Do we really mean the same? The relationship between word choices and computer mediated cooperative learning.

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Abstract: This study analyses how the exchange of text specific information in virtual cooperative writing can be improved. Based on findings concerning the automatic absorption of words in written communication (lexical alignment), we conducted a study with 64 students to determine whether there was a positive impact of the use of different terminology on the transfer of knowledge and the individual learning outcomes. As assumed, dyads that had cooperated with material containing different terminology asked more questions, gave more explanations and performed better in a following learning test than dyads whose learning materials contained the same terminology. The results are discussed with regard to their implications for selecting and creating further learning materials.

Introduction

In recent years, educational and social psychological research has increasingly investigated virtual cooperative learning scenarios (see, e.g., Erkens, Prangsma, & Jaspers, 2006; Hmelo-Silver & Bromme, 2007). The advantages of this setting for university learning are clear. Students can divide up a large amount of literature and—based on their individual elaborations of its content—create a joint text as a basis for presentations, assignments or exams. Because the collaborative task can be coordinated via e-mail and the knowledge acquired is transformed into written form via the same medium, face-to-face meetings no longer seem necessary. Furthermore, the advantages of computer-based, cooperative writing are directly apparent in the working process. As Galbraith (1999) pointed out, the process of cooperative writing can be conceptualized as constructing knowledge and solving problems. Knowledge is gained through interaction. Based on this exchange, meaning is socially constructed and, as demonstrated by Scardamalia, Bereiter and Lamon (1994), individual learning outcomes can be improved by social exchanges. However, cooperative learning scenarios also have some disadvantages. Apart from potentially negative motivational effects in cooperative learning groups (Kerr, 1983) and the heightened effort of coordination in net-based environments (Graesel, Fischer, Bruhn, & Mandl, 2001), negative effects on the quality of task processing can be expected. For example, Wittenbaum and Stasser (1996) have shown that learning groups often fail to pool their heterogeneous knowledge, but rather focus on "shared" information that all members know. These observations raise the question of how the transfer of task-relevant, material-specific information can be supported.

In the past, research has tended to draw on social-psychological paradigms such as the willingness to share information (Wittenbaum, Hollingshead, & Botero, 2004) to explain the phenomenon that members of learning groups are more likely to discuss shared than unshared information. In contrast, this study takes a psycholinguistic approach to the topic.

In general, information is transmitted by communication. Discourse characteristics can thus be expected to have an immense impact on knowledge gain in groups. Several empirical studies provide support for this assumption (Cohen, 1994a, 1994b; Marby & Attridge, 1990). Apart from the identification of relevant information and persuasion of one's partner in discussion (Stein, Calicchia, & Bernas, 1996), the formulation of task-relevant questions (King, 1989) and elaborated explanations (Webb, Ender, & Lewis, 1986) have been found to have a crucial influence on individual learning performance. These kinds of discourse characteristics establish the basis for the communication partners in dyads or groups to construct a common mental representation of their knowledge (Ickes & Gonzalez, 1996). According to Clark (1996), the assumption of this common representation, or common ground, enables the partners to formulate their statements in anticipation that the other will understand. The partner's feedback can signal whether or not this assumption was correct. There are two possibilities: either the partner understood the information given or he or she requires more details or further explanation. Clearly, information about the partner's knowledge should be as precise as possible, thus facilitating partner-specific adjustments, which in turn enhance the effectiveness and efficiency of communication (Nueckles, Wittwer, & Renkl, 2005).

In internet-based communication, characteristics of the shared learning environment determine how well the common ground is established (Clark & Brennan, 1991). Especially in online written communication, which is becoming increasingly important with the widespread use of new media (Goldberg, Russell, & Cook, 2003; MacArthur, 2006), use of the same vocabulary indicates an existing common ground. The choice of words is thus determined by the mere availability of words during communication (Jucks, Becker, & Bromme, in press). In other words, if an agent introduces a new term, and the partner absorbs it without asking its meaning or giving other signals of understanding, the agent will presume a holistic understanding of the word. There is

no need for every sense of the word to be explained. Several authors (Bromme, Jucks, & Wagner, 2005; Pickering & Garrod, 2004) concur that this absorption of words in communication, or lexical alignment, is automatic and depends on simple priming mechanisms.

Lexical alignment clearly facilitates the fast and effective production of a joint text. There is, however, a risk that task-relevant information known by only one learning partner might be ignored. How can this lack of information sharing be overcome? As mentioned above, lexical alignment indicates understanding. When the same terminology is used, learning partners may thus omit to pool their information. It may, however, be possible to facilitate the exchange of task-relevant information by complicating the understanding of the text—specifically, by introducing misalignment as defined by Pickering and Garrod (2004). The authors suggest that, when alignment is faulty, interactive repair mechanisms are activated. Only then do the partners ask questions or give explanations. Note that the lack of information sharing is caused primarily by the agents' failure to formulate questions (Ross & Cousins, 1995). Misalignment may be introduced by presenting learners with different text material: different authors use different terminology to describe the same underlying concepts. It can be assumed that learning material designed to introduce misalignment will support the transfer of task-relevant knowledge. Let us imagine the situation of a learning dyad at university being instructed to produce a written document about a given topic. The learning partners will probably divide up the literature and work individually. In a next step, they will discuss the task via e-mail. If they have worked on texts that use different lexical codes to describe the same theoretical concepts, they will be forced to ask and answer questions about the text-specific terminology in order to create a common ground. As a result of this additional semantic processing of task-relevant terms, knowledge will be constructed socially and elaborated more in depth.

This study was designed to explore whether and to what extent the use of different terminology in learning materials affects the transfer of knowledge in virtual cooperative learning environments and the individual learning outcomes. Our hypotheses are as follows:

Communication.

We predict that dyads using material containing different lexical codes (different-terminology condition) will ask more questions and provide more explanations than control group dyads using material containing the same terminology (same-terminology condition). The former group will communicate longer in order to establish a common ground. In addition, we investigate whether the experimental manipulation impacts satisfaction with working process in general.

Individual learning outcomes.

We expect to find differences between the two groups in terms of their subjective self-ratings of gained knowledge. In addition, participants in the different-terminology condition are expected to remember more words describing relevant concepts and to generate more of these words in a context-based knowledge test than participants in the same-terminology condition.

Method

Participants and Design

Participants were 64 psychology students (50 female, 14 male) at the university of Muenster with a mean age of 22.16 years (*SD* = 2.73). To ensure similar levels of expertise across the sample, only undergraduate students were recruited. The participants were assigned to 32 dyads; assignment of the dyads to the experimental conditions was randomized. Participation was voluntary and rewarded with credit points that were part of the study project.

Learning outcomes were assessed for each participant individually (sample size = 64 participants with 32 in each condition) but the communication process and the texts produced were analyzed within dyads (sample size = 32 dyads with 16 in each condition).

Procedure

Each participant was tested individually in a room equipped with the necessary technology, and in the presence of an experimenter. Access to external internet sites was blocked to prevent participants from using information sources other than the learning texts. To prevent participants from making any assumptions about their learning partner, the partners in a dyad got pseudo-email addresses (which were gender-neutral) and they did not meet at any time. At the beginning of the experiment, participants were administered a short test assessing their knowledge of topic to be covered. Their computer skills were also assured. The partners in each dyad were then given different learning texts to work on with no time limit. They then received a collaborative task which was to be discussed and completed with their partner via e-mail. No further instructions were given. When they were finished, they were administered a second knowledge test comprising the same items used at pretest as well as a cloze task (Taylor, 1957) and a short questionnaire rating their satisfaction with the working process and surveying demographic characteristics.

Materials

Learning texts

The learning texts were original extracts from two standard textbooks of developmental psychology (Oerter & Montada, 2002, pp. 420-422; Berk, 2005, pp. 294-297). Both extracts addressed Jean Piaget's preoperational stage; each was around 1000 words long. Except for some abridgements to ensure that the two texts had the same length and format, no modifications were made. Although both texts addressed the same topic, their main focus differed. Specifically, the main focus of text 1 (from Oerter & Montada, 2002) was on children's interpretation of nature and Piaget's concepts of egocentrism, assimilation and accommodation. In contrast, text 2 (from Berk, 2005) addressed the development of children's understanding of symbols.

Manipulation of the text material

To prepare the manipulation of the texts, we drew up a list of terminology specific to the topics covered. Fifteen key concepts were identified. Some of the terminology used to designate the same underlying concept in the original texts differed (e.g., stage vs. phase); some of it was the same (e.g., assimilation). In cases where the terminology was the same in both texts, we looked for synonyms in other textbooks dealing with the same topics (Flammer, 1996; Trautner, 1991). Each term was matched with a synonym that had the same meaning in the present context. Two different versions of the text material were constructed by manipulating the usage of the 15 key concepts. In the different terminology condition, the 15 key concepts were used in one encoding (e.g., phase) in one text and in the other encoding (stage) in the other text. In the control condition, the same terminology (phase) was used in both texts. When matching the words, we sought to maintain a balance across the texts in the use of terms stemming from Latin or Greek and typical Piagetian terms.

Collaborative task

We used a collaborative task that supported the integration of text elements and the production of inferences during the learning process, and thereby facilitated deep comprehension. The task was taken almost directly from Berk (2005). The first part of the task provided information about a little boy, Max, who already understood that his rocking horse was not alive and therefore could not move by itself. The second part described a situation in which Max and his father were fishing. The father asked Max why the river was moving. Max answered that the river was alive and therefore wanted to move. The participants were instructed to explain this paradox by writing an other and sending it via email to the experimenter. The only modification we made to the collaborative task was to replace the original "scooter" by a "rocking horse" to simplify the first part of the task. Whereas the first part of the collaborative task addressed information that was in the focus of text 2 (Berk, 2005) the second part of the collaborative task addressed information that was in the focus of text 1 (Oerter & Montada, 2002). Hence, in order to succeed in the collaborative task information exchange between peers was necessary.

Dependent Measures

Two levels of analysis were used: the communication process itself and the individual knowledge gain.

Communication

To assess communication of the dyads three measures were used:

Characteristics of the communication process. The length of the communication process was ascertained by using Microsoft Word® to count the number of words in each e-mail and by calculating a total. All statements related to making the acquaintance of the learning partner, coordinating the working process and exchanging information were included in the analysis. Statements concerning technical problems or that were simply copies of previous statements were excluded. We analyzed the terminology used during the communication process by counting how often each of the words in the list of central concepts (including words with the same root) was used.

Exchange of information. To assess information pooling, we determined the number of questions asked and explanations provided in each dyad. We restricted the assessment to questions and explanations related to Piagetian terminology. Assuming that participants in the different-terminology condition would be generally motivated to query and explain the meaning of words, we counted questions and explanations relating to all Piagetian terms, not only the manipulated ones. Participants' questions and explanations were transcribed and analyzed (by a second rater) according to predefined criteria. Interrater reliability for the numbers of questions asked ($K = 0.83$, $p < .001$) and for explanations given ($K = 0.91$, $p < .001$) was satisfactory.

Satisfaction with the working process. Additionally, participants rated their satisfaction with the cooperative working procedure and the jointly produced text, as well as the comprehensibility of their partner's statements. Responses were given on a 5-point scale ranging from *good* (5) to *bad* (1).

Individual learning outcomes

The individual knowledge gain was measured by the following indicators:

Prior knowledge. Participants were asked if they had previously heard of Piaget ("yes"/"no").

Subjective self-rating of knowledge. They were then asked to rate their knowledge of Piaget's theory on a 5-point scale ranging from *good* to *bad*.

Encoding of central concepts. To ensure relevant vocabulary was not primed in the pre-knowledge assessment, we used a rather conservative method to ascertain participants' prior knowledge of Piaget's theory. Specifically, participants were instructed to list all words they associated with the topic. With the exception of 8 words at pretest and 4 words at posttest, which were excluded because they were judged not to be specific enough to Piaget (e.g. development), all words listed by the participants were included in the data analysis. The number of listed nouns was counted for each participant.

After the collaborative task, the participants were administered the latter two instruments a second time.

Cloze procedure. We developed a cloze text in which participants must fill in words that have been removed to determine whether participants could reproduce the Piagetian terminology in a continuous text and thereby demonstrate an understanding of the underlying concepts (Taylor, 1957). All in all, 32 Gaps were placed using a rational deletion procedure, with content words (as subjects, objects, adjectives, and verbs) being removed (Kobayashi, 2002). Three criteria were considered when placing the gaps. Four gaps ensured a general understanding of the cloze procedure respectively the content of the task. For these gaps all participants performed similarly well. Further 24 gapped words were drawn from the list of manipulated terminology. We were thus able to test the participants' general knowledge gain and to determine which vocabulary they used (e.g., "stage" or "phase"). A final set of gaps tested the main topics covered in the two texts. To this end, we devised two abstracts, each containing four gaps that could only be filled when knowledge of the two learning texts had been exchanged. To complete abstract 1, which included both manipulated vocabulary ("perspective", "egocentrism", "anthropomorphic") and text-specific vocabulary ("artificiality"), participants needed to be familiar with the text-specific content of text 1; to complete abstract 2, they had to know to be familiar with the main topics ("as-if", "representative") and with the text-specific content of text 2 ("realistic").

Results

Our findings confirmed that presenting learners with materials containing different terminology affected the learning process, individual learning outcomes, and the text produced. In this section, we will detail the effects on all three sets of outcome measures. Unless otherwise indicated, analyses were performed using SPSS 14.

Communication

Characteristics of the communication process. Dyads communicated for about one hour (M = 53.25 minutes, SD = 12.20 minutes), with an average of 19 turns (M = 19.34, SD = 7.14). On average, participants in the different-terminology condition used 13.81 (SD = 7.18) items of manipulated vocabulary in their written communication; participants in the same-terminology condition used 12.31 (SD = 3.05) items of manipulated vocabulary.

There was the trend ($F(1,32) = 2.75$, $p < 0.07$, one-tailed) for participants in the different-terminology condition to communicate longer (M = 1127.44, SD = 463.42) than participants in the same-terminology condition (M = 900.69, SD = 290.67).

Exchange of information. We conducted a one-way ANOVA with the number of questions or explanations relating to the manipulated vocabulary as the dependent variable. Participants queried the meaning of the terms "assimilation", "accommodation", "as-if", "magical", "egocentric", "absorption of perspective", "anthropomorphic", "animistic", and "artificiality".

Analysis of the number of questions asked revealed a main effect of the terminology condition ($F(1,32) = 3.13$, $p < 0.05$, one-tailed), with participants in the different-terminology condition asking more questions (M = 1.00, SD = 1.21) than participants in the same-terminology condition (M = 0.38, SD = 0.72). Likewise, analysis of the number of explanations provided revealed a main effect of the terminology condition ($F(1,32) = 5.69$, $p < 0.05$, one-tailed), with participants in the different-terminology condition giving more explanations (M = 2.94, SD = 2.24) than participants in the same-terminology condition (M = 1.44, SD = 1.15).

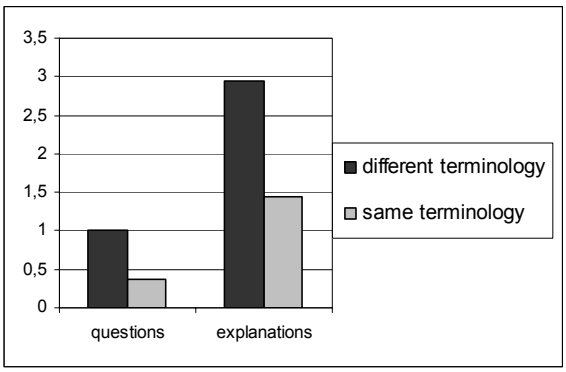

Figure 1. Mean number of questions and explanations used in communication processes.

Satisfaction with the working process. To enhance the interpretability of the results, all scores assessed by 5-point scales were recoded so that high scores indicated high endorsement of the items. One-way ANOVAs did not reveal significant main effects of the terminology condition for any of the dependent variables: satisfaction with the cooperative working procedure ($F(1, 32) = 0.01$, $p > 0.05$, one-tailed), satisfaction with the jointly produced text ($F(1,32) = 1.59$, $p > 0.05$, one-tailed), or comprehensibility of partner's statements ($F(1,32) = 0.79$, $p > 0.05$, one-tailed).

Individual Learning Outcomes

Before the experimental intervention, there were no differences in the prior knowledge ($\chi^2(1,64) = 1.00$, $p > 0.05$), subjective self-ratings ($F(1,64) = 2.21$, $p > 0.05$), or encoding of central concepts ($F(1,64) = 0.181$, $p > 0.05$) of participants in the two terminology conditions.

Knowledge gain. To examine the effects of terminology condition on students' learning performance, we conducted mixed (2×2) MANOVAs on subjective self-ratings of knowledge and the number of encoded concepts at pre- and posttest (see Table 3 for the descriptive statistics).

As expected, multivariate analysis revealed a main effect of time ($F(1,64) = 236.94$, $p < 0.001$, one-tailed), as well as a significant interaction of time and terminology condition ($F(1,64) = 6.25$, $p < 0.05$, one-tailed). Univariate analysis revealed a significant main effect of time on subjective self-ratings ($F(1,64) = 137.12$, $p < 0.001$, one-tailed) and on the number of encoded concepts ($F(1,64) = 371.72$, $p < 0.001$, one-tailed). Although there was no main effect of terminology condition ($F(1,64) = 0.05$, $p > 0.05$, one-tailed), the subjective self-ratings of participants in the same-terminology condition increased more than those of participants in the different-terminology condition, as indicated by a significant interaction of time and terminology condition ($F(1,64) = 6.56$, $p < 0.05$, one-tailed). In contrast, we found neither a significant main effect of terminology condition ($F(1,64) = 298.37$, $p > 0.05$, one-tailed) nor a significant interaction of time and terminology condition for the encoding of central concepts ($F(1,64) = 2.41$, $p > 0.05$, one-tailed).

Cloze test. On average, participants correctly filled 11.00 of the 32 gaps ($SD = 4.16$). We found no main effect of terminology condition on learners' performance in the two abstracts tapping the exchange of text-specific information ($F(1,64) = 0.91$, $p > 0.05$, one-tailed). However, the main effect of the two abstracts was significant ($F(1,64) = 25.88$, $p < 0.001$, one-tailed): participants in both conditions performed better in abstract 1 ($M = 1.86$, $SD = 1.13$) than in abstract 2 ($M = 1.27$, $SD = 1.04$). There was also a significant interaction effect between conditions and abstracts ($F(1,64) = 5.73$, $p < 0.05$, one-tailed), with participants in the different-terminology condition—unlike participants in the same-terminology condition—performing similarly well in both abstracts. Further analysis showed that there was a unique significant effect of abstract 2: participants in the different-terminology condition were better able to fill in these gaps than participants in the same-terminology condition ($F(1,64) = 2.18$, $p < 0.05$, one-tailed).

Discussion

Communication

We hypothesized that presenting learner dyads with materials containing different terminology would impact discourse characteristics. In accordance with our hypothesis, findings showed that participants in the different-terminology condition asked more questions and, in turn, gave more explanations to ensure mutual understanding than did participants in the same-terminology condition. We attribute this difference to the different-terminology participants' perception of a rather low common ground, signalled by the use of different terms during their communication on the collaborative task. Hence, automatic alignment was inhibited and the meaning of task-relevant terms had to be elaborated explicitly by asking questions. Thus, the learners formulated detailed explanations and, as predicted, information transfer was facilitated. In addition, participants

in the different-terminology condition communicated for longer than participants in the same-terminology condition, though the difference was not significant. Because there was no other experimental intervention, it can be concluded that this difference in the length of communication was also a result of exposure to different terminology. However, further analyses of the specific contents of communication are required.

Individual Learning Outcomes

The findings also support our hypothesis that elaboration and exchange of task-relevant, unshared contents can be improved by placing different vocabulary in cooperative learning materials. Participants in the different-terminology condition performed similarly well in both abstracts tapping the exchange of text-specific information. We suggest that these findings can be attributed to the formulation of questions about the precise meanings of terms, the greater elaboration of text content in the subsequent explanations, and the reinforced transfer of information. In addition, deeper comprehension was facilitated by the conception of the collaborative task, a high-level question in sense of Rouet et al. (2001) that called for the application of knowledge. However, despite their lower learning performance, the participants in the same-terminology condition rated their knowledge gains to be higher than did the participants in the different-terminology condition. This discrepancy between actual and perceived knowledge gain might be explained by the illusion of having learned more than is actually the case (illusion of knowing; Glenberg, Wilkinson, & Epstein, 1982). Because they used the same vocabulary, the learning partners may have assumed that their knowledge on the given topic was nearly complete. In contrast, the participants in the different-terminology condition were less confident about their actual knowledge because the different terminology indicated that much was not covered in the texts provided. Despite these differences in ratings of gained knowledge, there was no association between terminology condition and satisfaction with the general working process.

Limitations and Future Perspectives

Although the experimental setting investigated can be considered a typical learning situation at university, future research should investigate whether these findings can be transferred to other learning situations. One point worthy of consideration is the specificity of the terms used in this study. To use Piaget's terminology, the use of different terms seems to activate accommodation processes. However, this observation only applied to specific terms, such as "animistic", the meaning of which could not be deduced without explicit clarification by the learning partner, and which could therefore not be directly identified as synonymous with "anthropomorphic". These terms further illustrate an important characteristic of humanities terminology: both encode one underlying concept and can be used synonymously in learning texts. In contrast, the terminology used in the natural sciences tends to be very clearly defined and not necessarily exchangeable. In order to prevent uncertainty and complication of the working situation, future studies should determine for which terms the intervention is appropriate. Our findings on the participants' subjective self-ratings of knowledge provide further support for these suggestions. For example, it can be assumed that learners' perceived understanding is affected by the origin of terms (e.g., Greek, Latin, Germanic). A term like "as-if" might seem more familiar than a term like "symbol" in reference to an introduced theory. Furthermore, future studies should address the impact of other features of learning materials (e.g., form, structure, length, or illustrations).

Characteristics of the learning partners should also be considered. Spiro, Coulson, Feltovich and Anderson (1994) argue that humanities students can be expected to use heuristic procedures to solve problems and to debate different alternatives. These students can thus be assumed to recognize that two terms may exist to describe the same underlying concept. In addition, the age of the learners should have an impact on the development of assumptions about knowledge. Several researchers conclude that this development proceeds stepwise (King & Kitchener, 1994; Kuhn, 1991; Perry, 1970). The validity of the present results should thus be verified for other learners, such as school students. Further work is required to extend our findings to larger learner groups and, for example, to groups of learners with differing prior knowledge. Future research would further benefit from controlling for variables such as self-efficiency and commitment to performance.

Finally, our findings indicate that the terminology used in learning materials impacts learning behaviour. Hence, these aspects should be considered in the design and selection of learning materials.

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