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## **Status**

Published in *Computers in Human Behavior*, 21, 957-975.

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## **DOI:**

10.1016/j.chb.2004.02.025

<http://dx.doi.org/10.1016/j.chb.2004.02.025>

## **Please cite as:**

Schellens, T. & Valcke, M. (2005). Collaborative learning in asynchronous discussion groups: What about the impact on cognitive processing? *Computers in Human Behavior*, 21, 957-975.

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Computers in Human Behavior 21 (2005) 957–975

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# Collaborative learning in asynchronous discussion groups: What about the impact on cognitive processing?

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Available online 19 March 2004

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## Abstract

Does working in a Computer supported collaborative learning (CSCL) environment, and more specific, working in “asynchronous electronic discussion groups”, have an impact on cognitive processing? This general research question has been researched in a study involving 230 freshmen taking the course “educational sciences”. During four months, students were working in 23 discussion groups on collaboration tasks based on authentic situations and problems. The transcripts of eight groups were randomly selected and analysed. A variety of content analysis models was adopted to ground theoretical assumptions about the value of collaborative learning environments. The messages were coded building on the models by Veerman and Veldhuis-Diermanse (2001) and Gunawardena, Lowe, and Anderson (1997). The theoretical basis of the study integrates the models in a conceptual framework, building on the information processing approach to knowledge construction and social-constructivist principles. The results confirm that interaction in the discussion is very task-oriented, stays task-oriented and reflects high phases in knowledge construction. Clear results can be presented about the impact of the amount of discussion activity on the nature and quality of the discussions and the phases of knowledge construction. In the discussion section, methodological issues are presented. The research points at a number of methodological issues and directions for future research.

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*Keywords:* Cooperative/collaborative learning; Learning communities; Teaching/learning strategies; Distance education and telelearning

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## 1. Introduction and general research problem

The present study researches the impact of a specific type of groupware: asynchronous discussion groups. In the literature, this type of groupware is also referred to as *computer-supported collaborative learning environment* (CSCL<sup>1</sup>).

The asynchronous discussion groups researched in this study are a component of a large scale curriculum innovation of freshman courses at the Faculty of Psychology and Educational Sciences of the Ghent University. The innovation focuses on the implementation of social-constructivist principles, such as active learning, self-reflection, authentic learning, and collaborative learning. In our research, we focus on the innovation of the freshman course “Instructional Sciences”. This course introduces students to a large variety of abstract theories and conceptual frameworks related to learning and instruction. The innovation of the course started in 1998–1999 and is continuously monitored with research activities. Earlier studies focused on the way students perceive and experience the innovation and to what extent innovations are in line with student learning styles and capabilities (Schellens & Valcke, 2000). The actual research reports on the third phase in the re-design of the course “Instructional Sciences”. Asynchronous discussion groups were established to foster academic discourse and active individual knowledge construction. They were expected to further mental model construction and help students to apply the mental models in dealing with authentic problems. This brings us to the central research problem for this research paper. Does collaborative learning in asynchronous discussion groups result in enhancing academic discourse and knowledge construction?

## 2. Theoretical framework of the present study

How can we describe, explain and predict the impact of collaborative learning in a CSCL-setting on knowledge construction? Fig. 1 gives a graphical representation of the theoretical base for the present study. It integrates social-constructivist principles and concepts derived from the information processing approach to learning (see comparable approaches of Baker, 1996; Doise & Mugny, 1984; Erkens, 1997; Kreijns & Bitter-Rijkema, 2002; Petraglia, 1997; Savery & Duffy, 1996; Veerman, Veldhuis-Diermanse, & Kanselaar, 1999).

The centre of Fig. 1 represents the learning process at the individual level (student X). “Learning” is considered as an information processing activity. This builds on the central assumption that learners engage actively in cognitive processing in order

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<sup>1</sup> In the literature, different concepts are used to identify the educational use of ICT to support cooperative learning: cooperative learning environment, computer-supported collaborative learning environment, computer-supported intentional learning environment, collaboratory notebook, web-based learning environment. In the present paper, we consistently use the concept computer-supported cooperative learning environment (CSCL). This conceptualisation is most commonly found in the literature.

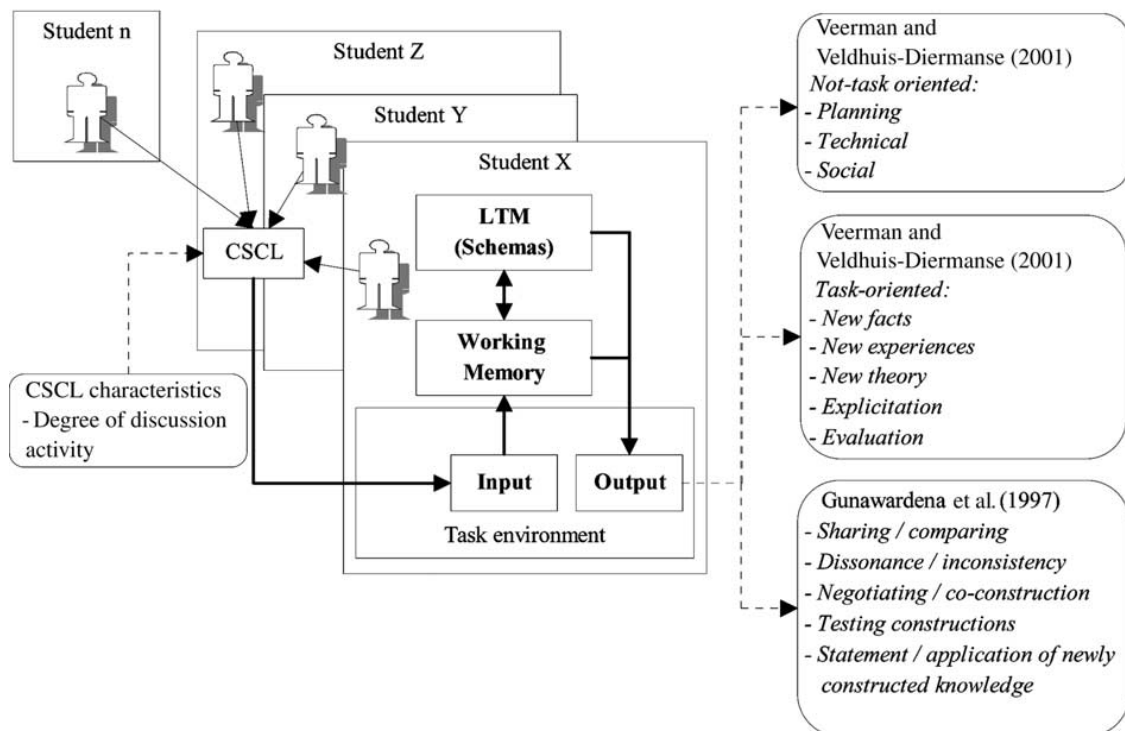


Fig. 1. Graphical representation of the theoretical base.

to construct mental models<sup>2</sup> based on their individual experiences. New information is in this way integrated with existing cognitive structures. This *active processing assumption* invokes three types of processes: selecting, organizing, and integrating (Mayer, 2001). The mental models are stored in and retrieved from long term memory (LTM). The processing activities are triggered by the task put forward in the task environment. The structure and theme of the task are therefore considered to direct these activities. Research of De Wever, Valcke, Winckel, and Kerkhof (2002) supports the importance of task structure to foster the knowledge construction process.

The task is put forward in a collaborative environment. This invokes *collaborative learning* that builds on the necessity of the learner to organise output that is relevant input for the other learners (Student Y to n). This exchange at input and output level is considered to reflect a richer base for the further cognitive processing at individual level. This assumption is central in the cognitive flexibility theory of Spiro, Feltovich, Jacobson, and Coulson (1988). Given the importance of the “group” in the CSCL-setting, characteristics of the group such as group size, are of importance.

The output is a key element in the theoretical base of the present study. The asynchronous nature of the discussion environment forces the learner to

<sup>2</sup> Authors in the field of cognitive science adopt a variety of concepts to refer to the cognitive structures that learners actively build and store in long term memory: mental model, cognitive structure, mental model, etc. In this paper, we adopt the concept “mental model”.

communicate the output in an explicit way. All the written communication in the CSCL-environment is therefore considered as relevant (cf. the concept of *entire Gestalt* of Gunawardena et al., 1997). The output mirrors the concrete processing activities. Individual processing is slowed down by the complexity of the complete problem since learners have to cope with both selection, organisation and integration processes. As a consequence, learners experience the *limited capacity* of their working memory (Mayer, 2001). Other authors refer to *cognitive load* in this context (Sweller, 1988, 1994). But learners in a collaborative setting can profit from the processing effort of others. The output of each individual student is organized since it is derived from his/her own mental models. The assumption is that this output is therefore more easily accessible by other learners in the collaborative setting. Since the input of other learners is more organized, students are expected to experience lower levels of cognitive load.

During the discussion processes, students working on the real life problems, present output that evolves along stages in the cognitive process. In Fig. 1, different types of output are identified. We build on the work of Veerman and Veldhuis-Diermanse (2001) and Gunawardena and Zittle (1997) to identify these types. The typologies will be used to analyse the transcripts of the written communication.

The analysis model of Veerman and Veldhuis-Diermanse (2001) builds on social-constructivist principles. The typology is more general compared to the model of Gunawardena et al. (1997) since it also focuses on non-task related activities. But the authors also present a clear relationship between types of collaborative activities and knowledge construction. They distinguish between task-oriented and not-task-oriented behaviour. This distinction helps to control for explicit interpersonal monitoring activities in the output and to check the balance between not-task-oriented and task-oriented communication. They differentiate four categories of not-task-oriented communication:

1. *Planning*: “Is it OK to discuss the arguments first?”
2. *Technical*: “How can we get rid of the delete-button on the screen?”
3. *Social*: “Good job!” and
4. *Nonsense*: “Who joins in to go to the movies?”

Considering our focus on the impact of CSCL on cognitive processing, we assume that social and planning behaviour are of central importance to foster cognitive processing. We expect that CSCL-settings will promote these types of communication.

Within task-oriented communication, they consider three basic cognitive processing activities:

1. *Presentation of new information*. Learners present information that is new in the context of the discussion. Further distinction is made between the presentation of information about
  - (a) Facts,
  - (b) Experiences or opinions and
  - (c) Theoretical ideas.
2. *Explicitation*. This is a type of communication that reflects a further refining and/or elaboration of earlier ideas.

3. *Evaluation*. This type of written messages corresponds to a critical discussion of earlier information or ideas. It goes beyond a simple confirmation or negation and reflects argumentations, reasonings, justifications.

We add a hierarchical structure to the typology of task-related communication. The consecutive types of communication represent higher levels of knowledge construction. This is represented in Fig. 2. We hypothesize that collaborative work in the CSCL-setting will foster cognitive processing, resulting in the observation of higher number of explication and evaluation types of communication.

The model of Gunawardena et al. (1997) is rooted in grounded theory, proposes an alternative for evaluating the construction of knowledge through social negotiation. They develop an interaction analysis model that includes five phases, reflecting

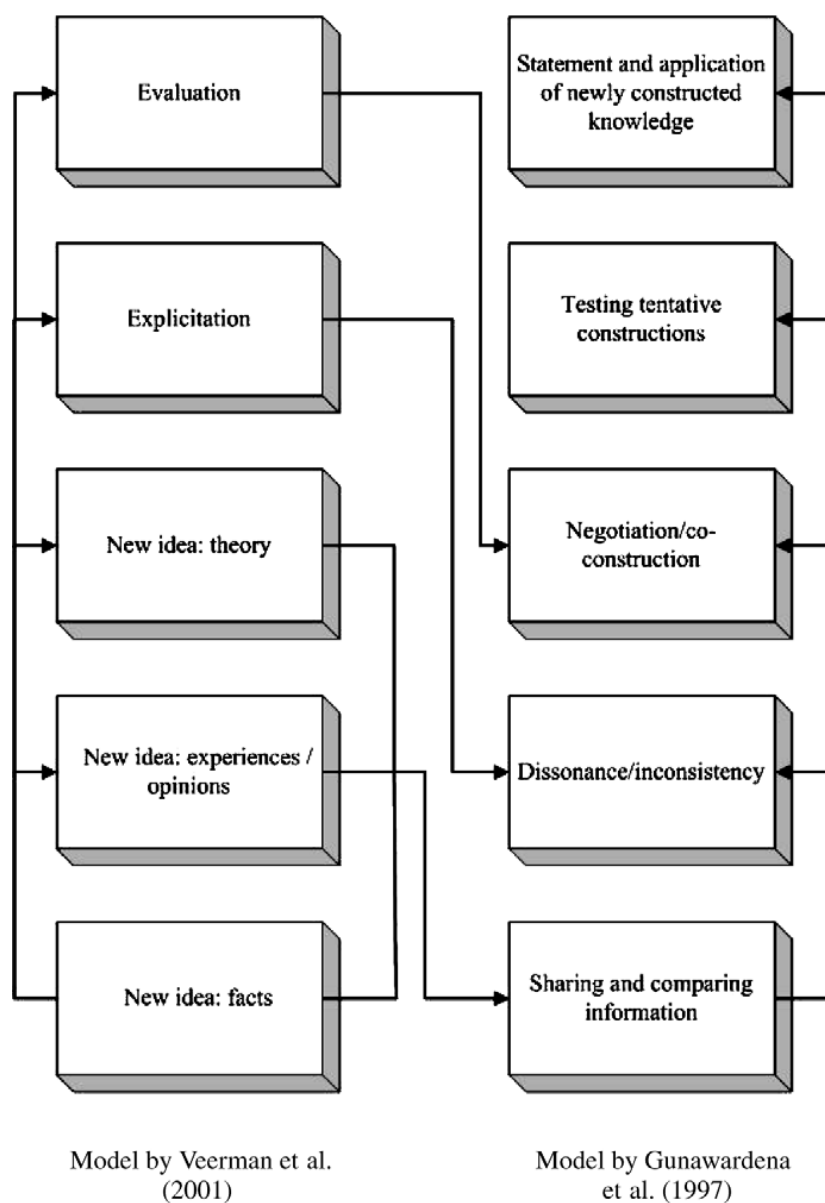


Fig. 2. Hierarchical structure in CSCL-communication as related to cognitive processing and theoretical relationships between both typologies.

the process of negotiation which must occur in a social-constructivist learning environment.

Although every phase in the model is important, in the long run one should reach the highest phases in the negotiation.

The phases of learning occur at the individual level and the social level and are described as follows:

*phase 1: sharing/comparing*

- observation,
- agreement,
- corroboration,
- clarification,
- definition,

*phase 2: dissonance/inconsistency*

- identifying and stating,
- asking and clarifying,
- restating and supporting,

*phase 3: negotiating what is to be agreed (and where conflicts exists)/co-construction*

- proposing new co-constructions that encompass the negotiated resolution of the differences,

*phase 4: testing tentative constructions*

- the new constructed statements of ideas may then be tested, and matched again to personal understandings and other resources (such as the literature),

*phase 5: statement/application of newly constructed knowledge*

- final revision and sharing again of the new ideas that have been constructed by the group.

The adoption of two different typologies to analyse cognitive processing in the discussion groups presents some advantages. First of all, hypothesis testing about the impact of collaborative learning in CSCL can be based on two different data sets. Secondly, since the two typologies are clearly interrelated, the analysis results are helpful to validate the individual typologies. The relationship between both typologies is also represented in Fig. 2.

### **3. Research section**

#### *3.1. General research question and hypotheses*

The central research question of the present study is the following: Does collaborative learning in asynchronous discussion groups result in enhancing academic discourse and knowledge construction? Building on the theoretical base, we put forward the following hypotheses to research this general question:

1. The proportion of task-oriented communication is larger than the proportion of non-task-oriented communication.
2. Communication in the discussion groups will become more task-oriented instead of non-task-oriented.

3. In the context of non-task-oriented communication, more ‘social’ and ‘planning’ communication will be observed, at the expense of interaction in relation to ‘technical issues’ and ‘nonsense’ interaction.
4. The CSCL-environment fosters higher phases of knowledge construction.
5. At the end of the research period, more communication reflecting higher phases of knowledge construction will be observed.  
Based on the results of earlier research (Schellens & Valcke, 2002), two new hypotheses were formulated:
6. The more discussion activity in groups, the more phases of higher knowledge construction will appear.
7. The phases of knowledge construction reached in the discussion groups are congruent with the applied task structure.

### *3.2. Research setting*

As stated in Section 1 to this paper, the research was set up in the faculty of Psychology and Educational Sciences and related to a freshman course on “Instructional Sciences”. This course is supported with an on-line learning environment that presents additional resources, links, planning information, calendar, news, self-assessment, etc. (<http://allserv.rug.ac.be/mvalcke/Onderwijskunde/index.htm>). At the start of the academic year 2001–2002, electronic discussion groups were added for the second time to this on-line environment. Participation in the discussion groups was now obligatory. Part of the evaluation was based on participation in the CSCL-environment. The discussion groups were planned during a complete semester. Each three weeks a new discussion theme was introduced. The objectives of participation in the discussion were communicated to the student: active processing of the new domain knowledge, presented during the weekly face-to-face working session and application of this knowledge while solving an authentic case.

The asynchronous discussion groups were implemented with the tool Web Crossing conferencing server (<http://webcrossing.com/>). This tool allows students to manage their own contributions and the discussion structure (threaded discussion).

### *3.3. Research design*

#### *3.3.1. Participants*

All students, enrolled for the 7-credit freshman course “Instructional Sciences” were randomly assigned to a discussion group ( $N = 230$ ). After one trial session, lasting three weeks, students had to participate in four consecutive discussions themes. Initial, 23 different discussion groups worked in parallel during four months.

#### *3.3.2. Procedure*

During the first face-to-face session of the semester, a demonstration was given of the CSCL-environment. Extra information was made available in the on-line environment. A number of strict rules was stated that defined the nature of expected student participation in the discussion groups: (a) Participation in the discussion

groups was a formal part of the curriculum. Therefore participation was scored and stood for 25% of the final score. (b) Successful participation implied that each student entered at least one primary reaction to solve the case, while making active use of the resources presented in the course reader. Secondly, each student was expected to reply at least once to the work of another student, building upon an argumentation and based on the available resources. (c) The moderator intervened at least once a week. He/she did not give concrete content feedback but rather structural feedback (scaffolding); e.g., Your reactions are not based on clear argumentations, based on specific resources. or “Most ideas presented neglect key features of theoretical models”.

### *3.3.3. Discussion themes*

In line with constructivist principles, the discussion themes were based on real-life authentic situations; e.g., a case study in which a teacher education institute implements digital portfolios or a position paper of the Ministry of Education about a school reform, or the implementation of a new curriculum for nurses. Students got the opportunity to work during three weeks on a case. After these three weeks they did no longer have access to the former theme or their input. A new discussion theme was presented in their discussion group. To control for a possible interaction between the content of a discussion theme and cognitive processing, the developers elaborated for each discussion theme a number of alternative discussion tasks.

### *3.3.4. Selection of the research data*

The transcripts of the output of 230 students in 23 discussion groups for four different themes represent a massive amount of research data. For the purpose of the present study, a subset of data was selected from the larger data set. The transcripts of eight groups were ad random selected. For each individual group, all the communication submitted in relation to the four discussion themes was used for analysis purposes.

### *3.3.5. Choice of the unit of analysis*

In line with the suggestion of Rourke, Anderson, Garrison, and Archer (2001), each complete message was chosen as the unit of analysis for the coding. This choice created some problems during the coding process. Some students presented, e.g., their own solution in the first part of a message and reacted to the input of other students in a second paragraph. In these cases, the researchers decided to split the message into different messages. This activity was carried out in connection to the actual coding of the units and reliability of this approach was controlled (*Cronbach*  $\alpha > 0.8$ ). A total of 1428 units of analysis could be identified in this way.

### *3.3.6. Coding of the messages in the transcripts*

Each unit of analysis was coded according to the two analysis models discussed in the theoretical section. Three independent researchers carried out this task. Every transcript was coded by each individual researcher. Atlas-Ti® was used as the coding tool. The researchers received training in the use of the package and had plenty of

time to exercise with the tool. Sample data were used for training. Group discussion helped to get acquainted with the particularities of the models and to reach mutual agreement about the coding category to be selected.

After the coding of each complete transcript of a discussion by each individual researcher, the quality of the coding was assessed by determining *Cronbach  $\alpha$* . A value of 0.7 was put forward as a criterion for inter-rater reliability. The initial values for the different discussions varied from 0.42 to 0.93. After negotiations, inter-rater reliability varied between 0.88 and 0.99. To check whether it was not always the same researcher changing the coding category, intra rates reliability was also calculated for each individual researcher. The latter represents the agreement between the first and second coding of a unit of analysis. The  $\alpha$  value was always  $>0.7$ .

### *3.3.7. Statistical analysis*

Statistical analysis builds on descriptive statistics and  $\chi^2$  to test the hypotheses. Considering the fact that the coding resulted in ordinal and nominal scale data, the latter technique is appropriate to test distributions of proportions and changes in proportions of observed coding categories. With the exception of two cells, cell frequencies were never less than 5. To test the hypotheses that suggest specific changes over time, we compared the transcripts of the first discussion theme with transcripts of the last discussion theme. This represents a time difference of about 4 months.

## **4. Results**

### *4.1. General results*

As stated earlier, 1428 units of analysis could be identified in the discussions. It is apparent that the communication in the CSCL-setting was for the most part task-oriented.

Only 83 messages out of the 1428 were completely non-task-oriented. 1095 messages were completely task-oriented and 250 messages were both task-oriented and not-task-oriented. The latter was the case if the message started with a question that had nothing to do with the discussion and the second part of the message on the other hand was a contribution to the discussion.

Table 1 gives an overview of the distributions of the messages that are completely not-task-oriented and the messages that are task-oriented. We notice that only in the discussions about theme 1, there are slightly more non-task-oriented messages. When we study the distribution of the different types of non-task-oriented communication in the transcripts of the four discussion themes, we can observe that half of the non-task-oriented communication is “social” and this remains the same for all of the discussion themes. There is a small increase in “irrelevant” communication and the “technical” communication gradually decreases.

Table 2 gives a summary of the distributions of the types of non-task-oriented communication.

Table 1  
Task- and non-task-oriented communication

	Theme 1 <sup>a</sup>	Theme 2 <sup>b</sup>	Theme 3 <sup>c</sup>	Theme 4 <sup>d</sup>	All themes <sup>e</sup>
Non-task-oriented	7.1%	5.5%	5%	5.6%	5.8%
Task oriented	92.9%	94.5%	95%	94.4%	94.2%

<sup>a</sup> *n* = 350.

<sup>b</sup> *n* = 403.

<sup>c</sup> *n* = 300.

<sup>d</sup> *n* = 375.

<sup>e</sup> *N* = 1428.

Table 2  
Distribution of non-task-oriented communication in the transcripts of the four discussion themes (Veerman et al., 2001)

	Theme 1 <sup>a</sup>	Theme 2 <sup>b</sup>	Theme 3 <sup>c</sup>	Theme 4 <sup>d</sup>	All themes <sup>e</sup>
Irrelevant	17.1%	12.0%	16%	27.4%	18.1%
Technical	14.5%	9.8%	9.3%	3.2%	9.2%
Planning	21.1%	22.8%	17.3%	21.0%	20.6%
Social	47.4%	55.4%	57.3%	48.4%	52.1%

<sup>a</sup> *n* = 76.

<sup>b</sup> *n* = 92.

<sup>c</sup> *n* = 75.

<sup>d</sup> *n* = 62.

<sup>e</sup> *N* = 305.

Table 3  
Types of task-oriented communication (Veerman et al., 2001)

	Theme 1 <sup>a</sup>	Theme 2 <sup>b</sup>	Theme 3 <sup>c</sup>	Theme 4 <sup>d</sup>	All themes <sup>e</sup>
Phase 1 New idea (facts)	0%	0%	0.4%	0%	0.1%
Phase 2 New idea (experience)	15.7%	12.3%	14.7%	15%	14.3%
Phase 3 New idea (theory)	20%	31.2%	38.9%	29.1%	29.6%
Phase 4 Explication	15.1%	16%	13%	15.5%	15%
Phase 5 Evaluation	49.2%	40.4%	33%	40.4%	41%

*Note.* Not all units of analysis reflect communication behaviour that could be coded along this typology. As a result, the total amount of units of analysis is lower than 1428.

<sup>a</sup> *n* = 325.

<sup>b</sup> *n* = 381.

<sup>c</sup> *n* = 285.

<sup>d</sup> *n* = 354.

<sup>e</sup> *N* = 1345.

Table 3 summarises the distribution of the types of task-oriented communication as discriminated by Veerman and Veldhuis-Diermanse (2001). We can derive from the table that most of the communication is related to the exchange of *new theories* and *evaluation*. Communication about *new facts* is hardly observed.

Table 4 shows the distribution of communication that reflects the phases in knowledge construction based on Gunawardena et al. (1997). We perceive very high

Table 4  
Phases in knowledge construction (Gunawardena et al., 1997)

	Theme 1 <sup>a</sup>	Theme 2 <sup>b</sup>	Theme 3 <sup>c</sup>	Theme4 <sup>d</sup>	All themes <sup>e</sup>
Phase 1	42.7%	47.7%	60.8%	56.8%	51.7%
Phase 2	17.3%	13.3%	13%	11.4%	13.7%
Phase 3	39%	36.7%	24.6%	30.6%	33.1%
Phase 4	0.6%	2.0%	1.4%	0.6%	1.2%
Phase 5	0.3%	0.3%	0.3%	0.6%	0.4%

<sup>a</sup>  $n = 325$ .

<sup>b</sup>  $n = 380$ .

<sup>c</sup>  $n = 284$ .

<sup>d</sup>  $n = 354$ .

<sup>e</sup>  $N = 1343$ .

percentages of communication in phase 1 (*sharing and comparing information*) and phase 3 (*negotiating what is to be agreed/co-construction*). Phase 4 (*testing tentative constructions*) and phase 5 (*statement/application of newly-constructed knowledge*) communication is almost non-existent.

#### 4.2. Results in relation to the hypotheses

**Hypothesis 1.** The proportion of task-oriented communication is larger than the proportion of non-task-oriented communication.

Applying  $\chi^2$  to test whether the observed frequencies reflect an equal distribution of the proportions is hardly necessary ( $\chi^2(1) 1115.297, p < 0.01$ ). Already at descriptive level, it is clear that we can accept the hypothesis.

**Hypothesis 2.** Communication in the discussion groups will become more task-oriented instead of non-task-oriented.

The very high frequencies of task-oriented communication observed during the first discussion hardly change during the last discussion. There is a small decrease in task-oriented communication but the changes in proportions are not significant ( $\chi^2(1) 1.129, p = 0.288$ ). Communication in the discussion groups is not becoming more task-oriented so we cannot accept the hypothesis.

**Hypothesis 3.** In the context of non-task-oriented communication, more ‘social’ and ‘planning’ communication will be observed, at the expense of interaction in relation to ‘technical issues’ and ‘nonsense’ interaction.

If we look at the changes in proportion in relation to the total amount of messages, we notice no significant changes for “nonsense” communication ( $\chi^2(1) 0.084$ ,

$p = 0.773$ ), “social” communication ( $\chi^2(1) 3.794, p = 0.051$ ), and “planning” ( $\chi^2(1) 3.281, p = 0.070$ ). This is different for the category “technical” communication, there we notice a significant decrease ( $\chi^2(1) 15.644, p < 0.01$ ).

If we apply  $\chi^2$  analysis to test changes in the proportions within the category non-task-oriented communication, we observe no significant changes in “social” communication and “planning”. There are however significant changes at the 5% level for “technical” communication and the “nonsense” communication ( $\chi^2(3) 9.318, p = 0.025$ ).

The hypothesis that in the context of non-task-oriented communication, more “social” and “planning” communication will be observed, and a decrease of “technical” and “nonsense” interaction will appear, has to be rejected. There is only a significant decrease in “technical” communication.

**Hypothesis 4.** The CSCL-environment fosters higher phases of knowledge construction.

We check this hypothesis twice, by carrying out the analysis on the data sets obtained by applying the two different analysis models. Building on the model of Veerman and Veldhuis-Diermanse (2001), we test whether the proportions of communication behaviour that mirror different phases of knowledge construction are equally distributed. Analysis of the descriptive data in Table 3 already suggests that no equal distribution is observed. This is confirmed by the  $\chi^2$  analysis ( $\chi^2(4) 662.654, p < 0.01$ ). We observe significantly less communication related to presentation of new facts (phase 1) and significantly higher amounts of communication that reflects ideas based on theories (phase 3) and evaluation (phase 5). In general, we can conclude that the hypothesis can be accepted. Application of the same analysis procedure to the data based on the model of Gunawardena et al. (1997), results in a different picture. Table 4 suggests also unequal distributions. This is confirmed by the  $\chi^2$  analysis ( $\chi^2(4) 1343.1, p < 0.01$ ) but in this case we observe to a significantly higher extent phase 1 and phase 3 communication types. Phase 4 and Phase 5 scarcely appear. In view of this results, we have to reject the hypothesis.

**Hypothesis 5.** At the end of the research period, more communication reflecting higher phases of knowledge construction will be observed.

This hypothesis questions whether there is a significant difference between the first and last discussion in the occurrence of communication that reflects higher phases of knowledge processing. Again, the hypothesis can be tested twice considering the two analysis models applied in coding the messages.

When testing the hypothesis on the data based on the model of Veerman and Veldhuis-Diermanse (2001), we expect an increase in the proportions of *new ideas based on theories, explicitation and evaluation*. The data in Table 3 suggest changes. There is a clear increase in exchange of *new ideas based on theories* but this is at the expense of a decrease of *evaluation*. This change in proportions is significant ( $\chi^2(4)$

20.387,  $p < 0.01$ ) but does not support the direction of the hypothesis. As a result we cannot accept the hypothesis.

As to the model of Gunawardena et al. (1997), the results in Table 4 suggest that there is again a change over time but this does not reflect a certain increase but rather a decrease in communication that reflects higher phases of knowledge construction. This change in proportions is significant ( $\chi^2(4) 31.149$ ,  $p < 0.01$ ). But the change is again not in line with our expectations. There is an increase of *phase 1* and this is at the expense of a decrease in *phase 2* and *phase 3*. There are no real changes regarding *phase 4* and *phase 5*. As a result we cannot accept the hypothesis.

**Hypothesis 6.** The more discussion activity in the groups, the more phases of higher knowledge construction will appear.

The data in Table 5 summarize the changes over time in the observed frequencies, considering the amount of messages within the groups. There are remarkable differences between the groups if we look at the amount of messages ( $\chi^2(2) 148.035$ ,  $p < 0.01$ ).

Table 5  
Distribution of the communication of groups with different levels of discussion activity ( $N$  = number of messages)

	Low discussion activity $N < 160$	$N > 159$ and $< 195$	High discussion activity $N > 194$
Non-task oriented	4.7%	5.2%	7.2%
Task oriented	95.3%	94.8%	92.8%
<i>Not-task oriented communication<sup>a</sup></i>			
Nonsense	29.4%	14.2%	17.5%
Technical	20.6%	11.2%	5.1%
Planning	5.9%	33.6%	11.7%
Social	44.1%	41.0%	65.7%
<i>Task oriented communication<sup>b</sup></i>			
Phase 1: New idea (facts)	0%	0%	0.2%
Phase 2: New idea (experiences)	20.6%	13%	12.6%
Phase 3: New idea (theories)	33.2%	35.7%	19.3%
Phase 4: Explication	10.3%	11.8%	22.1%
Phase 5: Evaluation	35.9%	39.5%	45.9%
<i>Phases in knowledge construction<sup>c</sup></i>			
Phase 1: Vertical questions	64.9%	54.7%	40.4%
Phase 2: Horizontal questions	13.7%	14.4%	12.7%
Phase 3: Statements	21.0%	29.0%	45.2%
Phase 4: Reflection	0.4%	1.3%	1.5%
Type 5: Scaffolding	0%	0.6%	0.2%

<sup>a</sup>  $n = 305$ .

<sup>b</sup>  $n = 1345$ .

<sup>c</sup>  $n = 1343$ .

The data show how non-task-oriented communication increases in groups with intensive discussions. This change is significant ( $\chi^2(1) 7.111, p = 0.08$ ) at the 5% level.

Secondly, there is a clear and significant change in proportions within the types of non-task-oriented communication ( $\chi^2(3) 44.776, p < 0.01$ ). Social communication is observed to a higher extent in discussion groups with a lot of messages. In these groups, there are less “nonsense” messages and communication focussing on technical aspects. As to the communication about planning, higher amounts are noticed in the medium groups.

Thirdly, there is also a clear difference in the frequencies of task-oriented communication between groups with few messages, groups with an average amount of messages and groups with intensive discussion ( $\chi^2(4) 117.524, p \leq 0.01$ ). The proportion of messages that are *explicitation* and *evaluation* is higher in groups with high discussion activity. In these groups, the order in the observed frequencies has changed. *Evaluation* is the most observed type of communication, followed by *explicitation* whereas in the other groups *evaluation* is also pre-dominant but is followed by *new ideas based on theory* instead of *explicitation*.

*New facts* is consistently the least observed type of communication.

Considering the model of Gunawardena et al. (1997), we again observe significant differences in the distribution of proportions between groups with different discussion activity ( $\chi^2(4) 192.662, p < 0.01$ ). Again there is a change in the relative proportions and in the order in the observed frequencies. In groups with a high amount of messages, most of the messages are observed in phase 3 whereas in the other groups phase 1 is dominant. Although there is a slight increase of messages in phase 4, the proportion of messages in phase 4 and phase 5 can be neglected.

In summary, the different steps in the analysis result in a consistent picture: we can accept the hypothesis.

## 5. Discussion

In this discussion section, the results are compared with the findings of other studies. In particular, we will compare the outcomes with our own preliminary research (Schellens & Valcke, 2002). A comparison with this earlier study helps to study the impact of some research design differences.

### 5.1. Discussion related to the hypotheses

**Hypothesis 1.** The proportion of task-oriented communication is larger than the proportion of non-task-oriented communication.

The results are in line with the results from our earlier research where a large percentage of task-oriented communication was observed (88.1%). This time, even larger proportions were found (94.2%). A first explanation can be related to the design of the task environment. Learners received very operational guidelines to

direct their discussion behaviour. Based on our findings with previous research, we decided to make these guidelines even more explicit. Next to an introduction during the first work session of the course instructional sciences, there was a clear description on the website of what we expected from the students. This is in line with recommendations of Johnson and Johnson (1996). A second explanation for the results can be related to the formal character of the work in the discussion groups. Students were well aware of the fact that the discussions were monitored and evaluated, but this time it was a formal part of the course. Students were obliged to participate and knew that this was part of their evaluation.

The results are also consistent with comparable studies of, e.g., McKenzie and Murphy (2000) and De Wever et al. (2002). These researchers also observed a large task-oriented communication and this is in contrast to earlier studies of, e.g., Henri (1994).

**Hypothesis 2.** Communication in the discussion groups will become more task-oriented instead of non-task-oriented.

Given the very high levels of task-oriented behaviour observed in the first discussion, one can expect that the proportion of task-oriented behaviour hardly increases. This ceiling-effect masks potential changes in the distribution.

**Hypothesis 3.** In the context of non-task-oriented communication, more ‘social’ and ‘planning’ communication will be observed, at the expense of interaction in relation to ‘technical issues’ and ‘nonsense’ interaction.

If we compare these results with our previous research, we notice some differences. In the earlier study we observed a drop in interaction about “planning” and “nonsense” communication. The discussions became slightly more “technical” and “social”. Possible explanations then were presented about an interaction effect for group size and the large number of technical communication. For the drop in communication about “planning” a possible explanation was found in the specific task structure of the discussion themes. The discussion themes were presented in a very operational way. Students were presented with a clear prescription about the way to solve the cases. This might have affected the need for group members, at the end of the four-month discussion period, to discuss in detail planning issues in relation to the last discussion theme.

In the present research, we did not change the way the assignments were presented (on the contrary, we made them even more structured), we only changed group size. Based on our previous findings, we choose a fixed group size ( $N = 10$ ). We noticed no significant differences in the distribution of communication about “planning” and “social” communication but there was an increase (significant on the 5% level) in the amount of “nonsense” messages and a decrease in the proportion of communication about “technical” issues. The latter can be explained by the system that, in contrast with last year, now was more reliable. The decrease of the proportion in nonsense communication is only significant at the 5% level and only if we consider the

distribution within non-task-oriented communication. If we put this proportion of nonsense communication in relation to the total amount of messages, there is no significant increase.

**Hypothesis 4.** The CSCL-environment fosters higher phases of knowledge construction.

Considering the results for both models, we receive different outcomes. Using the model of Veerman et al., our results are in line with the results of our previous research that the CSCL-environment fosters high levels of knowledge construction. Most of the messages can be categorised in phase 3 and phase 5. Probably due to the nature of our task structure, messages were not often identified as *phase 4* (see Hypothesis 7).

The results, building on the analysis model of Gunawardena et al. (1997) were different. As with the model of Veerman and Veldhuis-Diermanse (2001), we do not have equal distribution of proportions between the different phases, but we notice that especially phase 1 (*sharing and comparing of information*) and phase 3 (*negotiation and co-construction*) are dominant. The proportion of messages in phase 4 (*testing tentative constructions*) and phase 5 (*statement/application of newly constructed knowledge*) is very low. We try to explain these last findings in the discussion about Hypothesis 7 where we discuss the relationship between task structure and specific phases of knowledge construction.

The results of this analysis can also be used to control the content validity of the two analysis models applied to test this hypothesis. Given the interrelationship between both models (see Fig. 2), the results of the statistical analysis underpin the theoretical position of both models that identify phases in knowledge construction. The results confirm the theoretical mapping between phase 3 and 5 in the model of Veerman and phase 1 and phase 3 in the model of Gunawardena (see Fig. 2).

Still, the fact that 84.8% of the messages – using the model of Gunawardena – are situated in two categories raises some critical questions. These findings are in line with the conclusions of Fahy, Crawford, and Ally (2001) who mention the “lack of discriminant capability of instruments”. According to them, some previously used analytic approaches and tools have been acknowledged by their developers as failing to discriminate adequately among the types of statements appearing in transcripts. A major problem was that large portions of the transcript were coded into a very few interaction categories (Gunawardena et al., 1997; Zhu, 1996), with the result that the transcript’s communicative richness may not have been fully revealed.” (Fahy et al., 2001).

**Hypothesis 5.** At the end of the research period, more communication reflecting higher phases of knowledge construction will be observed.

The results do not support the hypothesis. Considering the model of Veerman and Veldhuis-Diermanse (2001) and the model of Gunawardena et al. (1997), we see significant changes in the distributions of proportions but they do not support our

hypothesis. There is a remarkable increase of theory based messages and of messages in phase 1. The overall pattern in the proportions of observed phases in knowledge construction remains the same. This can be explained by the content dimension in the discussion themes. Each discussion theme was based on a new body of knowledge. As a result, little transfer in knowledge construction from a former discussion theme could occur. This issue that should be taken into account in future research.

**Hypothesis 6.** The more discussion activity in the groups, the more phases of higher knowledge construction will appear.

The results of the analysis were very clear. Discussion activity (number of messages) clearly affects the types, structure and phase of knowledge construction in discussion groups. Groups with an intensive discussion (lots of messages) perform at a qualitative higher level. Within these groups there are slightly more non-task-oriented messages but this is mainly due to the fact that the number of “social” messages increases. “Nonsense” communication drops almost to zero.

In these groups, the level of knowledge construction is significantly higher. This is important because it points to the fact that if we can stimulate students to discuss, this leads to better learning results. The results suggest that we can speak of a critical duration and critical size of the discussions. It is hypothesised that this is related to social cohesion. In future research, this hypothesis can be checked by controlling for student satisfaction and student involvement.

**Hypothesis 7.** The phases of knowledge construction reached in the discussion groups are congruent with the applied task structure.

Analyses, based on the model of Veerman and Veldhuis-Diermanse (2001) show us that most of the messages are situated in phase 5 (*evaluation*) and phase 3 (*theory-based messages*). Messages are less situated in phases 1, 2 and 4. An explanation can be found in the explicit structure presented to the students in the task environment. Students were asked to ground their contributions in the resources made available and to react at the contributions of other students in a critical way. This explains why most of the messages are situated in phases 3 and 5. In the assignment, there is no mention of refining and elaborating information that was mentioned before. If this explanation is true, this is of importance for developers of learning environments that build on discussion groups. On the hand, the present study shows how a clear task structure fosters specific task-oriented communication, but on the other hand, the results also suggest that a too rigid task structure might inhibit the occurrence of specific types of cognitive processing. A careful balance should be respected between open and closed structure of the discussion tasks.

The results based on the model of Gunawardena et al. (1997) are comparable. Especially phase 1 (*sharing and comparing information*) and phase 3 (*negotiation and co-construction*) are observed. There are almost no messages in phase 4 (*testing and adjusting new hypothesis*) and phase 5 (*statement/application of newly constructed knowledge*).

Again we can explain this by the strong task structure. Students were never asked to test a hypothesis or to come to clear conclusions about newly developed knowledge. In our future research, we will try to change this by adding “roles” to the discussion groups, in other words, by adding another level of structure to the task environment.

## 6. Conclusions

To what extent does working in asynchronous electronic discussions foster knowledge construction? The general results of the present study present evidence to support some of the hypotheses put forward in relation to the general research question. Interaction in the discussions is very task-oriented, stays task-oriented and reflects high phases of knowledge construction. These results give us sufficient base to ground the frame of reference presented in the theoretical section of this paper. The theoretical model also puts forward the potential impact of the variables *size of discussion activity* and helps to point at the critical importance of the *task structure*. Clear results could be presented about the impact of the amount of discussion activity on the nature and quality of the discussions and the phases of knowledge construction. Discussion groups with high discussion activity perform better. Higher phases of knowledge construction are observed within these groups.

The impact of the variable *task structure* was stated, but remarks were made about the potential inhibiting effect on some specific communication such as *planning, explication, testing tentative constructions and application of newly constructed knowledge*.

The results were less clear as to the changes over time. We predicted that during the last discussion, the students would communicate more about issues that mirror higher level cognitive processing. The results pointed in the other direction.

From a methodological point of view, large groups of students have been involved during a long period of time and large quantities of units of analysis have been analysed. Extra attention was paid to guarantee high levels of reliability in the identification of the units of analysis and the coding of the interaction. At a basic level, we checked the content validity of the instruments by linking the analysis models and the theoretical frame of reference. A problem that appeared with the model of Gunawardena et al. (1997) is its lack of discriminant capability. A second remark is related to the lack of control groups in the research design. A future experimental design with control groups could help to research to a clearer extent the specific differential impact of the group discussion as compared to, e.g., students that solve the tasks in an alternative way. But this should take into account the authentic learning setting and respect for the learners as an individual and as a group member.

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