

## **Article**

Supporting active cognitive processing in collaborative groups: The potential of Bloom's taxonomy as a labeling tool

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## **Supporting active cognitive processing in collaborative groups:**

### **The potential of Bloom's taxonomy as a labeling tool**

#### **Abstract**

Research in the field of computer supported collaborative learning stresses the need to foster the collaborative process in view of attaining optimal cognitive involvement of all participants, a higher level of metacognitive regulation and an increased level of affective involvement. The present study involved 80 third-year university students, enrolled in the educational sciences, in a quasi-experimental study to research the impact of a scripting approach to support their collaborative work in asynchronous online discussion groups. Students in the experimental condition were required to label all their contributions to the discussions using Bloom's taxonomy. The results point at a significant differential impact of this scripting approach: a higher level of cognitive processing was attained and students in the experimental condition mirrored a higher degree of metacognitive regulation in relation to planning, achieving clarity and monitoring. Lastly, the students in the experimental condition were more affectively involved. Given the two-week duration of the study, it is remarkable that the positive impact of the scripting approach was attained after this relatively short period of time.

## **Introduction**

The meta-analyses of Slavin (1996) and Johnson and Johnson (1996) led the perspective to regard the potential of collaborative learning and cooperative learning as strong instructional strategies. Hattie's (2009) more recent meta-analyses point to a number of critical conditions that are needed to attain a positive impact of collaboration. Johnson and Johnson (1996) cite certain guidelines must be met to support collaboration: guarantee individual accountability, assure group accountability, develop communication skills, make sure that shared objectives are pursued, and break down complex group tasks.

Building on the capabilities of the Internet to support communication, collaborative learning has also become an integral part of learning management systems (LMSs). The implementation of LMSs have brought about a new strand of educational research focusing on computer conferencing (CC), computer-mediated communication (CMC), also resulting in an established research field known as Computer-Supported Collaborative Learning (CSCL). In addition, pioneering research of Henri (1992) introduced quantitative approaches (such as the number of messages, level of interaction) and qualitative approaches (such as surface or deep level processing) to study the impact of collaboration in these online learning environments (Pena-Shaff & Nicholls, 2004).

Despite a large body of studies that have reported promising and positive empirical evidence about CSCL (see Moore, 2002), there is a critical need for further development of CSCL and empirical research that demonstrates its promise. First, some authors addressed the non-conclusive results of a number of studies (Archer, Garrison, Anderson, & Rourke, 2001; De Wever, Schellens, Valcke, & Van Keer, 2006; De Wever, Van Winckel, & Valcke, 2008). Researchers pointed to low or uneven levels of participation (Lipponen, Rahikainen, Lallimo, Hakkarainen, 2003; Ma, 2009; Schellens & Valcke, 2005), low average levels of cognitive processing (Hakkinen, 2001; Schellens & Valcke, 2006), the impact of prior knowledge (Ertl

& Mandl, 2006), and struggles with the structure in the discussions (Vonderwell & Zachariah, 2005). These issues underscore the statement of Dillenbourg (2002) that online collaboration does not automatically lead to improved learning performance.

Secondly, a new generation of CSCL research has evolved, no longer focusing on the straightforward impact of collaborative learning on learning performance but rather on addressing the question: under what circumstances, in what particular learning environments, with what type of students, and in view of what kind of learning tasks does CSCL have a positive impact (Jacobson, 2001)? Such studies focus on testing the guidelines that have been derived from empirical studies about collaborative learning without ICT (Johnson & Johnson, 1996). In particular, recent studies center on the impact of adding structure to the collaborative tasks in the CSCL setting. As a generic term, authors have advanced the concept of *scripting* to refer to a variety of ways to structure collaborative tasks (De Wever, Schellens, Van Keer, & Valcke, 2008; Kollar, Fischer & Hesse, 2003, 2006; Lockhorst, Admiraal, Pilot, & Veen, 2002; Weinberger, Reiserer, Ertl, Fischer, & Mandl, 2005).

Weinberger et al. (2005) define a script as a detailed and explicit didactic contract between the teacher and the group of students regarding their way of working together. Schellens, Van Keer, De Wever, and Valcke (2007) distinguish between content-oriented and communication-oriented scripts. A content-oriented script helps learners to select, organize and integrate the knowledge base that is at the base of the collaborative task (such as knowledge about infections to solve a discussion task about tropic diseases). A typical content-oriented script invited participants to label their discussion contributions on the basis of the thinking hats of De Bono. In this way, discussion participants made explicit the level of critical thinking they wanted to express (Schellens, Van Keer, De Wever, & Valcke, 2009). A communication-oriented script fosters the engagement of group members in the collaborative process by helping them to adopt different or specific perspectives, to consider in a conscious

way the input of peers, etc. Typical examples of communication scripts build on the assignment of a role to the participants; such as moderator, summarizer, theoretician, etc. (De Wever, Schellens, et al., 2008). Both scripting types are expected to invoke (1) an active cognitive processing of the declarative and/or procedural knowledge; (2) the meta-cognitive regulation of the cognitive processes during the collaborative process, since adding structure helps to trigger meaningful discourse (Gilbert & Dabbagh, 2005); and/or (3) the level of interaction in the online discussion.

In the current study, participants were presented with content-oriented scripts when tackling group tasks in a CSCL-setting. Participants were invited to qualify their contributions using Bloom's taxonomy. Participants were required to add a label to each individual contribution to the online discussions, based on a level in Bloom's taxonomy. First, the theoretical basis for the study is presented in general and the particular scripting approach in particular. Next, the research design is described. After a discussion of the results, the implications of the research results, research limitations and directions for future research are presented.

### **Theoretical basis**

A large proportion of CSCL-studies builds on the social-constructivist framework to describe, explain or predict the impact of learning in a collaborative way. Social interaction is considered to be the key to the active knowledge construction of the individual participants in the collaborative activity (Vygotsky, 1978). The cognitive constructivist perspective builds on the assumption that the input of participants in the CSCL-environment sustains knowledge construction and learning due to the need to make individual knowledge explicit, which includes the process of retrieving the knowledge from their memory. In addition, learners have to (re)organize their knowledge due to the input of others in the discussion. The social constructivist perspective is that the online collaboration builds on a negotiation of meaning

and that this knowledge is co-constructed (Lazonder, Wilhelm, and Ootes, 2003). In online discussions, information being exchanged is pre-structured in nature, reflecting a variety of perspectives commented upon, and is assumed to be more accessible by the participants. This assumption is central in the cognitive flexibility theory of Spiro, Feltovich, Jacobsen, and Coulson (1988).

According to these perspectives, the key to learning is interaction in the online discussions. In summary, empirical CSCL studies focus primarily on cognitive assumptions about the impact of collaboration in instructional settings (see Baker, 1996; Doise & Mugny, 1984; Erkens, 1997; Kreijns & Bitter-Rijkema, 2002; Petraglia, 1997; Savery & Duffy, 1996). The CSCL environment fosters information processing, building on the assumption that learners actively engage in cognitive processing to construct mental models (or schemas) based on individual and shared experiences. In this way, new information is integrated into existing mental models. This assumption that cognitive processing is active invokes three types of processes in and between working and long-term memory: selecting information, organizing information, and integrating information (Mayer, 2001). The mental models that are constructed are stored in and retrieved from long-term memory.

However, as stated above, more recent CSCL research tries to tackle the problems observed in earlier studies about lower levels of engagement, lower involvement, lower levels of cognitive processing, etc. The introduction of scripts is a key feature in these studies. Scripts are expected to influence participants to construct specific arguments by providing students prompts on which they have to respond (Hamalainen, 2008; Kollar, et al., 2003; Weinberger, 2003; Weinberger, Ertl, Fischer, & Mandl, 2005). The scripts are expected to influence particular information selection, organization and integration processes in the cognitive information processing cycle. This is also central to the Knowledge Building theory of Scardamalia (2002) who states that collaboration takes place through symmetry in

knowledge advancement. This implies a reciprocal exchange of knowledge among learners: giving knowledge implies getting knowledge.

In addition, scripts will influence metacognition, in terms of the learners' conscious monitoring of cognitive processes. The concept of epistemic agency is central in this context since the scripting is expected to sharpen the level of epistemic agency. Epistemic agency implies that learners themselves manage the advancement of their knowledge building. They coordinate their personal ideas with others, and monitor how their collaborative efforts are proceeding (Erstad, 2004). Learners with a high level of epistemic agency evaluate themselves, define clear goals and reflect a stronger engagement in their activities. They reflect a high level of metacognitive awareness, resulting in higher degrees of planning, monitoring and evaluation of their cognitive processes (Scardamalia & Bereiter, 2006). In contrast, learners with a low level of epistemic agency behave in an undirected way, are less focused, and give little proof of self-judgment. A medium level of epistemic agency is reflected in inconsistent goal-directed behavior, a fluctuating degree of activity engagement, and inconsistencies in self-evaluation.

In this context, King (1998) pointed out the value of scripting in the context of peer collaboration to influence distributed cognition and metacognition. In the context of the present article, the taxonomy of Brown (1987) is used to develop an operational definition of metacognition. Brown distinguishes between metacognitive knowledge and metacognitive regulation. The latter comprises regulation processes such as predicting, planning, monitoring, and evaluation. It is hypothesized that asking participants to label consciously their online discussion contributions will affect their metacognitive regulation (see also Veldhuis-Diermanse, 2002). In particular, it is expected that the Bloom taxonomy labels will influence

prediction strategies (How difficult is this task?), planning strategies (What shall I do to execute this task?), monitoring strategies (What do I yet not know in order to attain my objectives?) and evaluation strategies (Have I grasped the full meaning of this concept?).

Lastly, the scripts are expected to influence the affective involvement of participants in the online discussions. Collaborative tasks are reported to pose challenges to learners (Schweize, Paechter and Weidenmann, 2003). Scripts are hypothesized to ease these challenges by promoting affective involvement. Veldhuis-Diermanse (2002) points in this context to three types of affective involvement: affective motivation, affective asking, and affective chatting. Affective motivation can be observed when learners give compliments, express their feelings, or thank other students. Affective asking is reflected in messages “in which students ask for feedback, responses or opinions. [...] This concerns quite the general question; the question is not specified” (Veldhuis-Diermanse, 2002, p. 52). Affective chatting is reflected in “social talks, talks about the weather, a coffee break, the newspaper and so on” (Veldhuis-Diermanse, 2002, p. 52). Because they adopt the collaboration scripts, participants feel more at ease, feel more able to carry out the complex task, and feel less overwhelmed. Consequently, they contribute more intensively to the discussions. Also, Mäkitalo, Weinberger, Häkkinen, and Fischer (2004) stress that scripts help to reduce uncertainty in learners. Veldhuis-Diermanse (2002) and Lugano, Nokelainen, Miettinen, Kurhila, and Tirri (2004) present clear empirical evidence that higher affective involvement in CSCL settings is associated with higher levels of cognitive processing related to cognitive variables. Mäkitalo, Weinberger, Häkkinen, and Fischer (2004) stress that scripts help reduce uncertainty in learners and consequently lead to higher performance as reflected in larger proportions of synthesis and evaluative comments in the online discussions.



### **Bloom's taxonomy as a scripting tool**

Bloom's (1956, 1984) taxonomy of educational objectives was developed as a tool for a variety of purposes. His taxonomy is organized from simple to complex and concrete to abstract cognitive categories (Krathwohl, 2002), representing a cumulative framework that has been widely applied in educational research (Kunen, Cohen, & Solman, 1981). The authors of the present study have adopted Bloom's taxonomy as a "language" about learning goals to facilitate communication across persons, subject matter, and grade levels. More specifically, Bloom's categories reflect levels in knowledge construction (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956). Constructing knowledge implies movement from basic descriptive comments of opinion to using a variety of cognitive strategies, such as analysis, evaluation and creativity (Anderson et al., 2001).

There are conceptual and application limitations in using any taxonomy (Chan, Tsui, Chan, & Hong, 2002). For instance, Kunen et al. (1981) questioned whether evaluation should remain as the highest level of the original taxonomy. Former students of Bloom have revised the original taxonomy (Anderson and Krathwohl, 2001). Their changes especially affected the structure of the taxonomy. Instead of a uni-dimensional structure, they present a two-dimensional table. The knowledge dimension refers to the type of knowledge being learned (factual, conceptual, procedural, or metacognitive). The cognitive process dimension refers to six levels in cognitive processing (remembering, understanding, applying, analyzing, evaluating and creating). The original concepts in the taxonomy are now presented as active verbs, and two categories were changed as to their hierarchical position: evaluation and creating (Krathwohl, 2002). The revision of Bloom's taxonomy implies that it is now applicable to analyze both learning outcomes and the cognitive process used by students to complete a task. In the context of the present study, the study examines the latter possibility.

A number of CSCL-studies adopted Bloom's taxonomy to direct the analysis of online discussion contributions (Meyer, 2004; Schrire, 2006; Zhu, 2006). In the present study the taxonomy categories are not only adopted to analyse the cognitive processing level reflected in discussion contributions. The present study also adopts the taxonomy as a scripting guide for the students. Students in the experimental condition were asked to add to each of their discussion contributions a label that is based on one of the cognitive process categories in Bloom's taxonomy.

### **Research question and hypotheses**

Building on the available theoretical base and empirical bases about the potential of scripts in CSCL settings, the central research question of this study focuses on the differential impact of labeling online discussion contributions on the basis of Bloom's taxonomy on cognitive levels, metacognitive regulation, and affective involvement. The study comprised an experimental condition in which students had to label their contributions on Bloom's taxonomy and a control condition in which no labeling was required. The following hypotheses are presented:

- a. Online discussions of participants in the experimental condition will reflect a higher proportion of higher levels in Bloom's taxonomy.
- b. Online discussions of participants in the experimental condition will reflect a higher level of metacognitive regulation.
- c. Online discussions of participants in the experimental condition will reflect a higher level of affective involvement.

As will be discussed in the methodology section, a critical issue in relation to scripting and CSCL is the extent to which respondents in the experimental condition act in congruence with the script. With respect to the present study, this implies that it is necessary to check whether

students actually label their messages on the basis of Bloom's taxonomy. Prior to the testing of the hypotheses, treatment confidence was tested.

## **Research design**

### *Participants*

The participants in the present study represent the total population of undergraduate students ( $N=80$ ), enrolled in the Educational Sciences program at Ghent University. The study was set up as a formal part of a Mathematics Education course and thus participation was required. All students participated in an online discussion to develop a shared group definition for the concept of mathematics. All participants were novices to the field of mathematics education.

### *Research procedure*

Before the formal start of the mathematics education course, all participants were asked to enroll themselves in one of the ten different electronic groups via the university's learning management system. All participants were novices in the mathematics education knowledge domain. The first five groups (40 students) were chosen to be involved in the experimental condition and the last five groups in the control condition. Group participants in the experimental conditions (five groups) were required to label their discussion contributions on the basis of Bloom's taxonomy (Bloom, 1984). All groups were required to tackle the same group task. However, they did not have access to the discussions of other groups. In view of this group task, students were asked to discuss their solutions in an online threaded discussion environment. To develop their final text product, students had in addition access to a wiki-environment. The following task was proposed (shortened version): *Develop a shared definition of the concept of "mathematics". In the literature, a variety of approaches, theories, studies, practices, and a long history can be observed. You are invited to analyze the multi-dimensional structure of this concept. You will develop a shared multi-dimensional definition*

*about mathematics. The basis for your analysis is an examination of the international literature. You are required to build at least on 50 different ISI-indexed journal publications. Your report will be developed as an article and has to respect the APA 5.0 specifications for text structure and source references.*

All groups had to carry out this task in their own online discussion setting and wiki environment. They did not have access to the working environment of other groups. No face-to-face meetings were organized with group participants during the two-week discussion period from February 13 till February 25, 2009. Participants in the experimental condition were also required to label each individual discussion contribution. Participants in the experimental condition groups were familiarized with the basics of Bloom's taxonomy of educational objectives: knowledge, comprehension, application analysis, synthesis, and evaluation. Bloom's taxonomy had been a key part of the course "Instructional Sciences", tackled during the previous academic year. Next to a theoretical introduction to the taxonomy, students learned in this course how to apply the taxonomy to categorize learning objectives, and how to develop them. In view of the present study, they received a short information leaflet that described Bloom's six cognitive process categories in the taxonomy, enriched with a number of examples helping to better understand each taxonomic level. Participants in the experimental groups were required to select a label category; the online system returned an error when no label was selected. No information with respect to Bloom's taxonomy was provided to the students in the control group setting.

The study took two weeks. Though students still had access to the discussion environment, and their final product in the wiki setting, they could no longer add or change contributions. All messages were logged and stored in electronic files for coding purposes.

### *Analysis procedure and analysis instruments*

As stated above, all discussion contributions of the students were used as data for this study (2225 valid messages). Two coding instruments were used by two independent coders to categorize the input of all participants. The coders received training about the two coding methods. First, all messages were coded on the basis of the six cognitive processing categories in Bloom's taxonomy. This implies that each cognitive message received a code ranging from 1 to 6. Second, the messages were coded on the basis of the instrument of Veldhuis-Diermanse (2002). Her instrument was developed through a grounded theory approach and focuses on analyzing students' learning in CSCL-environments (Veldhuis-Diermanse, 2002). It is partially rooted in the classification of Vermunt (1992), who distinguishes cognitive, affective, and metacognitive learning activities (Veldhuis-Diermanse, 2002; also see De Wever et al., 2006). Veldhuis-Diermanse (2002) reports a high level of reliability when using the instrument: Cohen's kappa ( $\kappa$ ) of .82. Only part of her instrument was used to study the impact on two dependent variables: the affective involvement and the metacognitive processing.

In this respect, Veldhuis-Diermanse (2002) distinguishes – as explained above – between three types of affective involvement: affective motivation, affective asking, and affective chatting. *Affective motivation* entails “expressions such as giving compliments because of clear or innovative contributions, or expressing feelings about the pleasant atmosphere or notes in which students are thanked for doing something” (Veldhuis-Diermanse, 2002, p. 52). *Affective asking* comprises messages “in which students ask for feedback, responses or opinions. [...]” (Veldhuis-Diermanse, 2002, p. 52). The *affective chatting* code is assigned to messages in which students have “social talks; talks about the weather, a coffee break, the newspaper and so on” (Veldhuis-Diermanse, 2002, p. 52). The metacognitive learning activities are subdivided into planning, keeping clarity, and

monitoring. Three types of *planning* are distinguished, i.e. presenting an approach or procedure to carry out the task (*presenting approach*), asking for an approach or procedure to carry out the task (*asking approach*), and explaining or summarizing the approach already adopted (*explaining approach*). When no planning activities are found in a particular message, a *no planning* code was assigned. *Keeping clarity* is subdivided into structuring the contributions in the database (*structuring database*), asking for an explanation, clarification or illustration as a reaction to a certain note (*asking clarification*), and giving explanation on unclear information in notes or answering a question asked by another participant (*giving explanation*). When no keeping clarity activities are found in the message, a *no keeping clarity* code was assigned to the message. With respect to *monitoring*, two types are distinguished: *keep watching* (monitoring the original planning, aim or time schedule) and *reflective process* (reflecting on one's own actions or on certain contributions to the database). When no monitoring activities are found in the message, a *no monitoring* code was assigned to the message.

As explained above, the coding of every message in the discussion fora was carried out by two trained independent coders. All messages were coded following the taxonomy of Bloom (cognitive learning activities) as well as following the categorization of Veldhuis-Diermanse (affective involvement and metacognitive learning activities). Of the total number of messages (N = 2225), 12.7 % was coded by both coders to determine interrater reliability (n = 282). Cohen's kappa was calculated and indicated a high reliability between the two coders. For Bloom, kappa = .95; for Veldhuis-Diermanse - affective involvement, kappa = .87; for Veldhuis-Diermanse - metacognitive planning, kappa = .89; for Veldhuis-Diermanse - metacognitive clarity, kappa = .91; and for Veldhuis-Diermanse - metacognitive monitoring, kappa = .88.

### *Statistical analysis*

The treatment condition is the independent variable in the present study (labeling condition versus non-labeling condition). Three main dependent variables are distinguished: (1) the level of cognitive processing as coded along the cognitive processing dimension in Bloom's taxonomy; (2) the level of metacognitive regulation determined on the basis of the coding instrument of Veldhuis-Diermanse (2002) that additionally distinguishes between planning, keeping clarity, and monitoring; and (3) the level of affective involvement, again determined on the basis of the coding instrument of Veldhuis-Diermanse (2002).

The analysis procedure started with a screening of the descriptive results. To study the differential impact of the experimental treatment in detail, nominal logistic regressions (also called multinomial logistic regressions) were used to look for significant differences between the experimental (labeling) condition and the control condition. This was done for the different coding schemes, based on Bloom (cognitive processing levels) and Veldhuis-Diermanse (metacognitive planning, clarity and monitoring; and affective involvement). The multinomial logistic regressions were calculated with SPSS 15.0. The regression test comprises first of all of an overall likelihood ratio test (based on a Chi-square analysis to study differences in proportions of observed categories between the experimental and the control condition). Secondly, the analysis focuses on a detailed nominal logistic regression studying where the overall differences can be attributed to, i.e. which of the specific differences are significant ( $p < .05$ ). In view of the nominal logistic regression analyses, a specific reference category was chosen. Choosing a reference category is a pre-requisite when applying multinomial logistic regression. The reference category is one category in the dependent variable serving as a comparison category.

As explained earlier in this article, treatment confidence matters highly when studying computer supported collaborative learning activities. Therefore, prior to running the statistical analyses, the degree of correct labeling by the participants in the experimental condition was controlled by calculating the correlation between the Spearman Brown correlation between the codes assigned to their messages by the students in the experimental condition and the codes assigned by the independent coders.

## **Results**

### *Descriptive results*

Table 1 presents a summary of the descriptive results, differentiating between the messages of students in the control and experimental condition and documenting the proportion of messages that were coded at each level or coding category.

\*\*\* Insert Table 1 about here \*\*\*

The analysis of the treatment confidence focused – as explained earlier - on the question whether the participants in the experimental condition applied the Bloom taxonomy labels in a correct way. A significant Spearman correlation of .710 was observed ( $p < .001$ ) between the codes assigned by the independent coders and the codes assigned by the participants in the experimental condition.

### *Differential impact on cognitive processing*

The first hypothesis centers on the differential impact of the labeling activity on cognitive processing and the cognitive levels attained. The key question is whether the labeling will result in a higher proportion of messages that were coded at a higher cognitive level in Bloom's taxonomy. On the basis of nominal logistic regression analyses, the extent to which specific Bloom categories were more or less present in the messages of students was analyzed, depending on the condition. Table 1 shows that there are small differences between the experimental (labeling) condition and the control condition with regard to comprehension,



application, and analysis. Larger differences can be seen with regard to the other Bloom categories (knowledge, synthesis, and education). It can be clearly observed that the latter categories are more often found in the experimental condition. Nominal logistic regression analysis was carried out to investigate whether these differences were significant. The proportion of messages coded as comprehension by the independent raters represents the largest number of messages (34.7% of all messages). In addition, messages coded as comprehension are found in a more or less equal proportion in both research conditions with only minor differences ( $n = 229$  (32.4 %) and  $n = 215$  (37.6 %) in respectively the experimental and the control condition). Therefore, this category was used as the reference category in the analysis. The likelihood ratio test returns a significant Chi-square value:  $\chi^2 = 53.30$ ,  $df = 5$ ,  $p < .001$ ). This indicates that there is a general effect of condition on the dependent variable “level of cognitive processing” (based on Bloom). Table 2 presents the specific regression coefficients that show in what specific categories the significant differences between the conditions can be found (as compared to the reference category).

\*\*\* Insert Table 2 about here \*\*\*

The results in Table 2 confirm what could be observed in the descriptive results reported in Table 1. Participants in the experimental conditions reflect significantly more messages focusing on knowledge, synthesis and evaluation. Compared to the reference category *comprehension*, the probability of observing knowledge category messages is 1.59 more likely in the messages of participants in the experimental condition, synthesis level messages are 1.78 times more likely to be found in the experimental condition, and evaluation messages are 11.03 times more likely to be found in the experimental condition where participants were required to label their messages. There were no significant differences between the experimental and the control condition in the categories comprehension, application and analysis (when compared to the reference category *comprehension*).

### *Differential impact on metacognitive processing*

The second hypothesis centers on the differential impact of the labeling activity on metacognitive processing. Will the messages of students in the labeling condition reflect a significantly higher proportion of metacognitive messages? Nominal logistic regression analysis was performed three times for each of the specific metacognitive activities. Table 2 also presents a summary of all the analysis results in relation to the messages labeled as specific metacognitive activities: planning, clarity, and monitoring.

For the *metacognitive planning* activities, the *no planning* category served as the reference category. The likelihood ratio test is significant ( $X^2 = 35.41$ ,  $df = 3$ ,  $p < .001$ ), pointing at an overall effect of condition on metacognitive planning. To investigate for which categories differences between the conditions can be found, the specific regression coefficients were calculated (see Table 2). Compared to the reference category, no differences are found with respect to “asking approach” but both “presenting an approach” (1.75 times more likely) and “explaining an approach” (1.70 times more likely) occur more often in the condition where participants were required to label their messages (respectively  $B = 0.56$ ,  $SE = 0.08$ ,  $p < .001$  and  $B = 0.53$ ,  $SE = 0.19$ ,  $p = .004$ ).

The likelihood ratio test in relation to the *metacognitive clarity* activities is also significant ( $X^2 = 12.91$ ,  $df = 3$ ,  $p = .005$ ). Compared to the reference category (*no keeping clarity*), “structuring the database of information” messages are 1.52 times more likely to be found in the condition where participants were required to label their messages ( $B = 0.42$ ,  $SE = 0.19$ ,  $p = .026$ ). There is no difference in relation to metacognitive messages that “ask for clarification”. Metacognitive messages that “give explanations” are 1.46 times more likely to be observed in the condition where participants were required to label their messages ( $B = 0.38$ ,  $SE = 0.13$ ,  $p = .003$ ).

The likelihood ratio test in relation to the *metacognitive monitoring* activities is also significant ( $X^2 = 46.71$ ,  $df = 2$ ,  $p < .001$ ). Compared to the reference category (*no monitoring*), “keep watching” metacognitive messages are 2.08 times more likely to be found in the condition where participants were required to label their messages and “reflective processes” are 4.45 times more likely to be found in the experimental condition (respectively  $B = 0.73$ ,  $SE = 0.18$ ,  $p < .001$  and  $B = 1.46$ ,  $SE = 0.32$ ,  $p < .001$ ).

#### *Differential impact on affective involvement*

To test the differential impact of labeling the messages in the experimental condition on affective involvement, nominal logistic regression analysis was applied. The likelihood ratio test returns a significant Chi-square value ( $X^2 = 31.26$ ,  $df = 3$ ,  $p < .001$ ). The results (Table 2) show a significant differential impact for one particular affective involvement category: “affective motivation”. Compared to the reference category (*not affective*), participants in the experimental conditions are 2.03 times more likely to utter “affective motivation” type messages ( $B = 0.71$ ,  $SE = 0.15$ ,  $p < .001$ ). No significant differences were observed in relation to “affective asking” and “affective chatting”.

### **Discussion**

The results of this study suggest that there may be a significant and positive impact due to the labeling of online discussion contributions on the basis of Bloom’s taxonomy. Firstly, it is observed that the labeling approach on the basis of this taxonomy is feasible. The results of the treatment confidence analysis indicate that participants were sufficiently proficient to apply this scripting approach. Studying the feasibility of a scripting approach and the way in which students actually make use of it is important in view of checking the treatment fidelity and should be done before the effectiveness and the impact of the scripts are studied (see also De Wever, Schellens, et al., 2008).

Secondly, the results at the cognitive level are clear. As hypothesized, significantly larger proportions of messages reflecting higher levels on Bloom's taxonomy were observed when participants are asked to label their messages. This results confirm the potential of scripts to foster cognitive processing (see for an overview Fischer, Mandl, Haake, & Kollar, 2006). The impact of the use of Bloom's taxonomy as a scripting tool is especially true in relation to Bloom's taxonomy levels of synthesis and evaluation. This supports the hypothesis that labeling requires participants to be more explicit about their cognitive processing in a collaborative task. However, also a significantly higher portion of knowledge level messages is observed. This is an unexpected result. Explanations for this higher proportion can be found in the theoretical basis. Knowledge construction – from a cognitive perspective – builds on the elaboration and organization of lower level knowledge components. A sufficient number of messages that reflect Bloom's knowledge and comprehension level are needed in view of developing higher level knowledge components or attaining higher level knowledge objectives. The latter was also observed in earlier studies of Schellens et al. (2007) when first year students were involved in a CSCL study. Since the students in the study of Schellens et al., were novices in the course knowledge domain of instructional sciences, it was not surprising that these students first had to focus to a large extent on gathering and exchanging basic level knowledge elements (such as facts and concepts). In the present study, third-year students did collaborate in a new knowledge domain in their educational sciences program: mathematics education. Again, large quantities of "knowledge" level messages might have been necessary to bring together a grounding knowledge base to develop higher knowledge elements.

Thirdly, the metacognitive effects are higher in the labeling condition compared to the control condition. For planning on the one hand and keeping clarity on the other hand, "asking an approach" respectively "asking for clarification" does not occur significantly more

often in the experimental condition. With the exception of these two categories, which can be called *asking categories* since both of them focus on asking for something, all other metacognitive skills - i.e. “presenting an approach” and “explaining an approach” with respect to planning, “structuring the database” and “giving explanations” with respect to keeping clarity, and “keep watching” and “reflective processes” with respect to metacognitive monitoring - occur significantly more in the experimental condition. The fact that the “asking-types” do not result in significant differences could be that this is such a basic metacognitive process that students do not need a script at this level. Scripting especially seems to stimulate the *non asking categories* in metacognitive processes. At a general level, the results are in line with comparable studies that focus on scripting and metacognition. Pifarré and Cobos (2009) present empirical evidence from a qualitative study suggesting that their tool supports the development of metacognitive knowledge. Also Kollar, Fischer, and Slotta (2005) and Fisher, Kollar, Haake, and Mandl (2007) summarize a number of CSCL-studies that underpin the potential of scripts to foster metacognition.

Lastly, a differential impact of scripting on the affective involvement of the participants was observed. This is especially true for “affective motivation”. These results can be linked to earlier research set up in collaborative settings. O'Donnell, Dansereau, Hall, and Rocklin (1987) already referred to the positive impact of scripting in face-to-face situations. Scripted dyads were more positive about the experience and perceived the situation as less anxiety-provoking (ibid, p.431). In addition, Newbern and Dansereau (2001) pointed at the positive impact on effective involvement. In this context they also explicitly referred to the metacognitive regulative impact of scripts. In CSCL settings, recent research of Rummel and Spada (2005) underpinned the value of scripts to foster the motivated engagement.

### **Implications and limitations**

The implications of the present study allow reflection on the assumptions in relation to the value of scripting approaches in CSCL settings. These scripts were introduced to tackle the less positive outcomes of earlier CSCL research. In particular, this study focused on adding a script that helped to influence cognitive, metacognitive, and involvement variables. The labeling approach adopted in this study proved to be successful and to support learners to attain higher cognitive processing levels, fostered metacognitive activities, and supported their affective involvement. This suggests that Bloom's taxonomy could be added to the list of scripting tools to structure tasks in CSCL-settings. The results also support the underlying theoretical assumptions about the impact of this scripting approach on cognitive processing, metacognitive regulation and affective involvement. However, a number of limitations should be considered.

Some authors refer to the critical nature of the task that may invoke other levels of knowledge construction (see Harper, Squires, & McDougall, 2000; Quin, 1997). These and other authors stress that the complexity, level of openness, and length of a task may influence the particular impact on cognitive outcomes. Future research should study the use of Bloom's taxonomy in relation to a variety of collaborative tasks. A second limitation is that the adoption of Bloom's taxonomy has been done without considering the critiques on the specific hierarchical structure. Marzano and Kendall (2007) repeat in this context that empirical studies could not always replicate the exact taxonomic structure, suggesting that "superordinate levels involved more difficult cognitive processes than did subordinate levels" (ibid, p.8). Future studies could study the internal dependencies between messages labeled at different levels along the taxonomy. Lastly, the duration of the study can be criticized. One might argue that the duration (2 weeks) is rather short. Yet, this critique can only partly be accepted. In the context of authentic instructional settings, a level of efficiency is to be considered. Teachers should not only adopt effective, but also efficient instructional strategies

that result in positive outcomes, within the time constraints provided by the formal teaching and learning setting. The fact that already after two weeks of intensive discussions a positive and significant impact was found, is therefore an interesting finding for educationists that are also concerned with too high time demands of particular instructional strategies (Land, 2008; Nachimias, Mioduser, Oren, and Ram, 2000).

### **Conclusions**

The present study was set up in line with the new research tradition in the field of computer supported collaborative learning to focus on scripting to support the collaborative process. The result of the present study suggests that Bloom's taxonomy is a fruitful scripting approach. Next to an impact on cognitive processing, the results also point at a critical influence on metacognitive skills and the affective involvement of research participants. A key finding was the fact that the positive impact was already found after a relatively short period of time, suggesting the efficiency of this scripting approach. Future research can build on the present research design and center on the specific impact of particular Bloom categories and whether the impact is sustainable in more longitudinal studies.

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