen, Beissner & Yacci, 1993). In order to evaluate the concept-maps, an expert concept map was constructed, capturing all important relations between the given concepts. Then for each subjects' concept map an overlay index was calculated by coding each exact match between the relations of the subjects' and the experts' map with a value of one, and each acceptable, but not quite correct match with a value of 0.5. No penalty was administered for false relations.

An additional item on a five-point Likert-scale was used to assess how confident students were regarding their knowledge. All items were presented in a pre- and post-test. In addition, some items have been presented in post-test only: In order to evaluate the behavior of the tutor, a sub-scale from an instrument provided by Schmidt, Dolmans, Gijselaers and Des Marchais (1995) for PBL-course evaluation was translated into

German. In addition, a general evaluation of the session on a scale from 1 (very bad) to 10 (very good) was given to the participants. The last item assessed the perceived importance of tutor moderation.

5.4. *Design and Procedure*

The study had an underlying 2 X 2 factorial design. The first factor was the variation of the communication medium (face-to-face versus computer-mediated communication). The second factor was the type of tutoring strategy (expert versus non-expert tutoring).

Participants formed groups of three learners each. These groups were randomly assigned to one of the four treatment conditions. The course of the study remained constant in all groups. First, there was the learning session where the background of PBL and the content of the learning material were explained (without referring to the experimental manipulation). Then the pre-test was applied. Subsequently, the problem was presented. Thereafter, the experimental conditions were operationalized: In a small-group session, the problem was discussed in order to identify learners' previous knowledge and to identify self-directed learning objectives. Half of the groups took part in a face-to-face discussion in a classroom accompanied by a tutor. In the other condition, students and tutor were distributed over four different rooms in the same building connected via the collaboration platform *EasyDiscussing*.

The second condition was also introduced in this stage of the experiment. In the expert-tutor condition, the tutor addressed issues relevant to the learning goals with the following strategies being allowed:

- Completion of information: Intervention of the tutor if none of the participants in the group was able to provide all necessary information in order to explain a certain topic or relationship. The tutor intervened, if learners did not mention all facts related to a certain topic. The intervention would only be made if the learners really did not get any further on their own behalf. If the participants, for example, did not collect all necessary symptoms that are crucial for an ICD-10 (International Classification of Diseases - 10th edition) diagnosis of depression, the tutor had to add the missing ones. The information provided by the tutor did not exceed the information given in the individual learning resources.
- Correction of wrong statements: If a learner provided wrong information the tutor pointed out that the participant's statement was wrong without giving any further feedback.

In the non-expert moderation condition, the tutor did not give any topic-related information or feedback related to the subject matter. The behavior was moderating only (according to the original meaning of this term), without asking directive questions. The only intervention was to ask participants to contribute to the discussion (primarily as a generic moderation task, but also following the current state of debate). From time to time, the tutor summarized participants' statements. The tutor in the expert-tutor condition did similarly. However, in the moderation-condition no feedback related to wrong statements was provided. Overall, two tutors who were experts in the domain and

in PBL led all groups in this study. They were briefly trained in both conditions, advised to follow their given behavioral script as mentioned above, and randomly distributed over all groups. Furthermore, they were not informed about the purpose of the study.

After the first discussion of the problem, which lasted about twenty minutes, an individual learning phase took place for approximately 45 minutes. In the face-to-face condition, each participant was led to a separate room with a personal computer containing the digital learning resource. In the CMC-condition, participants had access to the learning material at their assigned workstation.

After individual learning time, another second small group discussion took place. Students debated about how to solve the problem. The discussion lasted approximately 30 minutes. All treatment conditions were applied exactly as in the first discussion phase. Finally, a post-test and a final questionnaire had to be filled in by the participants.

5.5. *Variables*

One of the two independent variables was the communication medium regarding either face-to-face communication or CMC. The second independent variable was the type of tutor intervention with expert-tutor or non-expert tutor facilitation.

One of the dependent variables was knowledge acquisition measured by a knowledge test. Participants' own estimation about how certain they were about their knowledge were used as meta-cognitive measures. Students' perception of the course assessing overall satisfaction was indirectly assessed using participants' subjective evaluation of the session by a translated sub-scale for PBL course evaluation according to Schmidt et al. (1995). Finally, in order to test the success of tutor intervention, the content expertise of the tutor was estimated by the participants. This measure served as control variable and was also assessed using a subscale from Schmidt et al. (1995).

5.6. *Hypotheses*

The following hypotheses were tested within the experimental design.

Hypothesis 1 – Cognitive and meta-cognitive effects: The different tutoring strategies should lead to different outcomes related to knowledge acquisition. This assumption is mainly based on the concept of *cognitive congruency*, which states that expert tutor behavior would reinforce enhanced knowledge construction amongst learners of small groups and therefore directly address the groups' *production function*. This should lead to improved performance of learners in the expert-tutor condition in the post-test. A similar performance in the pre-test was hypothesized for all conditions. Tutor's contributions related to the content of discussion should support learners' coherence-building in the expert-tutor condition. This is not expected in the non-expert tutor condition. In addition, expert-tutor feedback should lead to learners' increased (self-) confidence related to their status of knowledge about the subject. Receiving a steady and content-related feedback, those participants should be able to assess their level of knowledge acquisition better than participants in non-expert tutored groups.

Hypothesis 2 – Subjective experience of the learning session: Using a pure non-expert moderation strategy, *social congruency* should be activated. Due to the combination of a high degree of learners' freedom created by a low level of instruction, participants are expected to be more active and motivated, and the *group well-being* should be fostered. Furthermore, there should be effects of the communication medium. As processes of social grounding are much more difficult in the CMC-condition, an interaction of both independent variables on learners' motivation is expected. Since participants in the non-expert condition can attribute knowledge acquisition to their own effort, they should be more satisfied with the learning success. In addition, learners in the face-to-face-condition, whose turn-taking and grounding is much easier achieved than in CMC, should be more satisfied with the learning task.

Hypothesis 3 – Tutoring strategy: Caused by problems with turn-taking in computer-mediated communication, the role of the tutor in CMC will be regarded as more important than in the face-to-face setting.

6. Results

In the following statistical tests we used individuals as units of analysis. This has some problematic methodological implications because the subjects are not independent from each other. Nevertheless, we decided to calculate results on an individual learner level in order to identify general, not group specific outcomes. Due to the relatively short time of intervention and randomization of group composition, we regard the influence of group dynamics as negligible. In order to test this assumption a multiple linear regression of group influence on dependant measures in the post test was computed. An ANOVA revealed no significant influence of group membership on individuals' motivation ($F(1, 46) = 3.21$, $p = 0.08$), knowledge ($F(1, 46) = 1.6$, $p = 0.21$) or tutoring experience ($F(1, 46) = 2.65$, $p = 0.11$). Thus, further analyses were computed on an individual level.

An analysis of variance over all dependent variables resulted in a significant effect of the independent variable "tutoring strategy" (Rao's $R(5, 39) = 2.67$, $p < 0.05$; Eta Square = 0.26), but no main effect related to communication medium (Rao's $R(5, 39) = 1.21$, $p = 0.32$; Eta Square = 0.13), as well as no significant interaction (Rao's $R(5, 39) = 0.84$, $p = 0.53$; Eta Square = 0.10). Further analyses included only specific effects of the independent variable "tutoring strategy". Due to insufficient requirements of scaling, we used non-parametric analyses to test specific effects. In order to adjust the Alpha-Level, a Bonferoni correction was made to Alpha = 0.008 excluding the main hypotheses (according to Bortz, 1999).

6.1. *Results on Cognitive and Metacognitive Parameters:*

In the knowledge tests, one credit was given for each correct multiple-choice answer. With regard to the open-ended questions, learners obtained from one to eleven points depending on the exhaustiveness of the answer. The calculated difficulty was P = 26.75 for the pre-test (Cronbach's Alpha = 0.84; average inter-item correlation = 0.21) and P =

70.4 for the post-test (Cronbach's Alpha = 0.72; average inter-item correlation = 0.06; taken together the difficulty was P = 48.57).

Concerning the assessment of the concept-mapping task, one point for each correct relation between two nodes was given, with a maximum score of 16 points. The computed difficulty was P = 50.67 overall (pre test: P = 33.04; post test: P = 68.3). In order to calculate pre- and post-test results, two general scores (pre and post) were computed integrating multiple choice questions, open-ended questions, and the concept-mapping task. A comparison between both tutor interventions revealed no significant pre-test difference (Kruskal-Wallis Test: H (1, 48) = 1.94, p = 0.17) but an improved performance of those in the expert-tutor condition in the post-test (Kruskal-Wallis Test: H (1, 48) = 4.48, p = 0.0342, d = 0.55). Both groups performed better in the post-test than in the pre-test (Wilcoxon Matched Pairs Test: Z = 6.03, p < 0.001, d = 1.64; see Figure 2 for all results in knowledge acquisition).

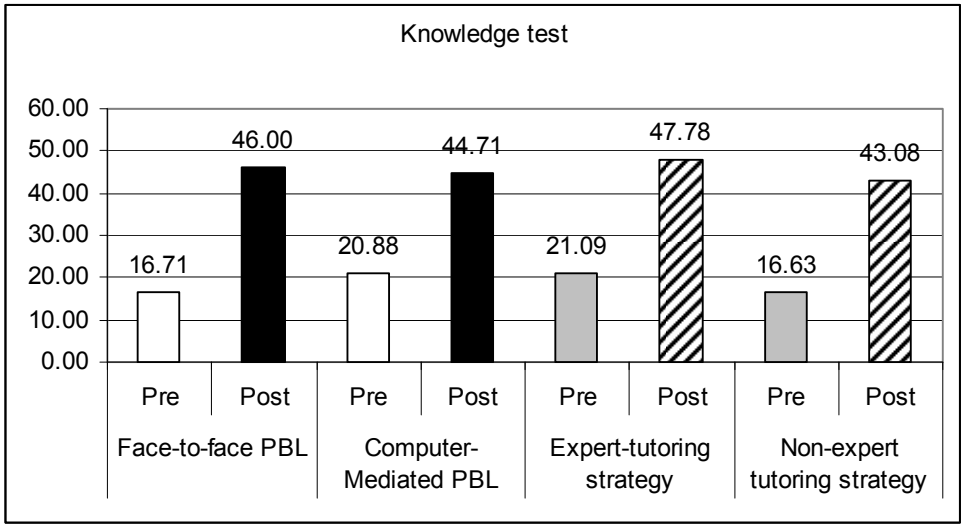

Figure 2: Results in knowledge acquisition

Participants' ratings relating to how confident they were regarding their knowledge also indicated no significant difference in pre-test measures in both tutorial conditions (Kruskal-Wallis Test: H (1, 48) = 0.23, p = 0.63). Comparing post-test outcomes, participants in the non-expert condition considered themselves as significantly more confident about their level of knowledge (Kruskal-Wallis Test: H (1, 48) = 4.07, p = 0.043, d = 0.56). This result is in the opposite direction to that stated in Hypothesis 1 (see Figure 3).

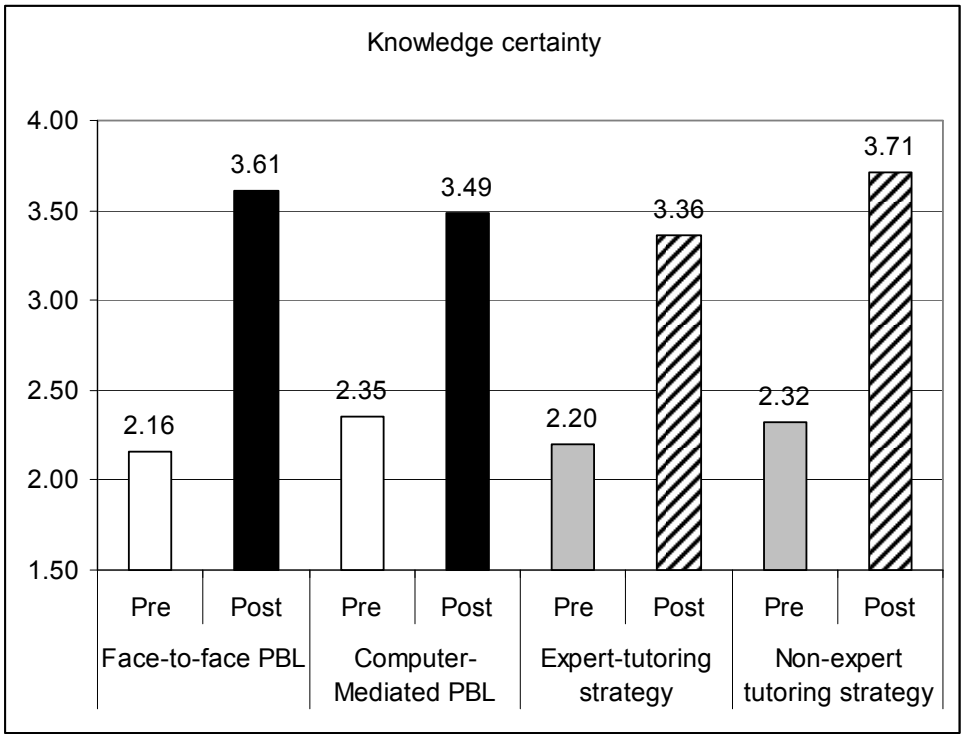

Figure 3: Results in knowledge certainty

6.2. *Results of Subjective Course Evaluation and Tutor Facilitation*

An analysis of the total points given to the course showed a significant better evaluation favoring the expert-tutor condition (one-sided Mann-Whitney U Test: U =191, $p < 0.05$; $d = 0.52$). There was no significant difference related to the importance of tutor facilitation (Kruskal-Wallis Test: H (1, 47) = 0.002, p = 0.96).

6.3. *ManipulationCcheck*

Comparing participants' ratings on the subscale of Schmidt et al. (1995) showed a higher competence rating of tutors in the expert-tutor conditions (Kruskal-Wallis Test: H (1, 48) = 5.17, p = 0.023, $d = 0.7$). This confirms the success of the manipulation although the Alpha-value does not surpass the Bonferoni-adjusted Alpha.

Summarizing the results of this study, the following table shows the descriptive data. For illustrating purposes Table 1 additionally shows the specific results for the main factor communicational device despite the missing main effect.

Table 1: Means and standard deviations

Means (SD)	Face-to-face PBL		Computer-Mediated PBL		Expert-tutoring strategy		Non-expert tutoring strategy	
Dependent measures	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Knowledge test	16.71 (6.98)	46 (6.53)	20.88 (11.91)	44.71 (10.34)	21.09 (9.7)	47.78 (9.02)	16.63 (9.97)	43.08 (7.83)
Knowledge certainty	2.16 (0.77)	3.61 (0.41)	2.35 (0.8)	3.49 (0.77)	2.2 (0.76)	3.36 (0.67)	2.32 (0.82)	3.71 (0.53)
Tutor's competence	N/A	4.23 (0.48)	N/A	4.27 (0.47)	N/A	4.42 (0.35)	N/A	4.09 (0.52)
Course evaluation	N/A	6.89 (2.38)	N/A	6.29 (2.63)	N/A	7.2 (2.16)	N/A	5.89 (2.71)
Importance of facilitation	N/A	4.13 (0.76)	N/A	4.58 (0.5)	N/A	4.44 (0.59)	N/A	4.34 (0.72)

6.4. *Qualitative Results*

In order to get an insight into the underlying processes of the different tutoring conditions applied in this study, the following text excerpts are used. The basic idea of this qualitative methodology was to find and interpret activities of interaction that support the quantitative results. Thus, there is no strict differentiation between results and their discussion in this section. We adapted techniques of sequential analysis (as commonly employed in conversation studies, e.g., Goodwin, 1981; Goodwin & Heritage, 1990). The approach here is derived from Sacks (1992; quoted in Glenn & Koschmann, in press). Sacks proposes to take singular sequences of conversation and analyze them in order to find rules, techniques, procedures or methods that can be used to generate the orderly features we find in the conversations we examine. We differ here from Sack's approach, however, because the usual depth of content analyses approaches is not attained. Rather, we were motivated by content analysis approaches in order to define sequentially relevant actions that illustrate underlying cognitive and social construction processes in order to consolidate the validity of the quantitative findings.

The first example is an extract from an expert-tutored group collaborating over the Internet. At that time, participants had reached the final problem solving discussion after the individual learning phase. Whilst using the shared workspace, participant 3 had just found a link between depression and anorexia nervosa in the case study. He states that Miss M.'s depression is based on her anorexia. The tutor (T) then asks:

T: *Can we be sure that the depression is a result of the anorexia nervosa?*

P3: *Not sure, but probably!* (P3 refers to Participant 3)

Here, the tutor asks the question in order make the learners rethink the probably over-generalized connection. Participant 3 immediately responds to the tutor. Directly after this response participant 1 goes off-topic.

Participant 1 (P1): *Is it possible that the mother is the origin of the cognitive disorder?*

T: *We only can assume that her mother is not very empathic. We can be sure that her mother is very achievement oriented.*

The tutor now leads back to the topic while Participant 3 (P3) is catching up with the thread from P1 (which was obvious within the log file). The tutor also gives her a short answer but then gives a final expert statement in order to get back to the original discussion topic.

T: *What do you know about the relationship between anorexia and depression?*

P3: *Not only her mother but also her sports career and her social contacts could have contributed to her disorders! Her new trainer might have been the trigger.*

T: *Correct! Her mother, her sports and her trainer create increasing pressure on Miss M.*

Now Participant 2 (P2) catches the tutor's question: *Depressive disorders can be evoked by anorexia nervosa. But they can also occur at the same time separately. They both have to be considered.*

Tutor finalizes this topic with the statement: *Correct! Both disorders are likely to occur together and both have to be considered and treated separately.*

Subsequently, P2 initiates a new thread. In the tutor's opinion this leads too far off-topic. Firstly, he tries to make participants aware of the fact that insufficient information is provided by the problem description. Since he is not successful, he drops this thread and changes the topic. Again, this seems to be going too far off topic in the tutor's opinion.

P2: *She is her new trainer since Miss M. is fifteen. Her trainer thinks her weight is too high. So there are eight years of diet.*

T: *We do not know if it is eight years. Anyway - a few months surely. We really do not know if she practiced diets for eight years.*

P3: *The trigger for her depression might have been breaking up with her boyfriend.*

T: *Which kind of therapy do you suggest?*

P1: *No, I do not think so. The depression seems to be the cause for break up and not vice versa.*

P2: *I think the break up is a symptom of her depression. There is social withdraw as ICD-10 symptom.*

P3: *...so the loss of a social relationship. And now she is under examination pressure which might have been the cause of depression.*

T: *Breaking up with her boyfriend, examinations, dissatisfaction with her weight could all together have influenced her depression.*

P2: *In my opinion the depression has been caused by cognitive dissonance according to what Hilde Bruch writes. What do you think?*

P3: *Maybe everything comes together.*

T: *There presumably distorted mother-child interaction. But we would need more information about Miss M.'s childhood.*

P2: *Everything seems a little bit foggy…*

T: *Shall we put her on medication?*

The change to medical therapy seemed to be successful for the learners. The participants gave up the discussion on other marginal relevant topics.

P2: *I would first try without medication.*

P3: *We first should assess the state of her neurotransmitters.*

This example illustrates how the tutor can use his or her expertise in order to structure the discourse. First, irrelevant and only marginally important topics are recognized. Further discussion about such an irrelevant topics can thus be avoided by means of tutor intervention. Second, direct inquiries into important issues (like, for example, the relationship between anorexia and depression) can trigger elaboration. A tutor who is not knowledgeable in the thematic field does not have the possibility to influence such a discourse systematically.

The following discourse extract is taken from a non-expert tutor discussion using computer-mediated communication after the individual learning phase. The tutor does contribute to the topic itself and stays on a level of common knowledge:

T: *Perhaps you can collect some information related to diagnosis, causes and treatment?*

P1: *Yes, but not every aspect of a certain diagnosis is fulfilled.*

T: *Just try to collect the available information you have!*

P1: *We do not know anything regarding the absence of her menstrual period, regurgitation and laxative.*

T: *Learner 2, what is your opinion on that?*

P2: *I am still thinking about that issue.*

T: *Learner 3?*

P1: *I will start a new node for treatment.*

P3: *Such symptoms do not have to occur!*

T: *Learner 3, just use the whiteboard in order to point out what's important for you.*

The tutor tries to initiate a fact-finding discussion. He could do this by providing direct hints or examples. Since this is not possible, the discussion broadens. Consequently, the tutor has problems to initiate problem-solving statements:

P2: *Is it important to find reasons or to give indicators for therapy?*

T: *What is the others' opinion on that?*

T: *Learner 1, Learner 3?*

P1: *According to the instructions we should find a treatment.*

P3: *Of course! But how could we do that without knowing anything about he origins of the problem?*

T: *Just make a try!*

P2: *OK! I think the problem is very serious because she neglects her life and gave up her sports career which was always very important to her. Is that not an alarm signal? I would send her to an institution.*

T: *Any additional comments on this?*

T: *Learner 3?*

T: *Learner 2?*

T: *Learner 1?*

Participant 2 made a global statement. The tutor tries to catch this up in order to make the discussion more profound. The learners hesitate with their answers. So the tutor tries to give hints by changing the topic abruptly and globally asking for a diagnosis. Indeed, learners provide answers soon but stay on a surface level without giving profound explanations:

T: *Well, what is your final diagnosis?*

T: *I would like to hear the opinion of ALL!*

P1: *Eating disorder with a moderately severe depressive episode.*

T: *Learner 3?*

P1: *Anorexia nervosa instead of eating disorder in order to be more precise.*

T: *Learner 2?*

P2: *Just a minute in order to have another glance at the case!*

P1: *I think there are enough hints for a moderately severe depression, aren't there?*

P2: *Is it not a severe depression? She is very desperate and fees worthless, etc….?*

P1: *What justifies a moderate one, Learner 3?*

P1: *For a severe one, I think, there are missing points like thinking about suicide or even trying to commit suicide.*

T: *Now, what do you all agree upon?*

P1: *Ladies, what do you think?*

P2: *OK, I think it is not justified to consider it as a severe depression. So, moderately severe!*

P1: *OK, Anorexia with a moderately severe depressive disorder?*

T: *Two for moderately, one for severe?*

Caused by an insufficient argumentation the tutor has no choice but to use votes to achieve a consensus. Participant 3 finally agrees without having elaborated the choices.

P2: *Her question about deeper sense shows that she is seeking for help; she is looking for a plan how to continue…*

P1: *Is the diagnosis OK for you, Learner 3?*

T: *Please provide an answer, Learner 3!*

P3: *I thought about this, yes, a moderately severe depression because she is desperate and has problem with her daily life.*

This example illustrates that a tutor without being knowledgeable in the field of discussion has to make greater effort in order to keep problem-solving discourse running. Methods used in the first discourse excerpt such as direct inquiries or enforcement of more important topics are not available. Thus, discussion remains on the surface, and learners remain reserved.

These two examples illustrate the potential but also the limitations of tutoring strategies dependant from tutors' different repertoire of knowledge-based strategies. In almost all other cases, similar structures could be detected. Nevertheless, these two examples are prototypical cases and should only be interpreted as supportive of the

quantitative results and not as isolated outcomes. Further in-depth analyses needs to be conducted in order to relate patterns within content analyses with experimentally controlled variables.

7. Discussion

Overall, the findings of the present study as well as prior research on (e-) tutoring suggest that tutor facilitation is an important factor in enhancing face-to-face as well as computer-mediated knowledge communication. Expected disadvantages of computer-mediated communication used for computer-mediated problem-based learning were not confirmed in these findings. Perhaps, by providing intensive group facilitation using tutors that were experienced in face-to-face as well as computer-mediated group facilitation, the influence of the communication medium was negligible. By means of adapting moderation strategies to the requirements of a group (face-to-face as well as in CMC), tutors were able to structure learners' communication and, thus, organize basic processes like turn-taking or provide immediate feedback. Yet, these findings are limited to text-based synchronous computer-mediated PBL, where in contrast to asynchronous CMC, basic mechanisms such as the possibility of immediate turn-taking or immediacy of feedback are given.

Furthermore, results suggest that tutor facilitation does not always lead to the same learning outcomes among PBL-students. The alternative hypothesis stating that an expert-tutor will enhance knowledge acquisition among learners and thus foster a group's *production function* (cf. McGrath, 1991) was confirmed. This particular outcome replicates some of the findings of PBL field-research (e.g., by Schmidt et al., 1994). In these particular field-studies, students who where facilitated by expert tutors had higher academic achievement than those tutored by non-experts. However, these results are limited to students that were at the beginning of their academic career. The influence of tutors' content-expertise seems to decrease in the course of education.

In this study, an attempt has been made to replicate the findings mentioned above in a controlled experiment. Although the expert-tutors were involved in designing the problem and the learning material it should be noted that he or she did not give more information away to participants than could be found in the individual learning resources (accessible to all participants). Thus, the conclusion is that the effects of the manipulation of the tutor's behavior resulted from structuring and elaborating contents and giving feedback, rather than from providing additional information.

One result of the current study is very surprising: Instead of finding participants in expert-tutored groups to be more confident related to their status of knowledge, the opposite effect occurred. Participants in non-expert tutored groups considered themselves to be more confident. This might be due to the lack of feedback related to wrong or correct statements in the moderated condition creating higher confidence. Another possible explanation might be that learners developed an "illusion of knowledge". This could have occurred since knowledge acquisition was primarily self-directed without expert support and external control.

A similar effect was found concerning participants' satisfaction with regard to the learning session. Contrary to the hypothesis that participants in the non-expert tutor condition should be more satisfied with the session, participants in the expert-tutor condition were more satisfied. This outcome can also be explained through field research about PBL. Schmidt et al. (1993) showed that beginners in PBL who did not have any experience with this way of studying needed more instruction. With growing experience in PBL, segments of instruction could be reduced in favor of learners' own knowledge construction processes. A similar conclusion was drawn by Reinmann-Rothmeier and Mandl (2001), who regarded direct instruction as an integral part of problem-oriented learning environments.

The unexpected difference in learners' satisfaction also might be due to the fact that participants had no experience in problem-based learning. The higher amount of instruction combined with an objectively enhanced knowledge acquisition might explain this unexpected difference. Under aspects of the concept of *cognitive congruency* it is necessary to have a tutor with content knowledge in the domain in order to provide a kind of structure for learners. The structure promotes fast "success" which might satisfy learners and, thus, contribute to a group's *well-being*). If a tutor is able to understand ongoing debates with underlying knowledge-based beneficial as well as unbeneficial problem-solving processes, he or she is able to provide a sample ideal model. Only by learners combining their own knowledge building processes with an external control instance, such as an expert tutor, can an adequate judgment based on self-monitored evaluation of their current status quo be possible. Due to the short time of intervention in the non-expert tutoring condition, establishing such an internal relation is hardly possible.

Participants' judgment of the tutors' competence suggests that the manipulation of the independent variable "tutoring strategy" was successful. The subscale contained items such as "the contributions of the tutor were relevant", "the tutor was able to provide answers to our questions", and "the tutor used his expertise in order to help us". In the expert-tutor condition, the tutor was seen as more competent than in the non-expert condition. In addition, there was a trend showing that tutor facilitation was considered more important in the CMC-setting than in the face-to-face scenario.

There are some limitations to the present study. The learning environment used in this research represents an abbreviated version of what normally happens. What would take half a week or longer in a regular PBL course has been cut down to 1 ½ hours in the experiment. In settings employing PBL-approaches such as in the field of medical education, there would undoubtedly be more time for small-group discussion and individual learning phases. But a directed and controlled investigation of different tutoring strategies as conducted in this study is difficult to accomplish. There are also some methodological considerations that have to be addressed. First, we used individuals as units of analysis. This has some problematic implications because the subjects are not independent from each other. Due to the relatively short time of intervention and randomization of group composition we regard the influence of specific group dynamics on individuals as negligible. Second, although this was a laboratory experiment, the

granularity of assessment has been rather on a macro than on a micro level. For example, we could have applied measurement of dependant variables at several crucial stages in the course of the study (e.g., additionally after initial discussion and after individual learning phase) in order to conduct process analyses. Such a methodology is also problematic due to its severe intrusion into the learning process (e.g., by priming students on the questions in the knowledge tests). Third, the dependant measures used in this study, especially the knowledge assessment, just passes criteria of acceptable internal consistency (as measured by Cronbach's Alpha). A reason for this may be the small sample size, which also had an impact on inference statistical hypothesis testing (e.g., some comparisons just reached a significant level). Fourth, ecological validity has to be addressed. The variables used here have been chosen because of their high ecological validity. The knowledge assessment is based on questions that are likely to be used in written examinations. Nevertheless, PBL is usually designed to last over several weeks to months and to foster skills beyond knowledge acquisition. Here, similar research has shown that PBL is likely to foster problem-solving skills, metacognitive competences, communication skills, etc. (cf. Albanese, 2000, Albanese & Mitchell, 1993).

Furthermore, the scale assessing students' perception is derived from applied research. Major limitations of ecological validity are with regard to tutoring strategy because the standardized tutoring strategies do not directly reflect tutoring practice. In applied PBL e-tutoring, many variables influence tutors' behavior. While we tried to model two extreme poles on a behavioral continuum, most tutors are likely to behave somewhere in-between non-expert moderation and expertise-based facilitation.

8. Conclusion

To summarize, the findings suggest that transferring a problem-based learning session into a computer-mediated learning environment is possible without any drastic restrictions. Together with an adequate tutoring or e-tutoring, we did not find a significant influence of the communication medium on measured outcomes in this study. Generally, tutor facilitation is crucial for the success of such an approach. The behavior of the tutor or his/her strategy should vary according to learners' requirements. Beginners should benefit more from an expert-tutor while advanced learners might gain more from a non-expert tutor facilitation that allows higher self-regulation in learning. This is where further research, especially in the area of CMC-supported PBL is needed. For instance, the design of this study could be used for advanced learners (e.g., clinical therapists). In addition, investigations of longer time and treatment spans (e.g., in vocational training using PBL or computer-mediated PBL) are needed.

Currently, the field of synchronous computer-supported collaborative learning is changing dramatically. By means of high-quality video-conferencing software some problems of grounding as well as turn-taking are vanishing but others arise. With this research we provide an approach that examines basic mechanisms of media-learner-interaction within a problem-based learning scenario that hopefully triggers subsequent research and also supports practitioners within PBL-courses. It does not seem to be the

media that influences successful learning. It is rather the ability to handle specific communication media characteristics in order to meet the learners' requirements and needs and to foster learning groups' production function, member support and group well-being by means of a social and cognitive congruent tutor.

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