

Adapting the “Communication-Scaffolding” Tools in a Web-based Collaborative Learning Environment

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Abstract: The work presented in this paper discusses the supported forms of the “communication-scaffolding” tools (i.e. sentence openers and communication acts) and the adaptation framework of a synchronous communication tool, called ACT. The main idea of the adaptivity lies in the provision of those “communication-scaffolding” tools that facilitate/support the group dialogue and promote student interaction/collaboration with respect to (i) the skills that the collaborative learning activities or the model of collaboration aim to develop to the students and/or (ii) the educational tool used for performing the activity. In order to determine the most appropriate set of the “communication-scaffolding” tools, a series of three qualitative empirical studies was conducted. The results of the studies drew implications about the form of the dialogue/ “communication-scaffolding” tools as well as the adaptivity of the provided “communication-scaffolding” tools.

Introduction

Many researchers seem to agree on the notion that collaboration can foster learning and boost student achievement as the students exchange their ideas and negotiate on them, share their expertise, give explanations, externalise their thoughts, argumentate on their actions or on their points of view, articulate their reasoning, and co-construct their knowledge (Baker & Lund 1997; Dimitracopoulou & Petrou 2003). Effective collaboration presupposes active and well-functioning groups that have the required skills to communicate and the cognitive skills to learn (Soller 2001). Unfortunately, the students do not always possess such skills. Usually, a preliminary training is needed in order the students to participate in an effective learning discourse or the instructors teach students not only the cognitive skills necessary to learn, but also the communication skills they need to cope with the requirements of effective collaborative learning (Lazonder, Wilhelm & Ootes 2003).

In the context of Computer-Supported Collaborative Learning environments (CSCL), the communication tools are usually text-based such as e-mail and chat boxes, which provide no guidance and support to the students during their dialogue. A number of research efforts are focused on the study of the group dialogue in terms of the skills, which are developed and the enrichment of the communication tools with specific features, which guide/support/promote the group collaboration/communication and increase the likelihood of effective discourse taking place. In many cases, the guidance takes the form of fully or semi-structured dialogue implemented through interfaces, which enable the students to select a sentence opener and/or a communication act from an available list (Soller 2001). The sentence openers are pre-defined phrases to start a contribution accompanied by additional text to complete the students’ thoughts while the communication acts denote the student’s intention/action by a couple of keywords. For example, the students might compose their messages by selecting (i) a sentence opener like “I propose to ...”, “I agree with ...” from a menu and then elaborating on this opener with additional text or (ii) a communication act like “Propose”, “Agree” from a menu and then expressing/explaining their intention/action with additional text. The use of sentence openers and/or

communication acts aims to guide the sequence and the content of the dialogue and support the students in the development/cultivation of specific communication skills.

Several systems have been designed to facilitate the group dialogue and guide the students' interaction through a structured communication interface. In BetterBlether (Robertson, Good & Pain 1998), the communication interface consists of sentence openers, which support the skills of good communication, trust, leadership and creative conflict. In LeCS (Rosatelli & Self 2002), the provided set of the sentence openers facilitate the process of reaching an agreement in the case discussion, while specific expressions enable the students to express their emotional state. In DEGREE (Barros & Verdejo 2000), the students have to select the type of their contribution (i.e. the communication act) such as proposal, question or comment, from a list, each time they add to the discussion.

The work, presented in this paper, takes previous work in structuring the group dialogue and the communication interface one step further by seeking to determine those sentence openers and communication acts, referred to as "communication-scaffolding" tools, that promote the collaboration with respect to (i) the skills (i.e. cognitive and communication) that the collaborative learning activities or the model of collaboration aim to develop to the students and/or (ii) the educational tool used for performing the activity. More specifically, this work contributes to the development of a synchronous communication tool with adaptive capabilities called ACT (Adaptive Communication Tool), in the context of a web-based adaptive collaborative learning environment, referred to as SCALE (Supporting Collaboration and Adaptation in a Learning Environment) (Gogoulou, Gouli, Grigoriadou & Samarakou 2003). ACT is designed to go a bit further than most communication tools in adapting the provided set of the "communication-scaffolding" tools according to the learning outcomes (i.e. cognitive and communication skills) addressed by the learning activity, the educational tool used for the elaboration of the activity or the model of collaboration followed by the group members. In this context, we followed a research-based approach and three qualitative empirical studies were conducted aiming to the determination of the widest and most appropriate sets of the "communication-scaffolding" tools. The results of the studies drew implications about the form of the dialogue and the form/adaptivity of the provided "communication-scaffolding" tools.

The rest of the paper is structured as follows. In the following section, we describe in detail the three empirical studies in terms of the process followed and the results of the qualitative analysis of the group dialogue. Afterwards, we discuss the implications drawn in terms of the forms of the dialogue/"communication-scaffolding" tools and the adaptation framework supported by the ACT tool. The paper ends with the main points of our work and our near future plans.

The Empirical Studies

Having as an objective to develop a communication tool with adaptive capabilities, able to facilitate/support the group dialogue and to help/guide the students to establish and maintain fruitful learning discourses, we conducted three qualitative empirical studies. The main goal of the studies was to examine/investigate whether the semi-structured form of the dialogue and the provided "communication-scaffolding" tools are aligned with the learning outcomes addressed by the learning activities, the model of collaboration followed by the group members or the educational tool used. The objectives of the three studies were supplementary concerning (i) the determination of the initial set of the sentence openers with respect to the learning outcomes addressed by the learning activities (first experiment), (ii) the verification/modification/enrichment of the initial set of the sentence openers and of a pre-determined set of the communication acts (second experiment), and (iii) the verification/enrichment of the set of the communication acts with respect to the skills addressed by the model of collaboration (third experiment).

The collaborative learning activities that we developed, addressed (i) specific and similar cognitive skills for three different subject matters (i.e. "Introduction to Programming", "Computer Architecture" and "Open and Distance Learning"), and (ii) different models of collaboration. More specifically, the cognitive skills are classified to the following four levels (i.e. we have adapted the six categories of cognitive processes proposed in (Anderson et al. 2001; Mayer 2002)):

- *Comprehension level* (Remember + Understand): this level includes cognitive processes and skills, which mainly concern the students' ability (i) to remember things, that is to recognize or recall facts, concepts, etc,

and/or (ii) to understand things, that is to interpret, explain and summarize the meaning of a concept, etc, on their own words/by using examples, to draw inferences from facts/processes and to reason their inferences, to identify and specify the main components or key points of a construct/concept, to distinguish, classify, compare and relate concepts/facts/etc.

- *Application level* (Apply): this level includes cognitive processes and skills, which mainly concern the students' ability to specify the main steps and to follow/execute a process and/or to implement/modify a "product" according to pre-specified rules/processes or by determining its constituent parts.
- *Checking-Critiquing level* (Evaluate): this level includes cognitive processes and skills, which mainly concern the students' ability to check the correctness and/or the completeness of a given "product" and to reason about their opinion.
- *Creation level* (Analyze + Create): this level includes higher-order cognitive processes and skills, which mainly concern the students' ability to analyze and compose a "product", design and construct a "product" by combining various processes/methods, plan and organize a project.

The students communicated using the chat tool of the NCSA Habanero collaborative environment, which provides logging capabilities and supports the record of the dialogue in log files. The studies took place during the spring semester of the academic year 2002-2003. A total of fourteen students volunteered to take part in the empirical studies (i.e. four undergraduate students for the "Introduction to Programming" subject matter, four undergraduate students for the "Computer Architecture" subject matter and six postgraduate students for the "Open and Distance Learning" subject matter). During the first and the second study the students collaborated in pairs while in the third study they collaborated in groups of two or four members following specific models of collaboration. The subjects were not familiar with computer-based collaboration, therefore at the beginning of the first study, we explained the whole process and supported them during the studies.

Determining the Initial Set of Sentence Openers according to the addressed Learning Outcomes

The objectives of the first empirical study were (i) to analyze the student-student discourse with respect to the cognitive skills that should be cultivated, and (ii) to determine the initial set of the sentence openers with respect to the learning outcomes (i.e. cognitive and communication skills) addressed by the learning activities.

The students were randomly paired acting equivalently during their collaboration. For the coordination of the group process and the facilitation of collaboration/communication, one student of each pair played the role of the "moderator", who was responsible for (i) the provision of their concluded answer to each question item/activity and (ii) the prompt to move on to the next question item/activity and to coordinate the process. The subjects collaborated in an unstructured dialogue form in the context of three learning activities addressing cognitive skills of the Comprehension level, Application level and Checking-Critiquing level. Each activity included a number of sub-activities/question items.

The qualitative analysis of the group dialogue was focused on the form of the dialogue that was used (i.e. whether the dialogue presented some sort of structure) and on the specific phrases that were used between the group members (i.e. whether there were specific recurring phrases denoting the sequence of the dialogue) (Gouli, Gogoulou, Grigoriadou & Samarakou 2003). The dialogue implied some sort of sequence adapted to the context of each activity/sub-activity. The students tended to constrain their messages, to use short and clear messages and to formulate their answers by using specific phrases (i.e. sentence openers) compatible to the activity/sub-activity under consideration. It seems that the structure of the activity/sub-activity, and subsequently the underlying leaning outcomes, guided the students' dialogue.

As far as the specific phrases that were used are concerned, the meaningful chat messages (some messages were considered meaningless including smileys, etc) were categorized as on-task and off-task messages. The analysis of the on-task messages revealed that the students tended to use specific phrases relevant to the activity/sub-activity (e.g. if the question item required the students to reason their answer, then they used sentence openers like "I believe that the answer is ... because..."). The observed sentence openers presented similarities for those activities that addressed cognitive skills of the same level, independently of the subject matter. We also observed sentence openers that were used in cases that the students asked for clarifications, for confirmation, for help, etc. More specifically, the on-task sentence openers were grouped into three categories: (i) sentence openers that were explicitly related to the addressed cognitive skills (e.g. the sentence opener "I think/I believe that") was used in cases that the addressed cognitive skills concerned the Comprehension level while the sentence opener "I believe that because" was used when the addressed

cognitive skills concerned the Checking-Critiquing level), (ii) sentence openers that facilitated and supported further the development of the communication skills, and (iii) sentence openers that were used exclusively from the student who acted as the “moderator” (e.g. “We both agree that ...”, “The final answer is ...”, “To summarize ...”, “Do you want to continue?”). The sentence openers concerning the cultivation of communication skills were further subdivided into sub-categories: (i) sentence openers requesting for clarification, justification, opinion, information, and confirmation (e.g. “What do you mean?”, “Why do you believe ...?”, “Please justify your proposal”), (ii) sentence openers giving explanation, clarification, justification (e.g. “I mean ...”, “Because ...”), (iii) sentence openers used for acknowledgement (e.g. “Ok”), (iv) sentence openers used for motivation (e.g. “That’s a good idea”), and (v) sentence openers expressing an emotional state and/or the need for help (e.g. “I have been confused”, “I don’t understand”, “I need some time to think”).

Verifying, Modifying and Enriching the Sets of Sentence Openers and Communication Acts according to the addressed Learning Outcomes

The objectives of the second empirical study were (i) to verify the initial set of the sentence openers and to modify/enrich it appropriately, (ii) to investigate the possibility of enriching the set of sentence openers with phrases/keywords related to the education tool (e.g. concept mapping tool, educational software) which is used for the elaboration of the learning activity, and (iii) to verify a pre-determined set of the communication acts with respect to the learning outcomes (i.e. cognitive and communication skills) addressed by the learning activities.

During the second empirical study, the students were also randomly paired, having the same duties and acting equivalently, while one of the group members played the role of the “moderator”. The initial set of the sentence openers, derived from the first study, was enriched with additional phrases mainly concerning the communication skills. This enriched set was used for the students’ collaboration in a semi-structured dialogue form. Regarding the communication acts, we determined an initial set making available to the students all those keywords that enable them to express their beliefs/opinions, to agree/disagree to a proposal, to ask for clarification, to reason their opinion/proposal, to make comments etc.

As far as the first two objectives are concerned, we developed three learning activities for each one of the three subject matters, which were slightly different from the ones of the first study but they addressed similar cognitive skills (i.e. concerning the Comprehension, Application and Checking-Critiquing level respectively). Also, we developed a learning activity, which urges the students to think of/reason/discuss/exchange ideas on a specific topic as well as to implement the solution of a given problem (Creation level). Upon the completion of each learning activity, the students were asked to answer a series of questions concerning the completeness, the adequacy, the usability and the difficulty of use of the available set of the sentence openers/communication acts as well as to mention any keywords-expressions that were missing and they wished to be available.

The analysis of the students’ dialogue of the first three collaborative learning activities as well as their answers/comments indicated the revisions that were necessary, mainly concerning the sentence openers that serve the cultivation of the communication skills rather those that support the development of the desired cognitive skills. The students used all the available sentence openers dedicated to the addressed cognitive skills or to the duties of the “moderator” and considered the available set adequate and easy to use. As far as the sentence openers concerning the development of the communication skills are concerned, the majority of the students used a part of them while they mentioned a couple of phrases suitable for requesting, and for clarification/help such as “In which part, do you disagree?”, “Why do you disagree”, “Any ideas?”. Regarding the sentence openers dedicated to the use of the educational tool (i.e. concept map), which was required for the elaboration of one of the learning activities in the context of the “Open and Distance Learning” subject matter, the students formulated phrases that were not available like “With what concept do you propose to link the [concept]?”, “Do you agree with the proposition [concept-link-concept]?”, “Lets think how to connect [concept] to [concept]”, “I propose to add the concept [concept]”, “I propose to link [concept] to [concept]”.

In the framework of the fourth activity, the majority of the students pointed out their preference to the use of the communication acts instead of the sentence openers, as they believe that they can express freely their opinion without guidance/constraints. It is worthwhile mentioning that the students who are familiar with the chat communication prefer the use of the communication acts, while the students who are unfamiliar, prefer the use of the sentence openers as they have at their disposal a form to compose their message. As far as the pre-determined set of the communication acts is concerned, the analysis revealed that the students (i) had difficulties

in using specific communication acts, such as “ContraProposal”, “ContraProposal and Argument”, “Guidance/Maintenance to activity’s elaboration” (their meaning was not considered clear), and (ii) used faulty a couple of communication acts such as “Comments” (they used it in some cases instead of “Propose”) and “Propose and Argument” (instead of “Propose”). In most cases, the difficulty of use of the provided set was characterized as minimal, its completeness/adequacy as sufficient and its usability as moderate.

Verifying and Enriching the Set of Communication Acts according to the Model of Collaboration

The objective of the third empirical study was the verification as well as the enrichment/modification of the pre-determined set of the communication acts according to the models of collaboration, which were followed by the group members during the accomplishment of a learning activity.

The students collaborated in a semi-structured dialogue form, following specific models of collaboration, and using the revised set of the communication acts. The models of collaboration that were followed include (i) the “Driver-Observer” model: the “driver” is responsible for making proposals, implementing the task and guiding the elaboration of the activity while the “observer” is responsible for making comments, asking for clarifications and expressing his/her opinion, (ii) the “Assessor-Brainstormer” model: the “assessor” evaluates any proposals, asks for clarifications and has the responsibility of the final answer while the “brainstormer” thinks of the answer, makes alternative proposals and responds to any questions posed by the “assessor”, and (iii) the “Clarifier-Questioner-Responder-Devil’s Advocate” model: the “clarifier” gives clarifications and s/he is the “moderator” of the group, the “questioner” asks for explanations/clarifications, the “responder” has the duty of making proposals and answering to relevant questions while the “devil’s advocate” poses contra-proposals and disagreements.

Each student, undertaking a specific role, had at his/her disposal a subset of the available communication acts appropriate to cover the needs of the role and to support the cultivation of the desired cognitive and communication skills. For example, in the context of the “Driver-Observer” model, the “driver” could use communication acts such as “Proposal”, “Clarification”, “Reasoning” and various actions like “Insert”, “Modify”, etc while the “observer” could use communication acts like “Question”, “Opinion”, “Comments”. Upon the completion of the corresponding learning activities, the students were asked to comment on the available list, to mention any difficulties they had in using the pre-determined set of the communication acts as well as to propose any missing keywords-expressions.

The analysis of the students’ dialogue as well as their comments revealed that the available set fulfilled their needs and supported adequately the duties of each role. The only revision that we made concerned the communication act “Comments” which was replaced by the “Comments for the activity” and the “Social Comments” in order to distinguish these two types of comments.

Determining the “communication-scaffolding” tools and the adaptation framework

From the empirical studies, we drew implications about the form of the dialogue supported and the form/adaptivity of the “communication-scaffolding” tools provided in the context of the ACT tool. As far as the form of the dialogue is concerned, we agree with many researchers notion (Dimitracopoulou & Petrou 2003; Soller 2001) that the fully/semi-structured form can promote reflection, improve shared understanding and collaborative argumentation, and increase task-oriented behavior/decrease off-task behavior. More specifically, the fully/semi-structured form of the dialogue guides/supports the students appropriately with respect to the skills that the learning activities or the model of collaboration aim to cultivate. Also, the fully/semi-structured form of the dialogue enables the automatic tracking of interactions without having to rely on natural languages parsers and facilitates the development of effective monitoring and intervention/scaffolding mechanisms.

To this end, in the development of the ACT tool, we followed the semi-structured form of the dialogue in order (i) to guide/support the students towards sharing their understanding, clarifying their meanings, reasoning their answers, organizing their ideas, etc, (ii) to eliminate the off-task discussions, (iii) to enable the automatic interpretation of the students’ interaction as well as the tracing of the dialogue states, and (iv) to facilitate the assessment process in terms of the expected learning outcomes. Regarding the “communication-scaffolding” tools, we support the sentence openers for the first three levels of cognitive skills as they are more

concrete and can be identified and assessed more easily, while in the case of the Creation level and in the case a model of collaboration is followed, the communication acts are considered more appropriate, since for higher order cognitive skills, it suffices to guide/assess the students in terms of their intention/action.

As it is considered important to provide the widest and most appropriate range of sentence openers and/or communication acts (Soller 2001), and to constrain the students' thinking in the desired directions, we support the students with the most meaningful and complete set of the sentence openers and the communication acts. The provided sets were developed taking into account the results from the aforementioned empirical studies and the subjects' feedback and comments. The supported categories of the sentence openers/communication acts include Proposal (P), Question (Q), Reasoning (R), Clarification (C), Motivation (M), Agreement (A), Disagreement (D), Need (N), Opinion (O), and Social Comments (S).

In ACT, a message is composed of one or more of the following building blocks: (i) a sentence opener (a pre-defined phrase) or a communication act (a pre-defined intention/action), which facilitates the automatic interpretation of the students' interaction, (ii) a reference, to an already sent message, and (iii) a free text, which is not interpretable by the system. The combination of a sentence opener/communication act with a free text serves two design goals. On the one hand it supports/guides the students' interaction and on the other allows the students to verbalize and express further their thoughts/ideas.

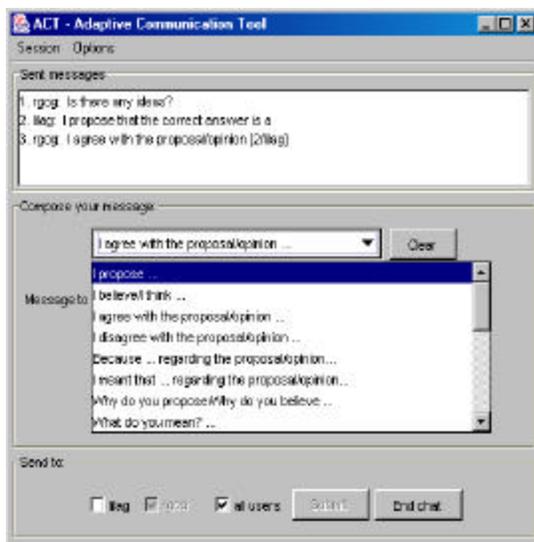


Figure 1: The set of the sentence openers used in cases of learning activities addressing cognitive skills of the Comprehension level

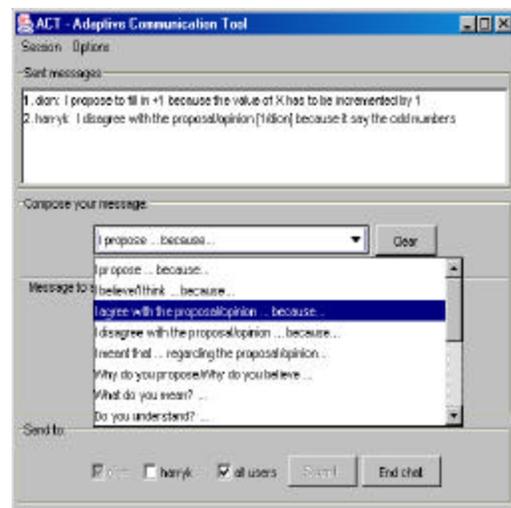


Figure 2: The set of the sentence openers used in cases of learning activities addressing cognitive skills of the Checking-Critiquing level

More specifically, a message composed of sentence openers may have one of the three forms: (i) *Sentence*, or (ii) *Sentence Opener / Argument*, or (iii) *Sentence Opener / Argument 1 / Conjunction / Argument 2*. In the first form, the student just selects a keyword from the available list. In the second and the third form, the student has to fill in the required argument or to make a reference to an already sent message. There are a couple of sentence openers that the student can either select a previous message as an argument or fill in the argument by him/herself. For example, in case of concluding the discussion on a specific question item, the student (the "moderator" of the group) may either select a message from the list as the final answer or s/he may write down the final answer: "We conclude that the final answer is [no of message / sender | text]". The message "Is there any ideas?" presented in Figure 1, corresponds to the first form while the messages "I propose that the correct answer is a" and "I agree with the proposal/opinion [2/lilag]" correspond to the second form. The message "I disagree with the proposal/opinion [1/dion] because it says the odd numbers" of Figure 2 corresponds to the third form; Argument1 is a reference message while Argument2 is a typed in message.

In case that communication acts are used, a message may have one of the two forms: (i) *Communication act / Argument*, or (ii) *Communication act / no of message / sender / Argument*. In both forms, the student has to fill in the requested argument by typing the desired text or by selecting an already sent

message in order to make a reference and afterwards typing the accompanied text. There are a couple of communication acts that the student can either select a previous message as an argument or fill in the argument. For example, in case of concluding the discussion on a specific question item or in case of agreement to a proposal, the student may either select a message from the list as the final answer/the reference proposal or s/he may write down the final answer/the agreement argument. Figure 4 depicts a short discussion between two students exchanging messages through communication acts and playing different roles. The student with the username vang, posed a Question concerning an already sent message (i.e. message 1).

The set of the provided “communication-scaffolding” tools is adapted appropriately on the basis of (i) the level of the cognitive skills addressed by the collaborative learning activity, (ii) the educational tool used for the elaboration of the activity, or (iii) the specific roles that the students undertake in the context of a specific model of collaboration. According to the adaptation framework, the sentence openers are aligned with the level of the expected cognitive skills (i.e. Comprehension, Application and Checking-Critiquing level) and the educational tool used, while the communication acts are aligned with the Creation level of the cognitive skills and the specific role that each student undertake in the context of a collaborative learning activity. Also, the communication acts are used to support the students’ dialogue in case learning activities do not explicitly address one out of the four aforementioned levels of cognitive skills, but they rather aim to cultivate to the students skills in communication, and/or to enable them to discuss/exchange ideas on a specific topic, or on the subject/solution of an activity. Figure 1 and Figure 2 depict a part of the provided set of the sentence openers in case the addressed cognitive skills correspond to the Comprehension and the Checking-Critiquing level respectively. The two sets differ in the sentence openers that are explicitly related to the addressed cognitive skills (i.e. the sentence openers devoted to the Checking-Critiquing level promote the cultivation of the reasoning skills by urging the students to fill in the argument of the “because” part) while they are the same as far as the sentence openers related to the development of the communication skills are concerned. Figure 3 and 4 present a part of the communication acts in case the “Driver-Observer” collaboration model is followed. The “Driver” has at his/her disposal all the necessary keywords for making proposals (“Proposal”), justifying his/her actions (“Reasoning”), etc, while the “Observer” has at his/her disposal communication acts for posing questions (“Question”), expressing his/her opinion (“Opinion”), etc. Moreover, there are sentence openers/communication acts that are available only to the “moderator” of the group.

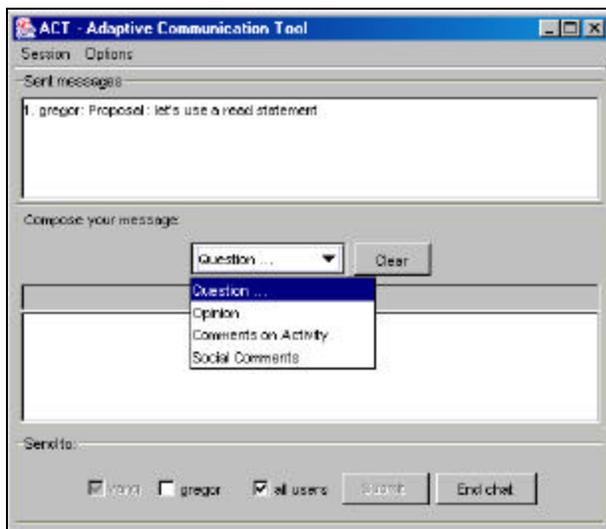


Figure 3: The set of the Communication acts available to the “Observer”

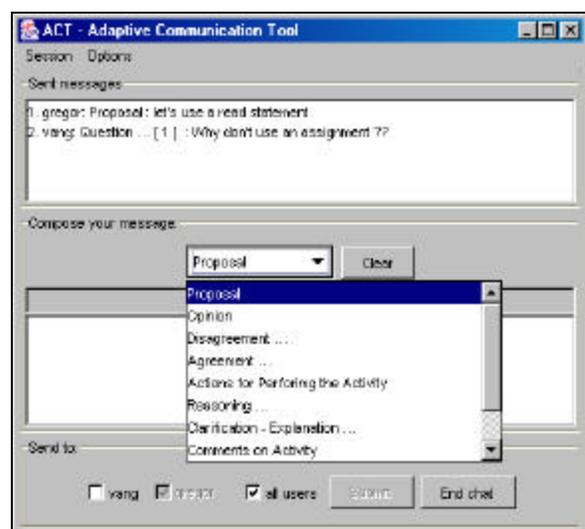


Figure 4: The set of the Communication acts available to the “Driver”

Conclusions and Future Plans

The “communication-scaffolding” tools that are used in the ACT tool are adapted according to (i) the

cognitive and communication skills that the collaborative learning activities or the model of collaboration aim to develop/cultivate to the students or (ii) the educational tool used for performing the activity. The three empirical studies that were conducted revealed that the sentence openers can serve effectively the development/cultivation of cognitive skills of the Comprehension, Application and Checking-Critiquing level while the communication acts are more appropriate for higher order cognitive skills regarding the Creation level of the learning outcomes as well as the support of the students' dialogue in the context of learning activities that aim to cultivate to the students skills in communication, and/or to enable them to discuss/exchange ideas on a specific topic. Also, the communication acts fulfill and support adequately the needs of various roles that each student may undertake in case a model of collaboration is followed during the elaboration of the activity. Taking into account the results of the studies, we determined, revised and enriched the set of the sentence openers and the communication acts making available all the necessary keywords-expressions for the cultivation of the desired cognitive and communication skills. In the near future, we plan to carry out a series of experiments in order to evaluate and revise appropriately these sets in the context of the ACT tool as well as to investigate the possibility of determining activity-specific "communication-scaffolding" tools.

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