# Supporting and Guiding Learners' Collaboration through a Structured Adaptive Communication Tool

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**Abstract.** This paper presents a web-based synchronous adaptive communication tool, referred to as ACT, which supports and guides learners' communication/collaboration by adopting the structured form of the dialogue and utilizing as "communication-scaffolding" tools both sentence openers and communication acts. The ACT tool adapts the provided set of the "communication-scaffolding" tools according to the cognitive skills addressed by the learning activity, the model of collaboration followed by the group members and the educational tool used for the elaboration of the activity. During their communication, learners have the possibility to enrich the predefined sets of the "communication-scaffolding" tools, to connect their messages with other already sent messages, to monitor their debate in a visual graphical representation form through the Dialogue Tree and to reflect on their communication/collaboration by accessing the results of the quantitative analysis of their contributions. The first empirical results are encouraging regarding the provided facilities.

## Introduction

Peer interaction is acknowledged as a significant factor in collaborative learning. However, there is no guarantee that learners have the expected productive interaction skills such as providing explanations, asking questions, and engaging in argumentative discussions (Lazonder et al. 2003). Moreover, especially in web-based collaborative settings, learners may have difficulties in communicating effectively due to their different experience with the supported communication media, to insufficient means in having a clear view of the contextual structure of the dialogue, etc. To this end, suitable instructional measures should be established in order to support learners during the collaborative learning process (Hron & Friedrich, 2003). Regarding the communication media, an instructional measure, which is usually followed and seems to be beneficial, is the structure of the dialogue; the dialogue may follow a (fully or semi) structured form implemented through communication interfaces, which contain predefined message scripts (i.e. sentence openers and/or communications acts) for the construction of the messages. The sentence openers are predefined phrases to start a contribution (e.g. "I propose to", "I agree with"), while the communication acts denote learners' intention/action accompanied by additional text to complete their thoughts (e.g. "Proposal", "Agreement").

A number of communication tools (synchronous or asynchronous) have been developed (either integrated in a CSCL (Computer Supported Collaborative Learning) environment or as standalone tools) to support the dialogue through a structured communication interface. In BetterBlether (Robertson et al. 1998), the communication interface consists of sentence openers, which support the skills of good communication, trust, leadership and creative conflict. In DEGREE (Barros & Verdejo, 2000), which is an asynchronous newsgroup-style system, learners have to select the type of their contribution (i.e. the communication act) such as proposal, question or comment, from a provided list. ALEX (Hirsch et al. 2004) is a structured dialogue tool, which enables learners to make arguments by selecting and completing partial sentences (sentence openers) while the Co-Lab tool (Lazonder et al. 2003) supports both the free-text and the structured dialogue. The results from studies in the context of such communication tools, revealed that the structured dialogue supports and increases participants' task-oriented behavior, leads to more coherence in discussing argumentatively the subject matter, promotes reflective interaction, lightens learners' typing load, guides the sequence and the content of the dialogue, enables the monitoring and the interpretation of the ongoing discussion and is characterized as an adequate pedagogical approach for virtual learning groups (Baker & Lund, 1997; Soller et al. 1999; Hron et al. 2000). However, the potential improper use of sentence openers/communication acts (e.g. the learners may use the sentence opener "I

think" in cases they wish to make a proposal or to elaborate on a point of view although sentence openers like "I propose", "To elaborate" may be available) and the restriction of using words imposed by the structured dialogue (i.e. the provided set of sentence openers can not fulfill all of the learners' expressions) are two disadvantages that should to be taken into account during the development of synchronous communication tools (Lazonder et al. 2003).

The work, presented in this paper, takes previous work in structuring the dialogue through a communication interface one step further. We developed a synchronous communication tool with adaptive capabilities referred to as ACT (Adaptive Communication Tool) aiming to guide and support learners appropriately during their dialogue. The ACT tool uses both the sentence openers and the communication acts as "communication-scaffolding" tools and adapts the provided set of the tools according to the cognitive skills addressed by the collaborative learning activity, the model of collaboration followed by the group members, as well as the educational tool used for the elaboration of the activity. Also, the tool enables learners to enrich the provided set of the "communication-scaffolding" tools with their own preferred sentence openers/communication acts. The learners can follow the dialogue progress and reflect on their communication/collaboration by accessing the Dialogue Tree as well as the results of the quantitative analysis of their contributions at any time during the elaboration of the activity. The first empirical results are encouraging regarding the provided facilities, i.e. the enrichment of the provided set of the "communication-scaffolding" tools, the possibility to connect the messages with other already sent messages and the monitoring of the debate through the Dialogue Tree.

The rest of the paper is structured as follows. In the following section, we present in detail the functionality of the ACT tool in terms of the "communication-scaffolding" tools used, the adaptive capabilities supported, and the facilities provided to learners. Afterwards, we discuss some results from a preliminary study that we conducted. The paper ends with the main points of our work and our near future plans.


## The ACT Tool

The ACT tool was developed in the context of the web-based adaptive collaborative learning environment, referred to as SCALE (Supporting Collaboration and Adaptation in a Learning Environment) (Grigoriadou et al. 2004), which follows the conceptual framework of the Activity Theory (Engeström, 1987; Cole & Engeström, 1993) and supports the individualized learning, the collaborative learning and the assessment process. Besides the SCALE environment, the ACT tool can run as a standalone synchronous communication tool. During the elaboration of a collaborative learning activity, learners communicate synchronously in groups of up to four members following a specific model of collaboration; they may collaborate either having the same duties or undertaking different roles aiming to cultivate specific cognitive and communication skills. In any case, one of the group members plays the role of the moderator, being responsible for the coordination of the group process (e.g. proceed to the next question, terminate the communication session), the summarization of the debate and the submission of the final answer.

As the ACT tool aims to guide and support learners appropriately during their debate, we followed the structured form of the dialogue, in order to (i) eliminate the off-task discussions, (ii) guide learners towards the underlying learning outcomes (i.e. cognitive skills) of the learning activity or the duties and responsibilities implied by the model of collaboration, (iii) facilitate the assessment process in terms of the expected learning outcomes, and (iv) enable the automatic interpretation of learners' interaction as well as the tracing of the dialogue states (Baker & Lund, 1997; Hron & Friedrich, 2003). ACT has a number of features, which are discussed below.

### The Interface of the ACT Tool

The ACT tool enables learners to communicate in the context of a specific collaborative learning activity. Once all the group members are logged in, the tool enters into the communication mode where learners can use the available "communication-scaffolding" tools to collaborate/communicate. In case some members are not logged in, the tool enters into the wait mode, showing which members of the group are already connected. Figure 1 presents the main screen of the ACT tool as it appears at the communication mode. It consists of the following areas:

- The *Dialogue Area*, which shows the debate that has taken place. The messages are recorded, numbered and presented in a chronologically sent order. Each dialogue message has the form: [message_number] [sender]: [message composed by the sender].

- The *Message Composition Area*, which enables learners to construct the message on the basis of the "communication-scaffolding" tool, which is provided (an analytical description of the message composition process is given in the subsection entitled "Constructing a Message with ACT").
- The *Message Submission Area*, which enables learners to submit the message to all or to selected members of the group.

Upon the completion of the collaboration in the context of a specific activity, learners may proceed to the elaboration of another subactivity or to terminate the communication session and exit the tool.
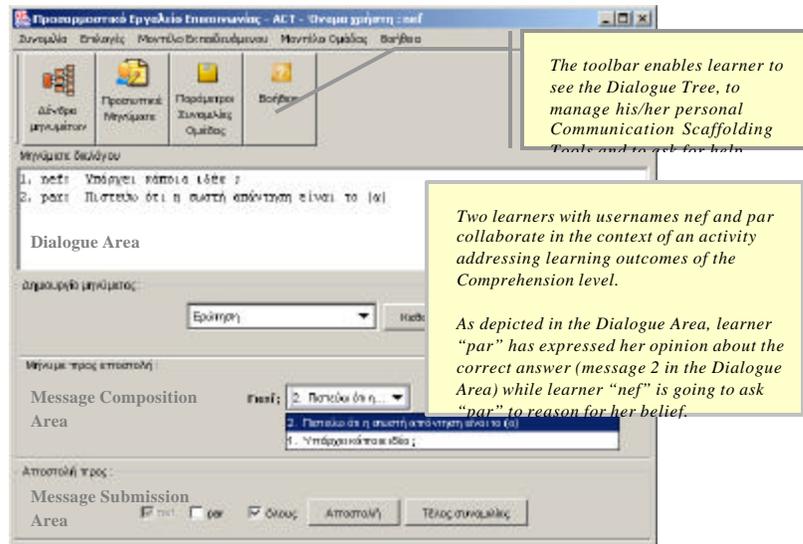


**Figure 1:** A screen shot of the ACT tool at the communication mode

## The Supported "Communication-Scaffolding" Tools

In ACT, the structured form of the dialogue is supported utilizing as "communication-scaffolding" tools both sentence openers and communication acts. For the determination of the most appropriate sets of the "communication-scaffolding" tools , we followed a research-based approach and we conducted three empirical studies during the design phase of the tool (Gogoulou et al. 2004). Based on the results revealed from the studies, the feedback received from the participants and the experience of the authors, we determined the sentence openers and the communication acts which are categorized to one or more of the following *discourse categories*: Proposal (P), Opinion (O), Question (Q), Reasoning (R), Clarification (C), Agreement (A), Disagreement (D), Inference (I), Motivation (M), Need (N) and Social Comments (S). The provided sets of sentence openers as well as communication acts include:

(i) a subset dedicated to the development of the cognitive skills addressed by the collaborative activity (e.g. the sentence openers: "I propose" , "I agree with"; the communication acts: "Proposal", "Agreement").

(ii) a subset facilitating the communication/collaboration (e.g. the sentence openers: "I don't understand. Can you help me?", "I need some time to think"; the communication acts: "Social Comments", "Comments about the activity"), and

(iii) a subset available only to the moderator of the group concerning cognitive skills as well as facilitation of the communication/collaboration (e.g. the sentence openers: "We conclude that", "Let's move on to the next question"; the communication acts "Final answer", "Group Coordination").

## Constructing a Message with ACT

In the Message Composition Area of the ACT tool, learner has access to the supported list of the sentence openers (or the communication acts) and can construct the desired message by filling in the required arguments depending on the sentence opener (or communication act) template. Table 1 presents the available templates for sentence openers and communication acts as well as a description of the template and indicative examples (some of the examples are depicted in Figure 1). In case the argument part of the message is a reference message, the learner can select the desired one from a pulldown list appearing next to the corresponding sentence opener/communication act in the Message Composition Area (Figure ). The sentence openers and the communication acts, which are available to the moderator of the group, enable him/her to fill in the argument by him/herself or to select a previous message as an argument. For example, in the case of concluding the discussion, the learner may either select a message from the list as the final answer or s/he may write down the final answer.

Besides the predefined sets of sentence openers/communication acts, the learner may define his/her own ones if the available ones do not cover his/her needs. The learner's defined sentence openers/communication acts are part of the learner's model and become available each time the learner uses ACT. For each additional sentence opener/communication act, the learner defines the text to be displayed, the accompanied arguments and the discourse category (e.g. Proposal (P), Question (Q)). At any time, the learner may add a new sentence opener/communication act or edit his/her set and proceed to any modifications (e.g. change the text) and/or deletions (i.e. delete one of his/her own defined sentence openers/communication acts).

| Template | Description | Example |
|---|---|---|
| **Sentence Openers** | | |
| [Sentence] | The sentence opener text | • *Very good idea*<br>• *I don't understand. Can you help me?* |
| [Sentence Opener][Argument] | The sentence opener text plus an argument which may be | |
| | (i) an explicit reference to an already sent message appearing on the Dialogue Area | *Why do you believe* [2/par]<br>where "2" is the message number of an already sent message, which has been sent by the learner "par" |
| | (ii) filled in by the learner<br>(iii) both a reference message and a filled in text | *I believe* the correct answer is (a)<br>*I agree with* [2/par] as far as the second part of the answer is concerned<br><br>where the filled in text "as far as the second part of the answer is concerned" explains further the learner's belief |
| [*Sentence Opener*] [Argument1] [*Conjuction*][Argument2] | The [*Sentence Opener*] and the [*Conjuction*] parts are sentence texts while [Argument1] and [Argument2] may be an explicit reference to an already sent message appearing on the Dialogue Area or may be filled in by the learner | *Because* the number has to be greater than 0 – *argument for* [3/nef]<br><br>where the first argument has been filled in by the learner while the second one is a reference message |
| **Communication Acts** | | |
| [Communication Act] [Argument] | The communication act text plus an argument which is filled in by the learner | *Proposal:* lets look at the diagram first |
| [Communication Act] [Reference to a message] [Argument] | The communication act text plus a reference to an already sent message appearing on the Dialogue Area plus an argument, which is filled in by the learner | *Clarification* [15/nef]*:* By "st", I mean the total number of students |

**Table 1:** The templates supported for sentence openers and communication acts. Italics denote the corresponding sentence opener text or communication act text, [X/Y] refers to the X message sent by Y.

**Adapting the "Communication-scaffolding" Tools**

According to the Activity Theory, the object of the learning activity, the mediational tools used, the rules and the division of labour followed by the subjects constitute essential elements of the conceptual framework (Engeström, 1987; Cole & Engeström, 1993). In ACT, the object of the learning activity is closely related to the expected learning outcomes, the mediational tools involve any tool that may be used during the elaboration of the activity (e.g. educational software), the rules include the supported "communication-scaffolding" tools and the division of labour depends on the model of collaboration followed. Taking into account these elements and having as an objective to support learners' communication/collaboration, to prevent floundering and guide their thinking towards the desired directions, we adapt the provided "communication-scaffolding" tools on the basis of (i) the level of the learning outcomes (i.e. cognitive skills) addressed by the collaborative learning activity, (ii) the specific roles that learners undertake in the context of a specific model of collaboration, and (iii) the educational tool, if any, used for the elaboration of the activity.

Based on the adaptation framework, sentence openers are aligned with the level of the expected learning outcomes (cognitive skills) of the Comprehension (Remember + Understand), the Application (Apply) and the Checking-Critiquing (Evaluate) level, while communication acts are aligned with the Creation (Analyze + Create) level of the cognitive skills (for more details about the levels of the cognitive skills see Gogoulou et al. 2004). Moreover, communication acts are aligned with the role that each learner undertakes in the context of the collaborative learning activity when specific models of collaboration are followed. Also, communication acts are used to support learners' dialogue in case learning activities do not explicitly address one out of the four levels of cognitive skills, but they rather aim to enable learners to discuss/exchange ideas on a specific topic or on the subject/solution of an activity. The communication acts are considered more appropriate for higher order cognitive skills, addressed by the learning activity or the model of collaboration, since it suffices to guide/assess learners in terms of their intention/action. We verified and finalized the above design principles of the adaptation framework by the results of the three empirical studies we conducted (Gogoulou et al. 2004).

The adaptation framework follows a three-level approach:

- 1st Level: At the 1st level, the adaptation mechanism checks if the group members are going to undertake specific roles during the elaboration of the activity/subactivity or to collaborate having the same duties. In the first case, communication acts are used as "communication-scaffolding" tool while in the second case the adaptation mechanism proceeds to the 2nd level in order to check for the level of the learning outcomes.
- 2nd Level: This level takes as input and checks the level of the learning outcomes. In case the level coincides with one of the Comprehension, Checking-Critiquing or Application level, then the dialogue is carried out with sentence openers otherwise with communication acts.
- 3rd Level: Once the "communication-scaffolding" tool, which is going to be used, has been specified, the appropriate sets need to be selected (e.g. the subset of the sentence openers dedicated to the development of cognitive skills of the Comprehension level is different from the one provided for the Checking-Critiquing level). At this level, the educational tool is also taken into account, as there are sentence openers/communication acts, which are dependent on the educational tool (e.g. when a concept mapping tool is used, sentence openers like "*I propose to link* [concept] *to* [concept]", "*Do you agree with the proposition* [concept-link-concept]?" are available).

All the group members have at their disposal the same set of sentence openers/communication acts if they collaborate having the same duties, otherwise the communication acts are adapted to each member according to his/her role (e.g. in case of the "Driver-Observer" model, communication acts like "Proposal", "Clarification", "Justification" are available to the "Driver" while communication acts like "Question", "Comments" are available to the "Observer"). In any case, the moderator of the group uses additional sentence openers/communication acts compatible to his/her additional duties.

**Monitoring the Dialogue**

In assessing learners' interaction and subsequently their collaboration, the CSCL environments offer mechanisms to automatically trace learners' actions and/or their dialogue. Usually, the data are recorded into log files and may be further analyzed in terms of high-level indicators (Mühlenbrock & Hoppe, 1999; Jermann et al.

2001). According to Jermann et al. (2001), CSCL environments may gather data about learners' interaction and show this information to them in a visualization form or process the data and coach/guide their interaction.

In the context of the ACT tool, learners' interaction is recorded into log files, which are accessible, by the tutor. Moreover, since we are interested in assessing learners' communication in terms of the skills addressed by the collaborative activity or the collaboration model, we keep records of learners' messages as these are classified to the aforementioned discourse categories (e.g. Proposal (P), Question (Q)) and proceed to their quantitative analysis. The data resulted from the analysis are part of the learner model and the group model and are accessible both to learners and tutor. The learner model keeps data about the contributions of the specific learner while the group model keeps data about the contributions of the whole group. The learners may access these data at any time during the communication/collaboration and in this way have an insight into their own contributions and their collocutors' contributions.

As learners' communication is carried out, the ACT tool automatically constructs and updates the Dialogue Tree. The messages are visually represented in a tree structure and grouped into sub-trees according to
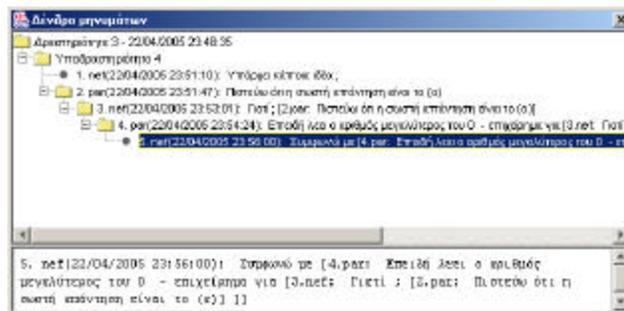


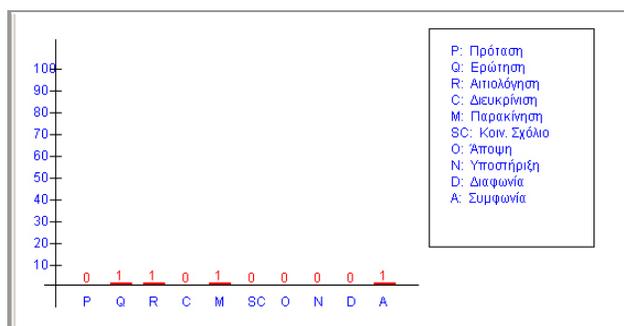**Figure 2:** The Dialogue Tree represents learners' debate in a graphical form



**Figure 3.** The visualization of the contributions of learner with username "nef" classified according to the discourse categories of the underlying sentence openers. The learner "nef" has so far asked for a reason (Q & R), agreed to her collocutor's opinion (A) and has attempted to motivate her collocutor to express her ideas (M).

the reference message. Learners can have access to the Dialogue Tree at any time during the communication/collaboration. The main advantage of such a graphical representation of the dialogue is that learners can see the dialogue in a different form, can trace the sequence of the dialogue more easily and can have a clear view of the dialogue progress. Also, the Dialogue Tree as well as the visualization of learners' contributions can stimulate them to reflect on their dialogue and improve their participation. In Figure 2, a screen shot of a dialogue tree is presented, while in Figure 3, a visualization of the contributions of learner "nef" is presented corresponding to the messages of the Dialogue Tree of Figure 2.

## Results from the Formative Evaluation of ACT

In the context of a formative evaluation of the ACT tool, an empirical study was conducted at the Department of Informatics and Telecommunications of the University of Athens. Thirty students, who attended the postgraduate course of "Distance Education and Learning", participated in the study, coming from a range of backgrounds and having different expertise in the use of communication media. The duration of the study was 4 hours. The participants were grouped into two-member (9 groups) and three-member (4 groups) teams, while one of the members undertook the role of the moderator. During the study, the learners had to accomplish four collaborative activities; for the first three activities, the learners of each group had the same duties and acted equivalently while in the context of the fourth activity, specific models of collaboration were followed (i.e. the "Questioner-Responder" model for the two-member teams and the "Questioner-Responder-Assessor" model for the three-member teams). Also, for the first two activities the sentence openers were used while for the last two, the learners communicated via the communication acts.

Regarding the usefulness and the appropriateness of the provided facilities, the analysis of the learners' responses on the questions accompanied each collaborative learning activity and the questionnaire given at the end of the study showed that

- a considerable number of learners (76%) found the facility of connecting a message with an already sent message useful since it reduces the typing load and facilitates the tracing of the contextual structure of the dialogue. However, 24% of the learners characterized the specific facility as indifferent because they believe that the complexity of the composition message process is increased.
- the majority of the learners (83%) considered the capability of the ACT tool to group messages into sub-tress and to represent the dialogue in a visual graphical form (Dialogue Tree) very useful because it enables them to monitor the dialogue in an organized and enjoyable manner, to evaluate the collaboration process more easily and to proceed to interventions in order to improve their participation. However, a number of learners (17%) mentioned that there was no need to consult the Dialogue Tree during the elaboration of the activities.
- most of the learners (66%) characterized the facility of enriching the predefined sets of sentence openers and communication acts with their own phrases useful. Approximately, 50% of the learners took advantage of the specific facility during the elaboration of the activities, defining one or two phrases.

Although the above results are preliminary, the facility of enriching the predefined sets of the communication acts/sentence openers with the learner's ones, gives a degree of freedom to learners. The visual representation of the Dialogue Tree supports the monitoring of the dialogue and learners claim that serves as a means to reflect on the collaboration process and to self-regulate their communication/collaboration.

## Conclusions and Future Plans

In this paper, we presented ACT, a synchronous adaptive communication tool, which supports the structured form of the dialogue. The discriminative characteristics of the ACT tool are: (i) the use of both sentence openers and communication acts as "communication-scaffolding" tools, (ii) the adaptation of the provided sets of the "communication-scaffolding" tools according to the learning outcomes addressed by the collaborative learning activity, the model of collaboration followed by the group members, and the educational tool used for the elaboration of the activity, (iii) the capability of alleviating the possible restriction of learners, imposed by the structured form of the dialogue, by enabling learners to define their own "communication-scaffolding" tools and enrich the provided sets, (iv) the capability of connecting a new message to other already sent messages, and (v) the monitoring of the group dialogue and its graphical representation through the Dialogue Tree. Towards the direction of supporting and guiding learners, we plan to develop and extend the monitoring and guiding mechanisms with a number of collaboration indicators and an intervention framework in order to analyse learners collaboration and support them in the regulation process.

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