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Motivation in a Computer-Supported Collaborative Learning Scenario and its Impact on Learning Activities and Knowledge Acquisition

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Abstract

Addressing a drawback in current research on computer-supported collaborative learning (CSCL), this study investigated the influence of motivation on learning activities and knowledge acquisition during CSCL. Participants' (*N* = 200 university students) task was to develop a handout for which they had first an individual preparing phase followed by a computer-supported collaborative learning phase immediately afterwards. It was hypothesized that in both phases current motivation (in terms of expectancy and value components) influences both learning activities and knowledge acquisition in a positive way. According to main results, only goal orientations (before learning) were associated with knowledge acquisition respectively observed learning activities during the collaborative phase. Expectancy and value components of current motivation related neither to observed learning activities nor to knowledge acquisition during collaborative learning but were in part associated with learning activities and knowledge acquisition during individual learning. The discussion addresses several possible explanations for these unexpected results.

Keywords: Motivation; collaborative learning; computer supported learning; learning activities; knowledge acquisition

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1 Introduction

When appropriately implemented, collaboration can foster learning by generating "understanding and problem-solving strategies that no group member had prior to collaboration" (Webb & Palincsar, 1996, p. 847). These benefits can even be enhanced in computer-supported collaborative learning (CSCL) scenarios with computer-mediated communication. In computer-mediated communication, collaborative knowledge construction can benefit, for example, from lasting external representations of utterances as provided by e.g. chat tools (Weinberger, 2003) or from the anonymity in communication (e.g. Ainsworth et al., 2010). However, collaborative and computer-supported collaborative learning are not per se beneficial. Therefore, current research on CSCL examines how to support learners by, for example, scaffolding their interaction (e.g. De Wever, Van Keer, Schellens, & Valcke, 2010; Mäkitalo-Siegl, Kohnle, & Fischer, 2010). In that, CSCL research has so far focused on cognitive aspects while motivational aspects have been widely disregarded. However, there is reasonable evidence that motivation plays a mentionable role also in CSCL settings (e.g. Astleitner, 2000). Therefore, it is our aim to explore how motivation influences computer-supported collaborative learning.

Following Murphy and Alexander (2000), there exist 20 different motivational terms. We possess a large body of research from different traditions showing that motivation plays an important role for individual learning (e.g. Del Favero, Boscolo, Vidotto, & Vicentini, 2007; Elliot, McGregor, & Gable, 1999; Pajares, 1996). However, as learning is, especially in the case of computer-supported collaborative learning, a complex process, assessing only a single motivation construct might not go far enough (Moos & Marroquin, 2010; Murphy & Alexander, 2000). A selective view of motivation like this might not be able to reflect all

relevant relations of motivation with learning processes (Murphy & Alexander, 2000). In contrast, a more holistic, integrative view like, for example, realized in the approaches by Eccles and Wigfield (2002), Narciss (2006), or Pintrich (2003), might provide us with insights about the differential relationship of different motivation constructs with learning processes. This is the more important since research on motivation influences on CSCL is rare and inconsistent, as the next paragraph will show.

1.1 Impact of Motivation on Computer-Supported Collaborative Learning

So far, only a few studies have approached motivation as an independent variable during CSCL (Bartholomé, Stahl, Pieschl, & Bromme, 2006; Hakkarainen, Lipponen, Järvelä, & Niemivirta, 1999; Howley, Chaudhuri, Kumar, & Rosé, 2009; Nokelainen, Miettinen, Kurhila, Floréen, & Tirri, 2005; Sins, Van Joolingen, Savelsbergh, & Van Hout-Wolters, 2008; Wang & Lin, 2007; Wolf & Prasser, 2006). Among them, we found only one study (Nokelainen et al., 2005) that used an integrative view of motivation, other studies either concentrating on one particular motivational construct like self-efficacy (e.g. Wang & Lin, 2007) or goal orientations (e.g. Hakkarainen et al., 1999) or taking a pragmatic view on motivation using the most promising constructs (e.g. Bartholomé et al., 2006). Nokelainen et al. (2005) assessed asynchronous collaboration in newsgroups on a task for which students had 2 weeks to complete it. The authors found positive effects of motivation on activity in the CSCL system and on the final course grade. However, they assessed the motivational constructs with only 1 item each.

Positive effects of motivation were also shown by other authors. Sins et al. (2008) found positive effects of mastery goal orientation on performance in a CSCL system. Wang and Lin's (2007) assessment of group composition concerning self-efficacy uncovered that dyads with homogenously high self-efficacy showed more high-level cognitive skills which in turn influenced learning outcome. Bartholomé et al.'s (2006) study in contrast indicated that only

a within the dyad heterogeneously distributed self-efficacy led to more help seeking behaviour and better performance while they found no effect for goal orientations or interest. Hakkarainen et al. (1999) again confirmed a relation of goal orientations with the number of explanation seeking research questions the students formulated but not with performance. In addition to these at least in part positive results, there are also studies that found no effect of motivation on CSCL. Howley et al. (2009) discovered no effect of goal orientations on performance and only marginal effects on substantive contributions to the problem solving. Wolf and Prasser (2006) also could not show an effect of interest, self-efficacy or achievement motivation on learning activities and performance in an online university seminar. Aside from the researched motivation constructs and the results, the learning scenario also varied in these studies from synchronous to asynchronous collaboration and between 5 hours and 4 university course sessions.

Apart from CSCL research, research on *collaborative learning in face-to-face settings* might also provide us with information what to expect for a CSCL scenario. Research in this area led to results quite similar to the ones in the context of CSCL, e.g. collaborative learning leads to greater skills acquisition for less self-efficacious participants than for more self-efficacious participants (Day et al., 2007), effective groups in collaborative learning tend to strive for mastery goals whereas not effective groups tend to strive for performance and entertainment goals (Hijzen, Boekaerts, & Vedder, 2007) and mastery goal orientation and performance goal orientation correlate negatively with high-level elaborations and performance (Veenman, Denessen, van den Akker, & van der Rijt, 2005). Again, also in this offline context, studies seldom take an integrative view of motivation, and again, their results are quite heterogeneous.

Research on *learning with computers* (without collaboration) might also turn out useful for the research of motivation during CSCL. In this context, there is much more research on

the impact of motivation (for a review see Moos & Marroquin, 2010). However, as this is a completely different learning scenario, learning activities and problems the students encounter and that such studies address are quite different from the collaborative setting. For example, emergent topics are the relation of interestingness and seductive details or relations of motivation with navigational patterns (c.f. Moos & Marroquin, 2010). Research on distance learning on the other hand indicates the importance of motivation in this context. For example, we know of higher drop-out rates in online distance education courses (Astleitner, 2000). Lack of motivation might be the cause for these results. On a more general plate, we can learn both from research on learning with computers and on learning in general that motivation in different facets plays an important role. Interest, for example, is associated with deeper learning and better learning outcome (e.g. Ainley, Hidi, & Berndorff, 2002) as are self-efficacy (c.f. Pajares, 1996) or mastery goal orientations (e.g. Elliot et al., 1999).

There are many studies on the impact of (computer-supported) collaborative learning on motivation (e.g. Järvelä, Järvenoja, & Veermans, 2008). However, as in this case motivation serves as dependent variable, this kind of research (as interesting and important it is) is not in the focus of this paper as we want to focus on motivation as *in*dependent variable.

To sum up: The few studies explicitly addressing the influence of motivation on CSCL mainly use single concepts of motivation instead of an integrative view which in turn is indicated to cover the complexity of learning (Moos & Marroquin, 2010; Murphy & Alexander, 2000). The settings are quite different ranging from long-term asynchronous to short-term synchronous scenarios. The results of the studies concerning the influence of motivation on learning activities and learning outcomes are also quite heterogeneous and sometimes contradicting (Bartholomé et al., 2006; Wang & Lin, 2007). From research on distance education (e.g. Astleitner, 2000) we got hints that motivation might play an

important role in this context. Studies covering collaborative learning (e.g. Day et al., 2007; Hijzen et al., 2007; Veenman et al., 2005) and individual learning with and without computers (e.g. Ainley et al., 2002) also indicate that motivation might be of importance for learning activities and learning outcome. Therefore, further research on the impact of motivation in CSCL with an integrative view of motivation is necessary.

1.2 Research Framework

Although there are many models covering the relationship of motivation and individual learning (e.g. Rheinberg, Vollmeyer, & Rollett, 2000; Wigfield & Eccles, 2000), there are no models for CSCL available. Therefore, we used the cognitive-motivational process model by Rheinberg et al. (2000) in order to identify relevant groups of variables for our explorative research of motivation effects in CSCL. Being a framework, this model provides the necessary relations and concepts for this purpose without being too specific. It assumes that current motivation influences process variables which serve as mediators and in turn influence knowledge acquisition. These process variables are time on task, motivational and functional state, and kind and quality of learning activities (Rheinberg et al., 2000). Several studies confirmed the proposed model relationships in the context of individual learning (e.g. Vollmeyer & Rheinberg, 2006).

As this model has been developed for individual learning, there are several aspects to be considered for researching CSCL: the concept of current motivation, the kind and quality of collaborative learning activities, and the non-independence of data during collaborative learning. These aspects are addressed in the following paragraphs.

1.2.1 Current motivation.

The authors of the cognitive-motivational process model use four aspects for current motivation, namely interest, challenge, probability of success and anxiety (Vollmeyer & Rheinberg, 2006) which were obtained empirically driven. However, integrative models

provide a theoretically sounder basis for conceptualization of motivation while not being contrary to those four constructs. Therefore, to further differentiate current motivation we used the integrative model by Narciss (2006) which in turn integrated models by Heckhausen (1977) and Eccles and Wigfield (2002) and is also in line with the model by Pintrich (2003). As a result, we understand current motivation comprising the following expectancy (1. + 2.) and value (3.-6.) constructs:

1. *Self-efficacy* (c.f. Bandura, 1997). The expectancy to perform the necessary actions in a competent way.
2. *Instrumentality beliefs*. This construct is derived from Heckhausen's (1977) outcome-consequence expectancies and covers the subjective probability that a specific consequence follows an outcome (c.f. Narciss, 2006).
3. *Attainment value* is "the personal importance of doing well on the task" (Eccles & Wigfield, 2002, p. 119).
4. *Interest* is a specific relationship between a person and a topic comprising cognitive and affective components (Krapp, 1999). It can be conceptualized as motivational disposition or as it is in this paper as a state (actualized interest).
5. *Intrinsic task value* (of performing the task) refers to activity oriented incentives sensu Rheinberg (e.g. 1987) and means "the enjoyment the individual gets from performing the activity" (Eccles & Wigfield, 2002, p. 120).
6. *Costs*. This construct includes appraisals of the necessary effort, of escaping alternatives as well as fear of failure or anxiety (Eccles & Wigfield, 2002; c.f. Pintrich, 2003).

Concerning collaborative learning, we further have to distinguish between motivation referring to the task on the one hand and motivation referring to the collaboration on the other hand. For example, the learner can be self-efficacious concerning the to be learned

topic or concerning the collaboration with her learning partner. This aspect has to be addressed when operationalizing the above constructs.

1.2.2 Learning activities.

The cognitive-motivational process model of learning assumes the kind and quality of (individual) learning activities to be a process variable and mediator of the relationship between current motivation and knowledge acquisition (Rheinberg et al., 2000). In the context of CSCL, collaborative learning implies a different notion of the kind and quality of learning activities. In research on collaborative learning, the following learning activities seem to be beneficial for learning (Fischer, Bruhn, Gräsel, & Mandl, 2002) which we assume to be relevant process variables for CSCL:

1. Externalization of task-related knowledge. This comprises in particular – apart from mere mentioning of knowledge – (elaborated) explanations the giving of which is assumed to be beneficial for learning (c.f. Webb, 1991).
2. Elicitation of task-related knowledge. In this category, questioning is the most important learning activity. It is, however, unclear whether questioning is beneficial for learning beyond the effect of (following) explanations (c.f. King, 1994; Renkl, 1997).
3. Conflict-oriented consensualisation. A socio-cognitive conflict (Doise & Mugny, 1984) enhances learning by showing different perspectives to the learners. However, Nastasi and Clements (1992) showed that only solving a conflict is beneficial for learning.
4. Integration-oriented consensualisation. This means the integration of different points of views, e.g. by solving a socio-cognitive conflict. This is to be distinguished from mere accepting a different point of view (quick consensus building: Weinberger & Fischer, 2006).

1.2.3 Non-independence of data.

During collaborative learning, it is intended that the learning partners influence each other (c.f. Cress, 2008). However, this might lead to a non-independence of data. Non-independence of data is at hand if data of participants belonging to the same group are more or less similar than data of participants not belonging to the same group (Kenny, Kashy, & Cook, 2006). This might be due to different reasons, one of them being mutual influence (Kenny et al., 2006) as it occurs during collaborative learning. There are different adequate methods of dealing with non-independent data (Kenny et al., 2006). In all cases, the dyadic (in case of two learning partners) influence has to be modelled explicitly. In our case, this means, for example, that learning activities of one partner might influence not only her own knowledge acquisition but also that of her learning partner and vice versa. The same goes for the relationship of current motivation before learning and learning activities.

1.3 Research Questions

From this research framework, we derived the following research questions.

1. Which aspects of current motivation influence knowledge acquisition during CSCL? If the proposed process variables are valid mediators, current motivation and knowledge acquisition should be related both during individual learning phases (Hypothesis 1a) and collaborative learning phases (Hypothesis 1b). Moreover, there should be a mutual influence relationship between current motivation and knowledge acquisition of both learning partners during collaboration (Hypothesis 1c).
2. Which aspects of current motivation influence learning activities during CSCL? We expect that current motivation relates to learning activities both during individual learning phases (Hypothesis 2a) and collaborative learning phases (Hypothesis 2b), and that there is a mutual influence relationship between current motivation and learning activities of both learning partners during collaboration (Hypothesis 2c).

3. Are learning activities mediators of the relationship between current motivation and knowledge acquisition? In particular, we assume that learning activities mediate the relationship between current motivation and knowledge acquisition during both individual learning phases (Hypothesis 3a) and collaborative learning phases (Hypothesis 3b) and that the partner's learning activities also mediate this relationship via mutual influence during collaboration (Hypothesis 3c).

2 Method

2.1 Sample

200 university students participated in exchange for 25 €. They were 18 to 31 years of age (M = 23.0, SD = 2.66, 65.5% female) and mainly enrolled in educational science or media communication. Of them 28 percent were first-year, 18.5 percent were second-year, 14 percent were third-year, and 39.5 percent were fourth-year and higher students.

2.2 Design and Procedure

The participants' task was to develop a handout on the test of significance in groups of two. This handout had to encompass an outline and main definitions. The partners of a learning group got a paper copy of one of two different short introductory texts from educational books as resources in order to create a certain degree of resource dependency (Johnson & Johnson, 1992). Both texts were comparable in length and difficulty. The study took place in two computer rooms. Learners in room 1 had to read text 1 while learners in room 2 read text 2. At the beginning of the study, participants were welcomed and asked to sit down in whichever room they wanted (not knowing about different learning texts) while sticking together with their friends. Dyads were built by randomly assigning participants of different rooms to each other. By doing this, it was ensured that the two members of a dyad each got a different learning text and that dyads were most probably built from participants who did not know each other. Due to organisational reasons, the learning time had to be held

constant. Every participant sat on a computer on her own. All instructions and questionnaires were presented on the computer screen.

Immediately before the collaborative learning phase, participants had an individual preparing phase to read their text and to prepare an individual version of the handout (c.f. table 1). This phase started with pretests on demographics and knowledge. After an extract of the learning text and after setting the learning goal, current motivation was assessed. Then, participants had one hour for individual preparation. For creating a pre-version of the handout, they had to use an editor on the course management system used later for the collaboration. After 30 minutes, a popup occurred to measure motivational and functional state. After the individual phase, participants had to report their individual learning activities, and knowledge as well as motivation after learning were assessed.

After a short break, the collaborative phase started with a test of current motivation concerning the collaboration and of goal orientations. Then participants had 90 minutes to jointly develop a common handout on the course management system. Therefore, they had a chat to talk to each other and a simple editor to develop the handout. The editor was based on wiki technology. After 45 minutes a popup occurred to assess motivational and functional state as well as an appraisal of the partner's motivation and competence. Chat statements and editor changes were logged and coded later. After the collaboration, a post test assessed knowledge and motivation after learning.

2.3 Material and Instruments

2.3.1 Knowledge.

The knowledge test consisted of six fact and seven transfer multiple choice tasks with four options of which none, one, several or all could be correct. This test was administered three times (before and after the individual phase, after the collaborative phase) via computer as part of the pre, in-between and post test in the same manner. Sample items are provided in

figure 1. *Knowledge acquisition* was operationalized by subtracting the pre test value from the in-between test value (individual phase) resp. the in-between test value from the post test value (collaborative phase).

Shared knowledge refers to knowledge all members of a group have in common (Weinberger, Stegmann, & Fischer, 2007). The amount of shared knowledge within the dyad was computed according to Weinberger et al.'s (2007) algorithm: Every item of the knowledge test that is solved by both members of the dyad is counted as shared knowledge item. The sum of these is divided by the mean value of the dyad in order to normalise it. The result indicates the amount of shared knowledge relative to the dyad's mean knowledge.

We can compare this to the amount of nominal groups' shared knowledge in order to distinguish shared knowledge as it occurs by chance from shared knowledge due to collaboration. *Nominal groups* (Taylor, 1955) are groups that are formed by the same number of people as the real groups they are compared with and who performed the same task but without interacting with each other or being aware of their membership in the nominal group (Larson, 2010). Therefore, nominal groups are a mere statistical entity (Larson, 2010). They provide a standard of group performance against which real interacting groups can be compared. In our case, we formed nominal groups by randomly grouping one member of a dyad with the partner from a different dyad.

2.3.2 Motivation.

Motivation was measured in both phases before, during, and after learning. For the purpose of this study, we focus on current motivation before learning.

Current motivation in both phases was assessed with the following self-constructed scales according to our research framework as there was no (German) instrument comprising all motivational constructs we assumed: self-efficacy, instrumentality beliefs, attainment value, interest, intrinsic task value, and costs (see Schoor, 2010, for further details). After

explorative factor analyses with varimax rotation factor values were computed (by regression) and used for all further analyses. Table 2 lists factors and sample items for the individual phase, table 3 for the collaborative learning phase.

After measuring current motivation before the collaborative phase, a questionnaire on goal orientations (SELLMO: Spinath, Stiensmeier-Pelster, Schöne, & Dickhäuser, 2002) followed. This instrument covers performance approach goal orientation, performance avoidance goal orientation, mastery goal orientation and work avoidance on a 5-point Likert scale. In its original version, the SELLMO cover general goal orientations at the university (beginning of every item: “For me, the point at university is…”); for our purpose, we changed this to a state version of goal orientations by altering the introduction sentence (“For me, the point in this session is…”). For sample items, see table 3.

2.3.3 Learning activities during individual phase.

Participants reported their learning activities immediately after the individual learning phase in a questionnaire based on the LIST (learning strategies in college education: Wild & Schiefele, 1994) which in turn is based on the MSLQ (e.g. Pintrich, Smith, & McKeachie, 1989). An exploratory factor analysis with varimax rotation revealed four factors for which factor values were computed (by regression). Resulting factors are listed in table 4.

2.3.4 Learning activities during collaborative phase.

During the collaborative phase, chat statements and editor changes were logged by the course management system. Two raters segmented these entries according to Strijbos, Martens, Prins, and Jochems (2006). They suggested to segment in “meaningful sentences” which is one sentence or a meaningful part of a sentence. They also suggested computing inter-rater agreement in segmenting by dividing the number of congruent segments by the total number of this rater. This procedure leads to two different inter-rater agreement indices

for both raters. In this study, the agreement was 83.7 % resp. 81.1 %. In cases of noncongruence, the raters and the first author negotiated the segments.

Thereafter, the segments were coded according to an adjusted version of the coding scheme by Weinberger and Fischer (2006). Categories were fixed a priori. The coding scheme differentiates on an epistemic dimension whether participants are engaged in task-related (epistemic) matters, in coordination or in other non-epistemic activities. On a second dimension, called dimension of social modes of co-construction, every segment was additionally related to a collaborative learning activity. For categories used see table 5 or Schoor (2010). The inter-rater agreement for these dimensions was with Cohen's $\kappa = .76$ resp. $\kappa = .73$ substantial (Landis & Koch, 1977).

2.3.5 Control variable: Appraisal of the learning partner's motivation and competence.

Additionally, during the collaborative phase the participants had to rate their partner's motivation and competence (8 items, e.g. "My learning partner is very motivated." – "My learning partner knows exactly what this is all about."). An explorative factor analysis revealed only one factor for which a factor value was computed. Internal consistency of this scale added up to $\alpha = .94$.

3 Results

The research questions were analysed via correlation and regression while accounting for multiple comparisons (Bonferroni correction). Due to technical failure, there are missing data for single questionnaires (in-between-test and popups) for 3 participants. These and their partners were excluded listwise. According to Graham (2009), this is a passable approach for dealing with a small percentage of missing data.

3.1 Descriptive Statistics and Knowledge Acquisition

Table 6 shows the mean points in the knowledge tests before (pre test) and after (in-between test) the individual phase as well as after the collaborative phase (post test). Due to extreme high values in the pre test, one participant was excluded from further analyses as well as his learning partner. This happened because the aim of this study was to investigate participants with homogeneously low prior knowledge. A repeated measurement ANOVA revealed that the increase of knowledge was significant ($F(2, 382) = 78.93$, $p < .001$, $\eta_p^2 = .29$). This was also true for the following planned contrasts: the increase during the individual phase ($F(1, 191) = 76.49$, $p < .001$, $\eta_p^2 = .29$), and the increase during the collaborative phase ($F(1, 191) = 17.25$, $p < .001$, $\eta_p^2 = .08$). All results were about the same for the sub-components factual and transfer knowledge which are therefore not reported here.

Additionally, the amount of *shared knowledge* within the dyads (computed according to Weinberger et al., 2007) is depicted in table 6. This increase also is significant ($F(2, 190) = 4.57$, $p < .05$, $\eta_p^2 = .05$). However, nominal groups in this study also ended with 31% of their knowledge being "shared" (c.f. table 6). This does not differ significantly from the real group's shared knowledge ($F(1, 190) < 1$, $p > .68$, $\eta_p^2 = .00$) indicating that the specific interaction with one's learning partner was not relevant for the amount of shared knowledge at the end of the collaboration.

Table 5 shows mean frequencies of learning activities during the collaborative phase for both dimensions. It reveals that on the epistemic dimension more than half of the segments were task-related and that on the dimension of social modes of co-construction externalizations were predominant.

For learning activities during the individual phase, the factor analysis resulted in factor values for each participant. Therefore, means are 0 and standard deviations 1. The same goes

for motivational variables apart from goal orientations. Table 7 shows descriptive data for these scales. There is a high mean of mastery goal orientation, whereas other goal orientations are middle to low in mean value.

3.2 Research Question 1: Current Motivation and Knowledge Acquisition

The first research question asked for the relationship of current motivation with knowledge acquisition during individual (Hypothesis 1a) and collaborative learning phases (Hypothesis1b) and the mutual influence of both learning partners (Hypothesis 1c). Regarding hypothesis 1a, table 8 shows correlations between the scales of current motivation (before the individual phase) and knowledge acquisition. There was one significant correlation, namely that of self-efficacy referring to the task with knowledge acquisition during individual learning.

Concerning the collaborative phase (Hypothesis 1b), there was no significant correlation of current motivation with knowledge acquisition (c.f. table 9). However, performance avoidance goal orientation correlated negatively with knowledge acquisition (r = -.19, p < .05).

In order to assess the mutual influence relationship of current motivation and knowledge acquisition of both learning partners (Hypothesis 1c), we conducted a regression analysis with the learning partner's knowledge acquisition as criterion and current motivation of both group members as predictors. We found no significant results ($F(10, 181) = 0.67$, $R^2 = .04$, adj. $R^2 = -.02$).

So far, dependent variable of the analyses was knowledge acquisition. However, one could argue that the group product, namely the handout, plays a much more important role than knowledge acquisition and that therefore motivation has to influence not (alone) knowledge acquisition but also the quality of the handout. Therefore, all analyses of the collaborative phase with knowledge acquisition as dependent variable were repeated with the

quality of the handout as dependent variable. This was done be regressing the quality of the handout on predictor variables of both learning partners of a group. However, no motivation construct was significant predictor of the quality of the handout.

3.3 Research Question 2: Motivation and Learning Activities

The second research question asked for the relationship of current motivation with learning activities during individual (Hypothesis 2a) and collaborative learning phases (Hypothesis 2b) and for the mutual influence of both learning partners on the relationship between them during collaboration (Hypothesis 2c). For the individual phase, participants reported their learning activities, whereas for the collaborative phase, learning activities were observed by logging chat statements and editor changes.

Concerning hypothesis 2a, table 10 shows relationships of current motivation with self-reported learning activities. In sum, self-efficacy referring to the task correlated negatively with attention problems, instrumentality beliefs correlated positively with elaboration and anxiety correlated also positively with attention problems. Concerning hypothesis 2b, there was no correlation of current motivation with observed learning activities. However, performance approach goal orientation correlated with the percentage of conflicts ($r = .26$, $p < .01$).

Concerning hypothesis 2c, we conducted regression analyses for each learning activity as criterion with current motivation of both learning partners as predictors. None of these regressions was significant ($0.61 \leq F\ (10, 181) \leq 1.58$; $.04 \leq R^2 \leq .08$; $-.02 \leq$ adj. $R^2 \leq .03$).

3.4 Research Question 3: Mediators

Necessary condition for mediation is a correlation of the predictor with the mediating variable and the dependent variable as well as a correlation of the mediating variable with the dependent variable (c.f. Baron & Kenny, 1986). This is in this study not true for any motivational variable (predictor), learning activity (mediator) and knowledge acquisition

(dependent variable) so that there cannot be any mediating relationship (Hypotheses 3a-3c). The same is true for goal orientations as predictors.

3.5 Exploratory Analysis of the Appraisal of the Partner's Motivation and Competence

Further exploratory analyses showed that the appraisal of the partner's motivation and competence (APMC) was important. The measurement of this appraisal took place during collaboration (at the same time as the measurement of motivational and functional state). The APMC correlated negatively with the percentage of elicitations (r = -.43, p < .001) and positively with externalizations (r = .27, p < .01). In order to better understand this relationship, we regressed the overall "work on task" category on APMC while using goal orientations as moderator (c.f. table 11). For each of the four goal orientations (mastery goal orientation, performance approach goal orientation, performance avoidance goal orientation, work avoidance), we conducted hierarchical regression analyses with APMC and the goal orientation as well as a moderator term APMC x goal orientation as predictors (c.f. Baron & Kenny, 1986). For work avoidance and performance approach goal orientation, even the simple model without moderation term could not significantly predict work on task. In contrast, APMC and mastery goal orientation were able to significantly predict work on the task (c.f. table 11), whereas the moderation term did not contribute significantly. In case of performance avoidance goal orientation, the moderator model explained significantly more variance than the simple model (c.f. table 11). As all variables were *z* standardized before the regression analysis, this last result means that participants with a positive APMC and high performance avoidance goal orientation (positive *z* value) as well as participants with a negative APMC and a low performance avoidance goal orientation (negative *z* value) did less work on the task.

4 Discussion

To sum up the results: With regard to the individual phase, there were relations of current motivation with knowledge acquisition (Hypothesis 1a) and learning activities (Hypothesis 2a) but no mediators (Hypothesis 3a). These results coincide with Wigfield and Eccles (2000) or Pintrich and De Groot (1990). The lack of mediators might be due to the measurement of learning activities via self report which is considered less valid than e.g. think aloud protocols (c.f. Bannert & Mengelkamp, 2008), but in this study, the collaborative learning activities were in focus and therefore the more economic method of self report was chosen to measure individual learning activities.

With regard to the collaborative phase, there were no relations of current motivation, knowledge acquisition (Hypothesis 1b) and learning activities (Hypothesis 2b). Only goal orientations correlated with learning activities and knowledge acquisition. Moreover, the assumptions about mutual influence of both learning partner's motivation on knowledge acquisition (Hypothesis 1c) and learning activities (Hypothesis 2c) were not supported by our data. Furthermore, exploratory analyses showed that the appraisal of the partner's motivation and competence might have played a notable role: participants who considered their partner more motivated and competent asked fewer questions and if they were additionally high in performance avoidance goal orientations, they made fewer contributions to the task.

All in all, these results were not expected. Especially the missing relations of motivation, learning activities, and knowledge acquisition during the collaborative learning phase raise questions. We can think of four possible explanations for these findings: an explanation concerning the validity of the measures, a no effect explanation, a task perception explanation and an interactive motivation construct explanation.

4.1 Validity of the Measures

The first possible explanation concerns the validity of the used instruments. First of all, the *knowledge test* might have been too difficult. In favour of this speaks that there were overall low knowledge scores. However, knowledge acquisition in both phases was significant, and correlations of knowledge acquisition with motivation were found for the individual phase. Therefore, we tend to exclude this concern.

Another measure was that of *learning activities* during the collaborative phase. We found almost no relations of collaborative learning activities with knowledge acquisition. However, earlier research using a very similar approach to measure learning activities (e.g. Weinberger, 2003) did find relations to knowledge acquisition. Moreover, an invalid measure of learning activities could not explain the missing relation of motivation and knowledge acquisition. Therefore, we are looking for other possible explanations.

Last main measure was that of *motivation*. We used very similar constructs and items in the individual phase and did find effects, although only for some constructs (self-efficacy, instrumentality beliefs, anxiety). Either way, our motivation constructs seemed not to capture those motivational effects which probably underlie the appraisal of the partner's motivation and competence. Therefore, the measurement of motivation might be a lead.

4.2 No Effect Explanation

A second possible explanation for our results would be that there are *no motivation effects* in CSCL. However, we found some effects of goal orientations on knowledge acquisition and on learning activities. Moreover, we interpret the exploratory finding of the influence APMC has on learning activities as a free-rider effect (e.g. Kerr, 1983) and therefore as another indicator for the importance of motivation during CSCL. *Free riding* refers to the finding that participants spend less effort on a task when working on it as a group than when they work on it individually. The perceived dispensability of own effort is

deemed to be one cause for this effect (e.g. Karau & Williams, 1993; Larson, 2010) which in our study might have appeared when the learning partner was perceived as highly motivated and competent. A perceived dispensability of one's contributions leads to a motivation loss and reduced effort (e.g. Karau & Williams, 1993). In our study, less competent learning partners (or learning partners feeling less competent) who pursued performance avoidance goals were apparently not motivated to contribute to the joint task. Instead, they became free riders by leaving the work to their assumedly more competent and motivated learning partners. Though, as this finding was an exploratory one, our results should be replicated. Karau and Williams (1993) in their meta-analysis on motivation losses in groups also found that a higher group cohesiveness prevents motivation losses. Therefore, a longer collaboration of the group might promote group cohesiveness and therefore motivational team processes which go beyond those observed in our study.

A more specific no effect explanation would be that in our scenario there was *no real collaboration* and no real knowledge acquisition during the collaborative learning phase. The small occurring knowledge acquisition during this phase might be due to the fact that during the collaborative phase participants wrote former unshared knowledge into the joint handout. In this way, the learning partner got information which was new to him. However, this does not mean that co-construction of knowledge took place (c.f. Summers & Volet, in press) because only the pure information could be enough to promote knowledge acquisition. In addition, real groups and nominal groups shared after collaboration about the same amount of knowledge. This means that being in a real group (interacting with a certain participant) made no difference. Due to our formation of nominal groups by using the data of the real group participants, this might either indicate that all groups learned and shared the same knowledge or that the groups indeed did not engage in active knowledge sharing but the amount of shared knowledge raised due to, for example, writing unshared knowledge into

the joint handout. In future, a knowledge test could be designed in such a way that small information entities are identifiable which are attributable to a specific information resource. Then the information entities could be tracked through the knowledge tests of both group members before and after collaboration. When analysing the interaction of the group, we could also code whether the participants talked about these information entities. By doing so, the information entities could be tracked throughout the interaction and this explanation could be explored further. An alternative way of how knowledge acquisition could have been promoted without collaboration is the testing effect (McDaniel, Roediger, & McDermott, 2007): McDaniel et al. (2007) found that the mere (repeated) testing of knowledge leads to knowledge acquisition. Overall, the comparably low mean of knowledge acquisition during the collaborative phase and the percentage of shared knowledge compared to nominal groups speak in favour of this specific no effect explanation.

4.3 Task Perception

Closely related to this is another possible explanation in terms of *task perception*. It might be that the participants understood the collaborative learning phase not as a learning opportunity, as it is proposed by theory of collaborative learning (e.g. Littleton & Häkkinen, 1999), but as a working task which they had to execute. Van Boxtel, van der Linden and Kanselaar (2000) also found that in a poster task requiring concrete actions like writing and drawing (which is close to producing a handout) participants talked less about content. This cannot lead to the hoped for deeper learning during collaborative learning. Both the few questions concerning understanding of the topic and the unexpected negative influence of a positive appraisal of the partner (free-rider effect) support this interpretation. Task perception might be different for participants with different values of mastery orientation. Dyads with homogeneously high mastery orientation might not be affected by this negative kind of task perception and learn nevertheless. However, we could not find support for this

in the data. Another argument against this explanation is the missing relationship of motivation with the quality of the group product. So this explanation is at least doubtable.

4.4 Motivation as an Interactive Construct

As a last possible explanation for the missing results in our study, we want to address the notion of motivation as an interactive construct. Although we found no direct effects of motivation before the collaborative learning phase on learning activities or knowledge acquisition, we assume that the free-rider effect we found in terms of the appraisal of the partner's motivation and competence indicates motivation losses of some participants and therefore the importance of motivation also during CSCL. However, we were not able to grasp these motivational processes by means of our motivation questionnaires. This might be due to several construct-related reasons.

For one, our chosen items might not have worked well and did not closely enough cover the desired constructs. In this case, reformulation of items would remedy this problem.

Another reason might have been the measurement point of motivation: we measured current motivation before the actual collaboration. Therefore, participants had no opportunity to get an idea of their learning partner. At least, motivation should be measured after a short period of collaboration. However, even a later measurement of motivation cannot detect dynamic changes of motivation over time (c.f. Schoor & Bannert, 2010) which might also play a role in collaborative learning (c.f. Reimann, 2007). For applying such a dynamic approach, we would need an assessment method which could be administered more frequently than self-reports, preferably continuously, to measure motivation. There are attempts to do so based on behavioural data (e.g. Ainley & Hidi, 2002; McQuiggan & Lester, 2006). These behavioural data, though, are not only ascribable to motivation but also to other causes like e.g. prior knowledge (c.f. Schunk & Pajares, 2007).

Last but not least we have to ask whether the motivation constructs we used, stemming from models of individual learning, are suitable to assess motivation in a group context. There are different ways of combining group members' motivation to assess group motivation. We chose to use both members' motivation scores as independent predictors of group behaviour. Other authors use, for example, means of individual scores (e.g. Sins et al., 2008). Another possibility is that of using a different construct which explicitly includes the group aspect. In favour of this speak the found effects for goal orientations which in part are such a construct as the presence of others is an important aspect of performance goal orientations. Of which nature such a construct could be, shows the example of self-efficacy and collective efficacy. Still being an individual measure, collective efficacy covers the group "members' appraisals of their group's capability as a whole" (Bandura, 1997, p. 478). Bandura (1997) defines perceived collective efficacy "as a group's shared belief in its conjoint capabilities to organize and execute the courses of action required to produce given levels of attainments" (p. 477). Although Bandura (1997) himself suggests to aggregate individual level measures of collective efficacy for a group-level value to analyse, this procedure suffers from the same interpretation problems as other aggregated data on group level: Aggregated data are only interpretable at the aggregated level, therefore not able to enlighten processes on the individual level (Cress, 2008). Moreover, whether or not data may be aggregated should be empirically tested (Kenny et al., 2006). However, it seems worthy to further explore whether the idea of collective motivation is applicable to other motivation constructs and whether collective efficacy and maybe other collective motivation constructs are able to predict group behaviour and outcome in a CSCL scenario. A starting point for a more collective view on motivation might be the collective effort model by Karau and Williams (1993) which extends the classic expectancy-value approach for individual action to the group context for collective action.

4.5 Limitations of the Present Study

There are some limitations of the present study. For one, participants did not know each other and collaborated only once. On the other side, this one session was quite long (4 hours). However, this was due to the aim of analyzing participants with no prior knowledge and to enable only one study session. Alternatively, participants could collaborate during a whole semester (c.f. Järvelä et al., 2008). This might also lead to more competence concerning collaboration which could lead to different results (c.f. Narciss & Körndle, 2008). However, the aim of the study was to investigate a setting quite common at German universities: Students have to prepare a seminar session together and this is the single case of collaboration during the whole semester. Therefore, our chosen scenario was an ecologically valid example for a singular collaboration.

4.6 Conclusions

For future research, the finding that the appraisal of the partner's motivation and competence plays an important role for task contribution has to be replicated and further assessed. Moreover, the probably most interesting and challenging task for future research is to develop constructs and methods for assessing motivation during CSCL in a valid way transeunt the existing approaches. In this context, both the interactive and collective nature of motivation in a group situation have to be taken into account.

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Table 1. Procedure of the study.

Individual preparing phase	Collaborative learning phase
1) Pretests (approx. 25 min) • Demographics • Prior knowledge • Instruction with learning text extract and setting of learning goal • Current motivation	*4) Instruction for collaborative learning phase and In-between-test 2* (approx. 10 min) • Instruction for collaborative learning phase • Current motivation concerning collaboration • Goal orientations
2) Individual preparing (approx. 60 min) Task: Reading text and creating pre-version of handout • Popup (after 30 min): motivational and functional state • Quality of pre-version of handout	*5) Collaborative learning* (approx. 90 min) Task: Developing a common handout • Popup (after 45 min): motivational and functional state, appraisal of the partner's motivation and competence • Observation of learning activities (Logfiles) • Quality of handout
3) In-between-test 1 (approx. 20 min) • Self-report learning activities • Knowledge • Motivation after learning 1	*6) Posttests* (approx. 20 min) • Knowledge • Motivation after learning 2
Break (approx. 15 min)	

Table 2: Current motivation scales, their internal consistency and a sample item for individual learning phase.

Current motivation scale	# of items	α	Sample item
Self-efficacy re. task	12	.97	I think after reading the text I will be able to explain to others how a test of significance works.
Self-efficacy re. computers	5	.91	I think I'm able to work with a new computer programme even when it's complex.
Instrumentality beliefs	4	.82	You have to know the test of significance in order to be able to conduct empirical studies.
Attainment value	4	.81	I'm intent on developing a good handout.
Interest	8	.92	I find the topic 'test of significance' fascinating.
Intrinsic task value	4	.91	I like working on handouts and outlines very much.
Utility value	3	.78	It's very important to me to be able to conduct empirical studies.
Anxiety	11	.95	When thinking about the learning objective, I'm a little concerned.

Table 3: Motivation scales, their internal consistency and a sample item for collaborative learning phase.

	# of items	α	Sample item
Current motivation before learning			
Self-efficacy re. collaboration	12	.96	I think I'm able to contribute to our understanding of the test of significance.
Attainment value of collaboration	5	.90	Handing in a good handout is very important to me.
Interest	4	.89	I find the topic 'test of significance' fascinating.
Costs of collaborative learning	10	.93	I think collaborative learning is more beneficial to learning than learning alone. (recoded)
Anxiety in collaboration	12	.94	I'm worried that I won't achieve the learning objective.
Goal orientations (SELLMO)			For me, the point in this session is...
Performance approach	7	.86	... to show that I'm good at this task.
Performance avoidance	8	.91	... that other participants don't think I was dense.
Mastery	8	.88	... to get new ideas.
Work avoidance	8	.90	... not to have work to do.

Table 4: Self-reported individual learning activities, their internal consistency and a sample item.

	# of items	α	Sample item
Elaboration	4	.76	I tried to relate new concepts or theories to concepts or theories already known to me.
Repetition	4	.71	I learned key concepts by heart to better remember important content.
Metacognition	3	.73	Before working on the material, I thought about how to proceed most effectively.
Attention problems	6	.94	I found myself being preoccupied.

Table 5: Mean frequencies of learning activities during collaborative phase (*N* = 192).

a) Epistemic dimension	M	SD	b) Social Co-Construction[a]	M	SD
Understanding of Matters	9.05	7.76	Externalizations	45.52	21.96
Clarification of task	1.10	1.41	Explanations	1.56	2.97
Work on task	61.28	25.73	Elicitations	7.66	4.67
Technology-related	5.60	5.42	Conflicts	6.62	8.18
Coordination	26.85	11.04	Quick Consensus Building	9.45	5.68
Other non-epistemic	21.99	15.98	Integration	0.62	3.47
Not categorisable	0.19	0.55			

[a] Only epistemic (Understanding of matters, clarification of task, work on task) segments.

Table 6: Descriptive data of knowledge tests (N = 192) as well as shared knowledge (in % of mean dyad knowledge) per dyad (n = 96 dyads).

						Nominal groups	
	M	SD	Max[a]	% shared	SD_{shared}	% shared	SD_{shared}
Pretest	2.58	1.70	13	.23	.27	.20	.26
thereof factual	1.35	1.03	6	.26	.34	.23	.33
thereof transfer	1.22	1.24	7	.09	.23	.08	.20
In-between test	3.92	2.22	13	.27	.23	.31	.22
thereof factual	1.86	1.13	6	.26	.31	.30	.29
thereof transfer	2.06	1.67	7	.22	.28	.24	.29
Posttest	4.44	2.59	13	.33	.25	.31	.22
thereof factual	2.31	1.34	6	.39	.32	.38	.29
thereof transfer	2.17	1.74	7	.21	.30	.18	.26

[a] Maximum points

Table 7: Descriptive data of goal orientations (*N* = 192).

	M	SD
Work avoidance	2.15	0.79
Mastery goal orientation	3.52	0.81
Performance approach goal orientation	2.51	0.79
Performance avoidance goal orientation	2.30	0.91

Table 8: Correlations of current motivation with knowledge acquisition during the individual phase (N = 192).

	Knowledge acquisition [a]
Self-efficacy re. task	.23*
Self-efficacy re. computer	.10
Instrumentality beliefs	.05
Attainment value	.03
Interest	-.00
Intrinsic task value	-.04
Utility value	-.08
Anxiety	-.13

Note. Adjusted for multiple comparisons (Bonferroni correction).

[a] Difference between in-between test score and pretest score.

* $p < .05$.

Table 9: Correlations of current motivation with knowledge acquisition during the collaborative phase (N = 192).

	Knowledge acquisition [a]
Self-efficacy re. collaboration	.07
Attainment value of collaboration	.00
Interest 2	-.01
Costs of collaborative learning	-.13
Anxiety in collaboration	-.06
Goal orientations	
Work avoidance	-.07
Mastery goal orientation	.06
Performance approach goal orientation	-.12
Performance avoidance goal orientation	-.19 [*]

Note. Adjusted for multiple comparisons (Bonferroni correction).

[a] Difference between posttest score and in-between test score.

[*] $p < .05$.

Table 10: Correlations of current motivation with learning activities during the individual phase (N = 192).

	Att[a]	Ela[b]	Rep[c]	Mc[d]
Self-efficacy re. task	-.27**	.06	.10	.05
Self-efficacy re. computer	-.03	.09	-.05	.05
Instrumentality beliefs	-.07	.26**	-.07	-.05
Attainment value	-.14	.10	.19	.12
Interest	-.14	.09	.06	-.07
Intrinsic task value	-.09	.04	.05	.14
Utility value	.11	.15	-.08	.08
Anxiety	.25*	-.03	.02	-.09

Note. Adjusted for multiple comparisons (Bonferroni correction).

[a] Attention problems. [b] Elaboration. [c] Repetition. [d] Metacognition.

* $p < .05$. ** $p < .01$.

Table 11. Regression analyses with APMC as predictor, goal orientations as moderators and work on task as criterion.

Model	R^2	Adj. R^2	ΔR^2	F	Δ F	t	B	SE	β
Moderator MO									
Model 1	.04	.03	-	F(2, 189) = 3.89 *	-				
APMC						-1.83	-3.39	1.86	-.13
MO						2.40	4.44	1.85	.17*
Model 2	.04	.02	.00	F(3, 188) = 2.59	Δ F(1, 188) = 0.23				
APMC						-1.83	-3.43	1.88	-.13
MO						2.40	4.47	1.86	.18*
APMC x MO						0.17	0.28	1.66	.01
Moderator PAv									
Model 1	.01	.00	-	F(2, 189) = 1.37	-				
APMC						-1.47	-2.73	1.86	-.11
PAv						0.89	1.67	1.87	.06
Model 2	.06	.04		F(3, 188) = 3.89 **	-				
APMC						-1.22	-2.23	1.83	-.09
PAv						1.43	2.66	1.86	.10
APMC x PAv						-2.97	-5.89	1.98	-.23

APMC = Appraisal of the partner's motivation and competence. MO = Mastery goal orientation. PAv = Performance avoidance goal orientation.

* p <.05. ** *p* < *.01*. *N* = 192.

Figure Captions

Figure 1. Knowledge test sample items for a) factual and b) transfer knowledge.

a) What is the p value in the test of sigificance?

- ☐ The power
- ☐ The level of significance
- ☑ The probability of a measured result given the assumption of H_0.
- ☐ The effect size

b) You developed a new headache drug and you are sure that it is more effective than Aspirin. In order to prove that, you conducted an experimental study and checked how fast the headacke of your participants evaporated. 10 participants received Aspirin, 10 other participants your new drug. Unfortunately, your result was not significant. However, as you are sure that your drug is effective, you want to conduct a new study. What can you do so that your result is this time significant?

- ☑ You examine this time 200 instead of 20 participants.
- ☑ You change your level of significance from 1% to 5%.
- ☐ You increase the effect in the population.
- ☑ You increase the power by decreasing the beta error by means of an increase of the alpha error.

Note. Correct items are indicated by ✓ which was invisible to the participants.