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Using sentence openers to foster student interaction in computer-mediated learning environments

Ard W. Lazonder*, Pascal Wilhelm, Susanne A.W. Ootes

Department of Instructional Technology, University of Twente, PO Box 217, 7500 AE Enschede, The Netherlands

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Abstract

This paper reports two studies into the efficacy of sentence openers to foster online peer-to-peer interaction. Sentence openers are pre-defined ways to start an utterance that are implemented in communication facilities as menu's or buttons. In the first study, typical opening phrases were derived from naturally occurring online dialogues. The resulting set of sentence openers was implemented in a semi-structured chat tool that allowed students to compose messages in a free-text area or via sentence openers. In the second study, this tool was used to explore the students' appreciation and unprompted use of sentence openers. Results indicate that students hardly used sentence openers and were skeptical of their usefulness. Because both measures were negatively correlated with students' prior chat experience, optional use of sentence openers may not be the best way to support students' online interaction. Based on these findings, alternative ways of using sentence openers are discussed and topics for further research are advanced.

Keywords: Computer-mediated communication; Cooperative/collaborative learning; Interactive learning environments

1. Introduction

Collaborative learning has enjoyed an increase in popularity over the past decades. Researchers seem to agree on the notion that collaboration can foster learning. Yet there is some controversy on the reason why this is so. Cognitive constructivists attribute the benefits of collaborative learning to peer elaboration. Giving explanations encourages a student to clarify and reorganize the material to make it understandable to others. This helps both parties to understand the

* Corresponding author. Fax: +31-53-489-2849.
E-mail address: lazonder@edte.utwente.nl (A.W. Lazonder).

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material better. The gains for the students receiving explanations are self-evident. The explainer benefits from the cognitive restructuring involved in peer tutoring in that it might trigger the detection and repair of misconceptions and knowledge gaps (Webb & Palinscar, 1996). Social constructivists hold a different view. They perceive collaborative learning as a joint process that is often referred to as negotion of meaning or co-construction of knowledge. Students construct a shared understanding of a given topic through argumentation, discussing the significance of personal beliefs until mutual agreement is reached. The knowledge basis that results from these argumentative discussions is synergetic by nature and shared by all group members.

Despite their epistemological differences, both views acknowledge the importance of peer interaction in collaborative learning. Theorists have argued that the quality of learning in small groups is strongly associated with the quality of interactions (Jarboe, 1996; Kumpulainen & Muttanen, 2000). Research has shown that three types of interaction skills are prevalent in productive learning dialogues. Students in successful learning groups more often provide explanations, ask questions, and engage in argumentative discussions than students from less effective groups (e.g., Chan, 2001; Okada & Simon, 1997; Van Boxtel, 2000). However, research also suggests that students do not necessarily have these productive interaction skills. As a result, preliminary training or (teacher) support during the collaborative learning process is needed for students to participate in an effective learning discourse (King, 1997; Webb & Palinscar, 1996).

In computer-supported collaborative learning (CSCL), student interaction is usually mediated by text-based tools such as email, discussion groups or chat boxes. While these tools enable student to participate in on-line discussions, they provide no guidance to students during these dialogue sessions. Yet students learning via CSCL technology need guidance and support online, just as students learning in the classroom need support from their teacher (Soller, 2001). Hence specific features might be added to communication tools to increase the likelihood of effective discussions taking place. Examples of such support entities include note types students can use to classify their contribution (Scardamalia & Bereiter, 1991; Guzdial & Turns, 2000), software coaches offering adaptive help during a learning conversation (Cook, 2000; Howe & Tolmie, 1998), and turn-taking mechanisms to keep a conversation from running out of synch (Moore, 1993).

The work discussed here explores the idea of using sentence openers to promote student interaction in synchronous CSCL-environments. Sentence openers are pre-defined ways to start a contribution that are usually followed by additional text to complete the student's thought. For example, a student might compose the message "Why do you think that the greenhouse effect is caused by CO_2 emission?" by clicking the opener "Why do you think" and typing his supplementary text. The underlying hypothesis is that sentence openers can encourage the use of certain interaction skills. By supporting productive interaction skills, the quality of a dialogue will improve which in turn is assumed to facilitate learning outcomes.

Research on the efficacy of sentence openers is scant. While various attempts to empower communication tools by sentence openers have been reported, few of these publications present empirical evidence on the learning benefits of sentence openers. In the next section, these attempts are reviewed and the factors that contribute to the efficacy of a sentence opener approach are identified. The sections that follow present two studies that addressed these factors and attempted to validate the assumption that sentence openers can foster learning. The final section integrates the findings from both studies and discusses their implications for the design of communication tools for computer-mediated collaborative learning environments.

2. Literature review

Bereiter and Scardamalia (1987) used sentence openers to increase student self-questioning during composition planning. Offering such sample phrases produced gains in planfulness, reflectivity, and quality of writing. The latter outcome may have encouraged Scardamalia and Bereiter to use the concept of sentence openers to structure students' interactions in CSILE. While sentence openers were not readily embedded in this environment, students were encouraged to copy teacher-generated opening phrases to their personal notebooks and refer to them during CSILE sessions (Hewitt & Scardamalia, 1998). These starting phrases served as a means to improve the quality of the interaction—that is, to let it look more like effective written communication.

The idea of actually integrating sentence openers in computer-mediated learning environments originated from the field of intelligent tutoring systems. Sentence openers served as vehicles for identifying and analyzing sequences of conversational interaction, thus allowing the system to monitor the ongoing discussion and to provide feedback on the students' participation in the dialogue. The rationale for a sentence openers approach is that the illocutionary act an utterance appears to propose is sufficient for a computer agent to judge the "gist" of a student's contribution (Cahn & Brennan, 1999). The underlying intention of an utterance can often be determined by the first few words, that is, the sentence opener. A computer agent can use these sentence-opening phrases to code and interpret a dialogue.

McManus and Aiken (1995) were among the first to put these ideas into practice. Their Group Leader tutor aided in collaborative problem solving by teaching collaborative skills to students during discussions. These skills were adapted from a typology proposed by Johnson and Johnson (1991) and each skill was linked to a unique sentence opener. Through this one-on-one relationship, sentence openers conveyed the central meaning of an utterance. The Group Leader maintained the student model as it monitored the discussion and assessed the student's use of the collaborative skills from the selected sentence openers. To illustrate, the tutor might note that a student rarely checks if he understands his group mates correctly, and recommend that the student composes a message using the opener "What I think you mean is...". The Group Leader received a positive response by the students, and paved the way for further research along these lines. Recent applications can be found in Matessa (2001) and Soller (2001).

Moving away from the idea of intelligent tutoring, Baker and Lund (1997) examined whether requiring students to use sentence openers improves the quality of their interaction. They compared two different communication interfaces; a dialogue box allowing for free typewritten text to be exchanged, and a structured interface using sentence openers. Students using the latter interface produced about twice as much task-focused interactions and slightly more reflective interactions. Said differently, the sentence opener interface led to less off-task communication and more argumentative discussions. In the wake of the Baker and Lund study, several attempts to structure student interaction through sentence openers have emerged (Guzdial & Turns, 2000; Robertson, Good, & Pain, 1998).

Except for CSILE and CaMILE (Guzdial & Turns, 2000), the tools discussed so far support synchronous communication, allowing students to work in real time without experiencing a time lapse. Students perceive communication as an ongoing dialogue in which messages are short and communication is fast. Synchronous communication thus creates a pressure to contribute quickly

because the messages scroll up the screen and the focus of the conversation may change. Consequently, contributions are generally not thoroughly evaluated, elaborated questions are rarely asked, and support for explanations is somewhat superficial (Veerman & Veldhuis-Diermanse, 2001). Such sub-optimal dialogues substantiate the need to promote productive interaction skills through sentence openers. In synchronous communication, sentence openers have the additional advantage of lightening students' typing load, thus complying with the students' perceived need to react as fast as possible.

While the aforementioned communication tools were designed to support student interaction, they contained features that may have had an adverse effect on the quality of the dialogue. One potential limitation is that, as in the Baker and Lund study, sentence openers were drawn from face-to-face dialogues. Another, related constraint is that students were required to use a given set of sentence openers. Both issues are detailed below.

Readily deriving sentence openers from face-to-face conversations passes over the discrepancy between oral and written communication. Speech differs from writing in that 'students say different things, and say things differently'. The first distinction refers to the nature of the communication. That is, the communicative acts used in written communication differ from the ones used in oral communication. For example, Straus (1997) revealed that computer-mediated groups have higher proportions of task communication and disagreement compared to face-to-face groups. The second difference pertains to the linguistic character of spoken and written language. Baron (1997) asserted that, compared with speech, written communication is characterized by more diverse vocabulary, higher grammatical complexity, and more frequent use of adverbial subordinate clauses (e.g., "since", "while") and disjunctions (e.g., "however", "in contrast"). The advent of 'chattalk' signals yet another difference. To increase interaction speed, youths use shortcuts such as abbreviations (e.g., "B4" for "before") and acronyms (e.g., "CU" for "see you"; "BTW" for "by the way") that do not occur in oral discussions. As a result of these differences, sentence openers adapted from face-to-face communication might inhibit rather than support students in verbalizing their thoughts during online discussions.

This supposition is all but far fetched. Soller (2001) assessed the suitability of sentence openers derived from face-to-face dialogues. She found that approximately one out of three attributes students wanted to communicate did not match with the sentence opener they selected. Such a suboptimal match may instigate students to adjust the meaning of an utterance to the sentence openers available. It can also bring about an ungrammatical or unnatural dialogue. To illustrate, Robertson et al. (1998) found that children who had difficulty choosing appropriate sentence openers, randomly picked an opener in order to be able to contribute to the discussion ("*I want to know* no we should not do that"). McManus and Aiken (1996) observed excessive use of the most generic sentence opener ("I think"), probably because it allowed students the most freedom to express their thoughts.

Such improper use of sentence openers is likely to occur when students are required to use sentence openers. Given the richness of language, it seems somewhat optimistic to assume that a set of sentence openers can capture all of a student's expressions. It might therefore be more fruitful to combine sentence openers with a free text input option. In the ideal case, such a semi-structured communication tool would strike a balance between offering just the right amount of support to foster student interaction, and allowing enough freedom for students to verbalize their thoughts. As this tool offers students a choice on how to start a contribution, sentence openers

can foster student interaction only if certain conditions are fulfilled. First, sentence openers should support productive interaction skills. That is, they should assist students in giving explanations, questioning, and argumentation (Chan, 2001; Okada & Simon, 1997; Van Boxtel, 2000). Secondly, students should be able and willing to use sentence openers on their own accord. Such voluntary use might be augmented by designing sentence openers that resemble the wording students' spontaneously adopt. Students' acceptance of sentence openers may further be enhanced by supporting prevalent utterances, regardless of whether these expressions underlie productive interaction skills.

The second part of this paper describes two studies that examined these conditions in synchronous online interaction. The first study was performed to derive sentence openers from naturally occurring, online dialogues. Participants in this study collaborated on an inquiry task, using an unstructured chat tool for communication. The resulting set of sentence openers was implemented in a semi-structured chat tool that allowed students to compose messages in the free-text area or via sentence openers. In the second study, this tool was used to explore the students' appreciation and unprompted use of sentence openers. This study also aimed to examine whether sentence opener usage improves the quality of synchronous interaction, and, as a result, enhances learning outcomes.

3. Study 1

3.1. Method

3.1.1. Participants

Thirty-six students from secondary education volunteered to participate in this study. There were 9 boys and 27 girls with a mean age of 14.1 years (S.D. = 0.5). Students registered for the experiment in self-selected groups of three, leading to 12 triads. All students had prior chat experience, and 75% chatted at least once a week. They received a small fee for participation.

3.1.2. Materials

The groups worked on a computer-supported inquiry task called *Peter Gardner* (cf., Hulshof, Wilhelm, Beishuizen, & Van Rijn, in press). This task invited students to discover how each of five factors affects the temperature inside a greenhouse. These factors were weather condition (sunny, partly cloudy, or cloudy), blinds (open or closed), windows (open or closed), humidity (damp or dry), and season (spring, summer, fall, or winter). Students could discover the impact of a single factor by manipulating input variables and observing their joint effect on the temperature inside the greenhouse. The values of an input variable could be set by clicking the corresponding icon on the left side of the screen (see Fig. 1). Selected values appeared in the experiment window on the right side of the screen. Once all variables were set, students had to predict the outcome by selecting a value from the pull-down menu. They could then click the Result button to run the experiment. In the experiment window, the actual outcome appeared in boldface; the students' prediction appeared in roman.

Microsoft NetMeeting was used to share Peter Gardner, thus enabling triads to perform this task as a team. The program's interface was visible to all group members, but students had to

take turns in interacting with it. Microsoft NetMeeting further facilitated online collaboration through a chat box and a whiteboard. The chat box supported unstructured, synchronous communication; the chat history was shown linearly (see Fig. 2). The collaboration whiteboard offered students a joint graphical workspace. It contained a predefined set of variables, relations, and values students could use to represent the impact of the input variables on the temperature inside the greenhouse (see Fig. 3).

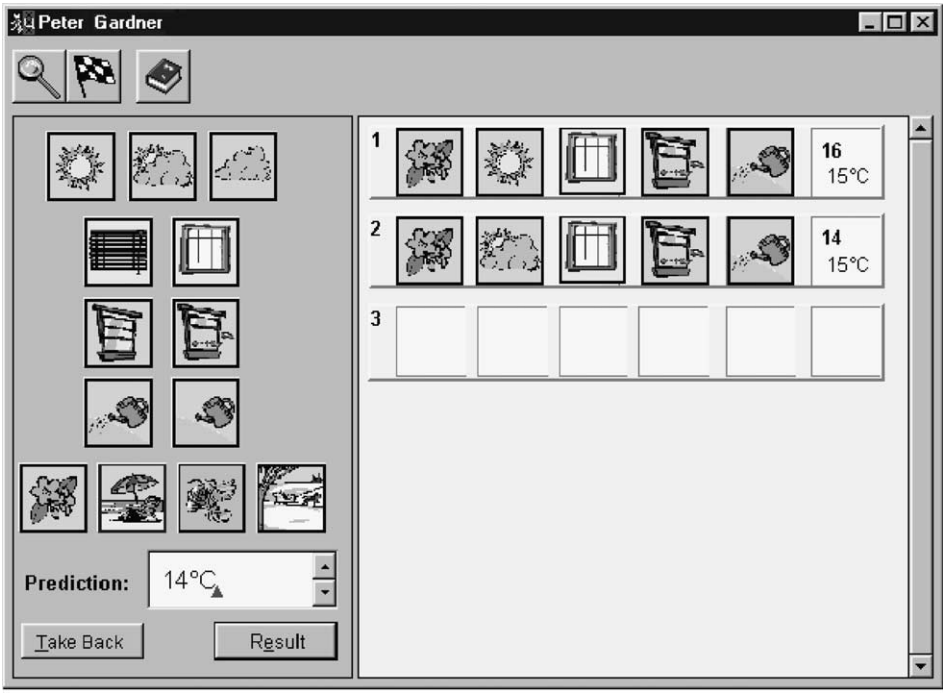

Fig. 1. Interface of *Peter Gardner*.

Fig. 2. Interface of the chat tool.

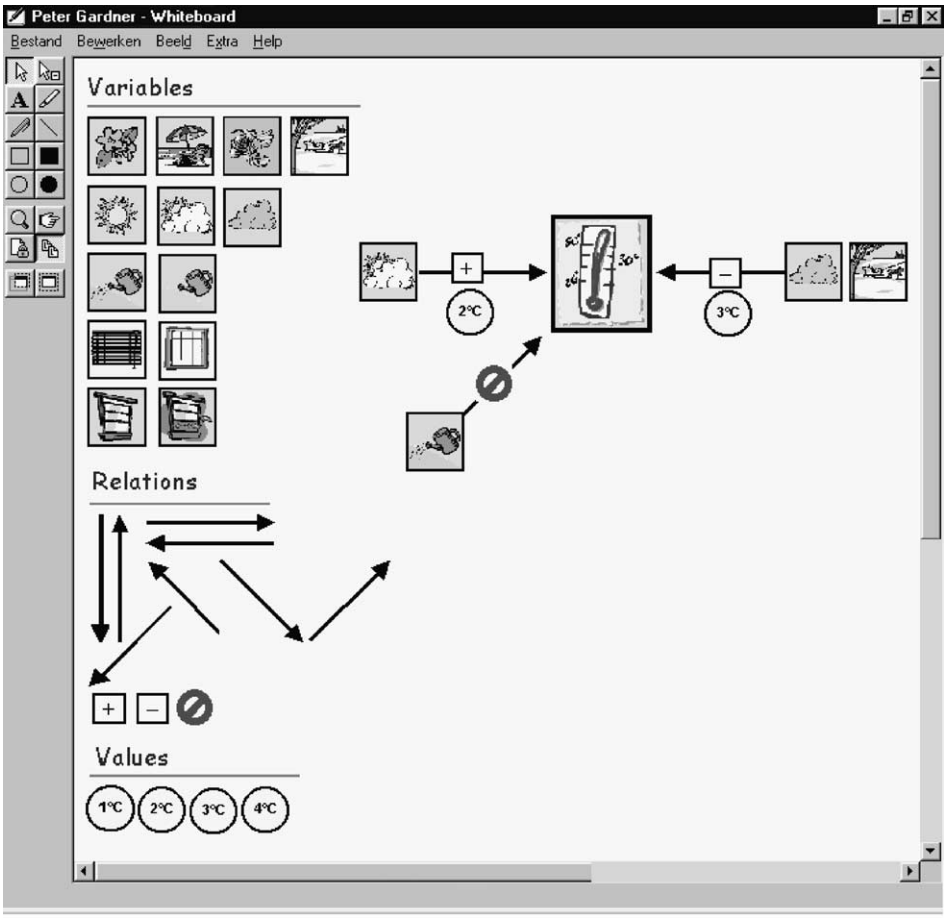

Fig. 3. Screenshot from the collaboration whiteboard.

3.1.3. Procedure

The experiment was conducted in two sessions, which lasted up to 3 h. Both sessions took place in a computer class equipped with 27 Pentium II computers. Separate seatings prevented group members from face-to-face communication. At the beginning of a session, students were informed on the experiment's goal and received instructions. One of the experimenters demonstrated the software by means of a simple inquiry task (controlling the water level of a river) which closely resembled the *Peter Gardner* task. After the introduction each student completed a short background questionnaire. Subsequently, they worked in triads on the practice task for 15 min. After a short break, the groups started the *Peter Gardner* task. The maximum time for task completion was 1 hour.

3.1.4. Coding and scoring

All measures were scored from the chat history files. First, chat messages were segmented into utterances: a collection of words with a single communicative function. Each utterance was then categorized as on-task or off-task communication. Next, the nature of the communication

conveyed by each on-task utterance was classified as communicative act (e.g., statement, question, order) on the basis of a validated coding schema (Erkens, 1997; Van Boxtel, 2000). Three raters scored one chat log of 321 utterances to assess inter-rater reliability. Agreement scores resembled the original values (81% or higher). Finally, sentence openers for productive and prevalent communicative acts were taken from the chat history files.

3.2. Results and conclusions

The chat logs contained 4560 messages. The number of meaningful utterances was lower (4456) because some messages were meaningless (e.g., ''yadidoedoe'') or uncodeable. The latter messages included smileys ((:o)) and expressions (??!!!!). A total of 804 utterances were off-task (18%), the remaining 3652 utterances were classified as on-task communication. A typical on-task dialogue is shown below.

Excerpt 1

1	Mary	Shall we make pictures first
2	Joan	Yes
3	Joan	Think logically
4	Mary	First 1?
5	Joan	Sun
6	Joan	Closed
7	Joan	Open
8	Sue	Change just one picture at a time and make a note
9	Joan	No
10	Sue	Yes
11	Joan	Start with spring
12	Joan	Okay
13	Mary	Ok, outcome?
14	Joan	Hm, outcome
15	Joan	Think
16	Joan	22
17	Mary	Can't
18	Joan	You?
19	Mary	17??
20	Joan	Hm 18
21	Mary	Ok

As this fragment illustrates, students exchanged short messages while largely ignoring the rules of grammar. Because of this chat style, only 4% of all messages contained more than one utterance and the average length of an utterance was 8.2 words.

Table 1 shows the classification of the on-task utterances. The first five acts were deemed fit for support through sentence openers. Statements, questions, and arguments were included because

Table 1
Overall use of communicative acts

	Absolute frequency	Relative frequency (%)	Range (%)
Statement	1128	30.9	11.2–47.7
Question	817	22.4	14.1–33.8
Proposal	613	16.8	8.5–30.9
Confirmation	395	10.8	3.6–18.1
Argument	256	7.0	2.0–14.5
Order	156	4.3	0.7–10.5
Judgment	110	3.0	0.3–7.9
Repetition	95	2.6	0.0–11.2
Negation	82	2.2	0.7–3.9
Total	3652	100	

these acts underlie productive interaction skills. That is, students use these acts to state explanations, ask and answer questions, and engage in argumentative discussions. Statements and questions also qualify for support based on their frequency of use. The same goes for proposals and confirmations. Together, these five acts covered nearly 90% of the on-task utterances. In the remainder of this section, each act is characterized using Van Boxtel's (2000) typology, and prevailing opening phrases are identified.

A *statement* provides new information that does not relate to previous utterances. Statements are used to give explanations. Four types of statements were repeatedly found in the chat logs. First of all, students frequently notified each other when a certain action had been performed. These statements were preceded by the sentence opener ''I have''. Secondly, students used the opening phrase ''I think'' to express ideas that were not directly related to the information on screen. Conversely, statements that did refer to information on screen started with the text ''It is''. The fourth type of statement expressed the students' ignorance and was usually introduced by the words ''I don't know''.

Questions are elicitative utterances that ask for the group members' response. Excerpt 2 illustrates three types of questions that prevailed in the chat logs. Evaluative questions (line 3 and 4) served to check whether group members agree with an outcome, an approach to the problem, or a division of tasks. Consistent with the students' chat style, these questions were brief (''OK?'', ''True?'', ''Yes?''). The phrase ''Is this OK?'' can be used to verbalize these requests.

Excerpt 2

1	Marc	Make it right
2	Beth	What do you want Carl?
3	Marc	Like this?
4	Marc	Is this ok?
5	Carl	I don't get it
6	Marc	Should it all have a + ?

7	Carl	How did you get the numbers?
8	Marc	Why not a−?
9	Carl	Marc take control
10	Marc	I think it's weird
11	Marc	Carl, are you serious?
12	Marc	Hah okay
13	Beth	What are you doing Carl?
14	Marc	What should I do now?

Lines 6–12 show various examples of open questions. Although such requests for new information addressed a wide variety of topics, they were often preceded by the words "What", "How", and "How much". The utterances in line 13 and 14 are practical questions concerning task execution. These questions differed with regard to the person(s) they addressed, referring either to the whole group ("What are we going to do?"), a single group member ("What are you doing?"), or a personal action ("What should I do now?").

Proposals denote suggestions for common actions. Excerpt 1 illustrates that students used both implicit and explicit proposals. In the first line, Mary explicitly proposes to do some experiments ("make pictures first"). In line 5–7, Joan implicitly proposes the values Mary should select for the variables. Although her directions are straightforward, and might even be considered orders, they can be countered by her group members. Then Sue suggests an overall strategy for designing the experiments. Her proposal is implicit; it could be read as "We should change just one picture..." or "Let's change just one picture...", but she found a shorter way to verbalize her idea.

As with practical questions, proposals pertained to the actions of the group, a group member, or one's personal actions. Some proposals closely resembled a practical question; they even used the same sentence opener (e.g., "Shall we...", "Shall we...?"). Although this may seem a matter of coding (the presence or absence of a question mark), there is a more fundamental difference. Practical questions are less directive: they merely ask what to do. Conversely, proposals such as "Shall we..." and "Shall I..." were usually followed by a concrete suggestion for action.

Confirmations are short, positive reactions to a previous utterance. Prevalent confirmations were "yes" and "okay"; their use is illustrated in the Excerpt 1. Students occasionally added text to a confirmation (e.g., "Yes, that's okay", "OK, that's good"). Since these add-ons merely repeated the confirmation, they were not included in the sentence openers. The sentence openers thus were a straightforward "Yes" and "Okay".

Arguments are logical extensions of previous utterances and thus reflect reasoning. Excerpt 3 exemplifies the type of arguments used by most groups. The fragment starts with Mandy on the whiteboard. She has just deleted some + and −signs that denote the relationship between variables (a "traffic sign" stands for "no relationship").

Excerpt 3

1	Lucy	You delete everything??
2	Emmy	But it was ok
3	Mandy	But that open window isn't negative
4	Emmy	They are relevant!!

5	Emmy	They shouldn't get a traffic sign!!.
6	Mandy	No
7	Emmy	There is a plus attached
8	Lucy	Sorry
9	Emmy	If you open the window, it gets colder, so negative
10	Emmy	Right?
11	Lucy	If there is something already, then you should not delete it, unless it is really incorrect, okay?
12	Mandy	Yes, but summer and an open window is correct, isn't it.
13	Lucy	Yes, but then the heat disappears too.
14	Emmy	Just look at the icons
15	Mandy	Yes but then it should be 20 degrees

The students in this fragment used four types of arguments. Explanatory arguments elucidate a given statement and were often designated by the sentence opener "because". Nearly all conditional arguments used an "if...then" clause. Conclusive arguments are used to wrap up a discussion or to state a conclusion. They were often preceded by the opener "So". Counter arguments disprove a given statement. Typical sentence openers were "But..." or "Yes, but...".

These opening phrases were not necessarily used to start an argument. Some openers appeared in the middle of an utterance ("Mandy should do it *because* she understands the whiteboard"). This frequently occurred with conclusive arguments: students first advanced a thesis and then drew a conclusion from that information ("It is warmer in summer, *so* your solution is incorrect") Furthermore, not every argument was preceded by a sentence opener. For instance, Emmy gave a counter argument (utterance 4), a conclusive argument (utterance 5) and an explanatory argument (utterance 7) but never used a sentence opener that is indicative of those arguments.

Such implicit use of sentence openers also occurred with statements and proposals. This leaning toward brevity is probably attributable to the students' chat style. As the above fragments illustrate, students tended to communicate by rapidly exchanging short messages. By omitting opening phrases, students can reduce typing load and increase the rate at which ideas are exchanged. Whether students maintain this chat style when sentence openers can be generated by a single mouseclick is examined in the next study.

4. Study 2

4.1. Method

4.1.1. Participants

Forty-three students (27 boys, 16 girls) from secondary education participated in this study. Their mean age was 14.6 years (S.D. = 0.7). All students had prior chat experience, and 72% chatted at least once a week. Students registered for the experiment in self-selected groups of three, leading to 14 groups.[1] They were given a small fee.

[1] One group consisted of four students.

4.1.2. Materials

The software was identical to that of Study 1, except that the students communicated via the semi-structured chat tool displayed in Fig. 4. This tool allowed students to compose a message from scratch in the free text area, or to start a contribution by selecting a sentence opener. All sentence openers emanated from Study 1 and were grouped according to their communicative function. Students could select a sentence opener by a single mouseclick. The corresponding phrase appeared in the dialogue box, where students could complete it and forward it to their groupmates by clicking the Send button. If the students clicked on one of the grey short cut buttons, the corresponding utterance was readily sent to their group members.

Two questionnaires assessed the students' appreciation of sentence openers. The first questionnaire measured perceived usefulness and was administered prior to the hands-on part of the study. It consisted of 20 items (half of which were fillers) that were judged on a four-point Likert scale. Items dealt with the ease of selecting appropriate sentence openers, the facilitative effect of sentence openers on thought verbalization, and their impact on the speed of the dialogue. Filler items addressed other features of the applications and the students' beliefs about working in groups. The second questionnaire asked students to rate the usefulness of sentence openers in view of their experiences with the semi-structured chat tool. It contained the same items as the first questionnaire. Students again scored each item on a four-point scale. The reliability of both questionnaires was satisfactory (Cronbach's alpha >0.79).

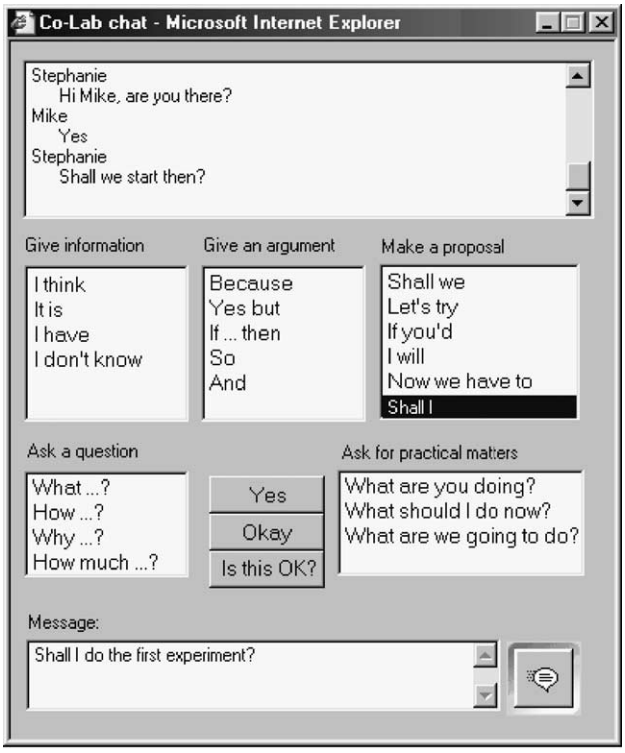

Fig. 4. Interface of the semi-structured chat tool.

4.1.3. Procedure

The experimental sessions were conducted following the directions from Study 1. In addition, students filled out two questionnaires: one after the introduction and one after the session.

4.1.4. Coding and scoring

As in Study 1, all chat messages were segmented into utterances and on-task utterances were classified as communicative act. For each act, explicit and implicit use of sentence openers was scored from the chat logs. Explicit use represents the number of times students actually selected a sentence opener. Implicit use was indicated by the number of utterances that—from a linguistic point of view—could have been preceded by a sentence opener, but were composed in the free text area. The usefulness of sentence openers was denoted by the scores from the questionnaires. Higher scores indicated higher usefulness. Quality of interaction was indicated by the proportional use of communicative acts that underlie productive interaction skills (i.e., statements, questions, arguments). Learning outcomes were scored from the Whiteboard.

4.2. Results and conclusions

The groups wrote 3633 messages containing 3390 meaningful utterances. The 2449 on-task utterances were analyzed to establish the students' use of sentence openers. As can be seen from Table 2, sentence openers were used 197 times ($M = 14.1$; S.D. = 10.4), meaning that approximately one out of 13 utterances was composed using a sentence opener. Although there is no absolute standard for this measure, these findings suggest that students make little use of sentence openers. Data for implicit use of sentence openers support this claim. Nearly half of the utterances could have been composed using a sentence opener. For supported communicative acts, these scores ranged from 39 to 80%.

The low scores for explicit use further suggest that sentence openers had little effect on the quality of interaction. The data bore this out: the use of communicative acts underlying productive interaction skills (i.e., statements, questions, arguments) was comparable to that of Study 1. This in turn made it impractical to consider learning outcomes. Sentence openers were expected to have an indirect effect on this measure. That is, learning outcomes would improve because the quality of the interaction would improve. Since the latter part of this prediction could not be

Table 2
Use of sentence openers for on-task communication

	Explicit use	Implicit use
Statement ($n = 639$)	10 (1.6%)	249 (39.0%)
Question ($n = 680$)	87 (12.8%)	298 (43.8%)
Proposal ($n = 368$)	10 (2.7%)	251 (68.2%)
Confirmation ($n = 285$)	78 (27.4%)	198 (69.5%)
Argument ($n = 206$)	4 (1.9%)	165 (80.1%)
Other ($n = 271$)[a]	8 (3.0%)	48 (17.7%)
Total ($n = 2449$)	197 (8.0%)	1209 (49.4%)

[a] All unsupported acts, i.e., repetitions, orders, judgments, and negations.

confirmed, the former part could not either. Besides, the infrequent use of sentence openers makes it rather improbable that differences in learning outcomes are attributable to sentence opener usage per se.

Students rated their appreciation of sentence openers before and after the session. Their initial impression of sentence openers was a slightly positive one: the mean score for perceived usefulness was 2.8 (S.D. = 0.7). Significantly lower scores were obtained for actual usefulness [$M = 2.3$, S.D. = 0.6; t (42) = 6.6, $P < 0.01$], indicating that students' opinion of sentence openers decreased after they had actually used them.

There was a strong positive correlation between the two usefulness scores (see Table 3). Students with high perceived usefulness scores also had high scores for actual usefulness. This in turn implies that the observed decrease in usefulness applies to a vast majority of the students. The correlations between the use and usefulness of sentence openers were marginally significant. Apparently, students with high usefulness scores used more sentence openers than students with lower usefulness scores. However, the relatively low correlations suggest that this conclusion does not apply to all students. It could be that some students with high usefulness scores made little use of sentence openers. A more plausible explanation might be that some students with low usefulness scores put the sentence openers to the test, and concluded that sentence openers are indeed of little use to them.

Furthermore, both usefulness scores correlated negatively with chat experience. Students who chat frequently thought less positively of sentence openers than students who chat less often. This might be explained from the students' chat style. Informal observations have revealed that students with high levels of chat experience are used to typing and sending short messages at high speed. During this study, students maintained in this chat style, being unwilling to adopt an alternative way to compose messages. This explanation was substantiated by the negative correlation between chat experience and the use of sentence openers.

5. General discussion

This paper explored whether sentence openers can foster student interaction and learning in computer-mediated learning environments. The underlying idea was that the quality of synchronous interaction can be improved by offering sentence openers for productive interaction skills.

Table 3
Correlations between usefulness of sentence openers, use of sentence openers, and chat experience

	Actual usefulness	Use of sentence openers	Chat experience[a]
Perceived usefulness	0.55**	0.27*	−0.31*
Actual usefulness		0.26*	−0.31*
Use of sentence openers			−0.43**

Because students completed the usefulness questionnaires on their own (i.e., independent of their group mates), usefulness scores were analyzed for individual students ($n = 43$).

[a] Spearman rank correlations.

* $P < 0.05$; ** $P < 0.01$.

Superior, more meaningful dialogues were further assumed to yield higher learning outcomes. However, several conditions should be fulfilled for the anticipated effects to show.

The first condition, which stated that sentence openers should be derived from naturally occurring online dialogues, was addressed in Study 1. Typical opening phrases were taken from the students' chat history files. In keeping with the main assumption, the analyses focused on communicative acts that represent productive interaction skills. Prevalent acts were also included because this was believed to enhance the students' acceptance and use of sentence openers. The analyses further suggest that the students' chat style might interfere with their use of sentence openers. Students mostly wrote brief messages, often using sentence openers implicitly. The set of sentence openers reflected this chat style in that most openers were brief, thus increasing the chance that students would use sentence openers on their own accord.

According to the second condition, sentence openers should not be imposed. The sentence openers from Study 1 were therefore implemented in a semi-structured chat tool that allowed students to compose messages in the free-text area or via sentence openers. This tool supports students' thought verbalization by offering various possibilities to start an utterance. Yet it does not restrict the students' natural choice of words: the free-text input option provides a safety net in case none of the openers fits the sentence a student tries to compose.

Because there is always a possibility that students rely too heavily on the free text option, a semi-structured tool is functional on condition that students are able and willing to use sentence openers. The former condition implies that there should be ample opportunities for students to use sentence openers. The results from Study 2 bore this out: the wording of the sentence openers was compatible with nearly 60% of the utterances. The observed use of sentence openers compares unfavorably with this standard. No more than 8% of the on-task utterances were composed using sentence openers. Due to this bottom effect, the effects of sentence openers on student interaction and learning outcomes could not be assessed.

There is reason to believe that the students' appreciation of sentence openers affected their use. Research has consistently shown that students are enthusiastic about sentence openers (e.g., Baker & Lund, 1997; Robertson et al., 1998; Soller, 2001). The students in Study 2 held a different view. Initially they were somewhat reserved with sentence openers—their scores were just above the scale's midpoint. Their actual usefulness scores were lower, suggesting that their experience with the chat tool had an adverse effect on their attitude towards sentence openers.

These inconsistent findings may be explained from the students' experience with information and communication technology. When the cited studies were conducted, synchronous online communication was still in its infancy. Nowadays the pervasive use of chat boxes has familiarized students with this type of communication. They may therefore have a more critical stance toward new features of a chat tool. More importantly, students with high levels of chat experience may have developed a personal chat style. Since conventional chat boxes merely contain a free-text input option, students may have difficulty in using sentence openers on their own accord. This explanation is corroborated by the correlations from Study 2. Students with high levels of chat experience used fewer sentence openers and were less favorable of sentence openers compared to inexperienced students.

In sum, sentence openers were largely neglected because students were skeptical about their benefit. Ironically, this made it impractical to validate the presumed benefit of sentence openers on interaction quality and learning outcomes. This deadlock may be difficult to overcome. Chat

boxes are, and will probably remain popular among youths. As a result, their levels of chat experience will increase, and the current data show that this will have an adverse effect on their appreciation of sentence openers. Future studies might therefore consider using a structured chat box. Although requiring students to use sentence openers conflicts with the conditions stated in this paper, it may be the only way to discover if and how sentence openers foster interaction and learning.

On the other hand, the alleged disadvantage of imposing sentence openers may be revisited in view of the present findings. Students in both studies exchanged messages at high speed. On average, one message was sent every four seconds. Clearly, this leaves little room for deliberation and reflection. Requiring students to use sentence openers may decelerate the pace of their conversation. In this view, it could even be advantageous for sentence openers to conflict slightly with the students' own choice of words, because this will force them to reconsider their contribution. This might cause a more productive learning dialogue.

In asynchronous communication, students feel less pressure to contribute quickly. Asynchronous writing therefore tends to be longer and more carefully structured than synchronous writing. Could it be that sentence openers are more useful in this type of communication? Bereiter and Scardamalia (1987) showed that sentence openers can facilitate asynchronous written communication, but their study leaves it unclear whether this conclusion applies when sentence openers are integrated in a communication tool. This reservation seems important as Study 2 demonstrated that students are reluctant to change their personal communication style. Because students also have considerable experience with asynchronous communication (e.g., email, discussion groups), it is unclear whether they are willing to abandon habits and adopt sentence openers. Future research is needed to answer these questions.

Research should also continue to explore the use of sentence openers in intelligent tutoring systems. Our technical know-how is so advanced that it should be possible for an intelligent agent to generate potentially relevant opening phrases on the basis of a previous utterance. For example, if a student would ask a closed question ("Do you agree?"), the tutor would analyze this utterance and attach the openers "Yes" and "No, I disagree because..." to this message before sending it to the other students. Similarly, open questions or proposals could be equipped with openers that represent arguments such as "I agree because..." and "Yes, but...". Generic opening phrases ("I think...", "Another question is...") should occasionally be added to allow students to change the subject of conversation. The tutor can thus mediate student interaction by suggesting a designated set of opening phrases to react to an utterance. By tailoring sentence openers to the ongoing dialogue, their relevance and usefulness may be increased.

It would also be interesting to examine if sentence openers can be tailored to the topic of conversation. This would nicely fit in with recent work on object-oriented chat boxes (Singley, Singh, Fairweather, Farrell, & Swerling, 2000). Unlike a generic chat facility, object-oriented chat tools allow students to link chat messages to objects on the screen. Messages are tethered to an object by an arrow. These pointers serve as demonstrative and a locative in the chat message, thereby easing the typing load on the student. Object-specific sentence openers might further reduce the students' typing load. Phrases that appear in the middle of a sentence might also qualify for support, especially when they are prevalent or difficult to type (e.g., scientific formula). It is however unclear whether such phrases can be adapted to the objects on screen. Nor has it been established whether students appreciate and use this type of support. Research into these issues is

needed to grasp the roles of sentence openers in CSCL, thereby providing a solid basis for designing better user support.

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References

Baker, M., & Lund, K. (1997). Promoting reflective interactions in a computer-supported collaborative learning environment. *Journal of Computer-Assisted Learning*, *12*, 175–193.

Baron, N. S. (1997). Letters by phone or speech by other means: the linguistics of email. *Language & Communication*, *18*, 133–170.

Bereiter, C., & Scardamalia, M. (1987). *The psychology of written composition*. Hilldale: Erlbaum.

Cahn, J. E., & Brennan, S. E. (1999). A psychological model of grounding and repair in dialog. In *Proceedings, AAAI Fall Symposium on Psychological Models on Communication in Collaborative Systems* (pp. 25–33). North Falmouth: American Society for Artificial Intelligence.

Chan, C. K. (2001). Peer collaboration and discourse patterns in learning from incompatible information. *Instructional Science*, *29*, 443–479.

Cook, J. (2000). Cooperative problem-seeking dialogues in learning. In G. Gautier, C. Fransson, & K. Van Lehn (Eds.), *Intelligent tutoring systems* (pp. 615–624). Berlin: Springer.

Erkens, G. (1997). *Cooperatief probleemoplossen met computers in het onderwijs* (Cooperative problem solving with computers in education). PhD thesis, University of Utrecht, The Netherlands.

Guzdial, M., & Turns, J. (2000). Effective discussion through a computer-mediated anchored forum. *Journal of the Learning Sciences*, *9*(4), 437–469.

Hewitt, J., & Scardamalia, M. (1998). Design principles for distributed knowledge building processes. *Educational Psychology Review*, *10*(1), 75–96.

Howe, C., & Tolmie, A. (1998). Computer support for learning in collaborative contexts: prompted hypothesis testing in physics. *Computers & Education*, *30*, 233–235.

Hulshof, C. D., Wilhelm, P., Beishuizen, J. J., & Van Rijn, H. FILE: a tool for the study of inquiry learning. *Computers in Human Behavior* (in press).

Jarboe, S. (1996). Procedures for enhancing group decision making. In B. Hirokawa, & M. Poole (Eds.), *Communication and group decision making* (pp. 345–383). Thousand Oaks: Sage.

Johnson, D. W., & Johnson, R. T. (1991). *Learning together and alone*. Englewood Cliffs: Prentice-Hall.

King, A. (1997). Ask to THINK—TELL WHY®©: a model of transactive peer tutoring for scaffolding higher level complex learning. *Educational Psychologist*, *32*, 221–236.

Kumpulainen, K., & Mutanen, M. (2000). Mapping the dynamics of peer group interaction: a method of analysis of socially shared knowledge processes. In H. Cowie, & G. Van der Aalsvoort (Eds.), *Social interaction in learning and instruction* (pp. 141–161). Amsterdam: Pergamom.

Matessa, M. (2001). *Interactive models of collaborative communication*. Paper presented at the 23rd Annual Conference of the Cognitive Science Society. Available: http://www.hcrc.ed.ac.uk/cogsci2001/pdf-files/0606.pdf (accessed 23 August 2002).

McManus, M. M., & Aiken, R. M. (1995). Monitoring computer-based collaborative problem solving. *Journal of Artificial Intelligence in Education*, *6*, 307–336.

McManus, M. M., & Aiken, R. M. (1996). Teaching collaborative skills with a group leader tutor. *Education and Information Technologies*, *1*, 75–96.

Moore, D. (1993). *Dialogue games for intelligent tutoring systems*. Unpublished doctoral dissertation, Leeds Metropolitan University.

Okada, T., & Simon, H. A. (1997). Collaborative discovery in a scientific domain. *Cognitive Science*, *21*(2), 109–146.

Robertson, J., Good, J., & Pain, H. (1998). BetterBlether: the design and development of a discussion tool for education. *International Journal of Artificial Intelligence in Education*, *9*, 219–236.

Scardamalia, M., & Bereiter, C. (1991). Higher levels of agency for children in knowledge building: a challenge for the design of new knowledge media. *Journal of the Learning Sciences*, *1*(1), 37–68.

Singley, M. K., Singh, M., Fairweather, P., Farrell, R., & Swerling, S. (2000). Algebra jam: supporting teamwork and managing roles in a collaborative learning environment. In *Proceeding of the ACM 2000 Conference on Computer supported cooperative work* (pp. 145–154). New York: ACM.

Soller, A. L. (2001). Supporting social interaction in an intelligent collaborative learning system. *International Journal of Artificial Intelligence in Education*, *12*, 40–62.

Straus, S. G. (1997). Technology, group process, and group outcomes: testing the connections in computer-mediated and face-to-face groups. *Human-Computer Interaction*, *12*, 227–266.

Van Boxtel, C. A. M. (2000). *Collaborative concept learning*. PhD thesis, University of Utrecht, The Netherlands.

Veerman, A.L., & Veldhuis-Diermanse, A.E. (2001). *Collaborative learning through computer-mediated communication in academic education*. Paper presented at the Euro-CSCL, Maastricht, The Netherlands.

Webb, N. M., & Palinscar, A. S. (1996). Group processes in the classroom. In D. C. Berliner, & R. C. Calfee (Eds.), *Handbook of educational psychology* (pp. 841–873). New York: MacMillan.