# ISSA Proceedings 2002 – A Collaborative Model Of Argumentation In Dyadic Problem-Solving Interactions


*1. Introduction*

Within a cognitive approach to argumentation, our research deals with the argumentative processes of knowledge co-construction in dialogue (Baker, 1999). From this point of view we have been designing experimental situations favouring argumentation in dyadic problem-solving (Quignard & Baker, 1998; Baker, Quignard, Lund & van Amelsvoort, *this volume*) over several years, in order to understand the roles of argumentation in the resolution of conceptual problems (Baker, 1998; Baker, Brixhe & Quignard, 2002). Whereas our previous research focussed on socio-cognitive conditions promoting emergence of argumentation between learners (Quignard, 1999 from a previous work of Golder, 1996), in this paper we address the problem of analysing the argumentation processes carried out in problem-solving dialogues and the interactional phenomena by which knowledge is collaboratively elaborated. On one hand, our cognitive approach to argumentation is naturally very closely related to pragmatics studies of dialogue, which aim to describe or analyse the relationships between the use of language and its social or contextual implications in concrete situations. On the other hand, the phenomenon we want to explain – argumentation – has been very well described in normative models of dialectics, which give quite solid bases for defining the limits of argumentation phases, their genuine moves and schemes (attacks and defences) and their rules. The proof of the consistency of such dialectical systems (see fore example Barth & Krabbe, 1982) is another argument in favour of their universal domain of application. These two very different approaches to argumentation are not necessarily to be opposed when the pragmatic foundations of the logic of these systems can be defined with some degree of formality (see for example Quignard & Baker, 1997). Recent developments in pragma-dialectics (van Eemeren & Grootendorst, 1992) have shown the efficiency of this

combination, being both a normative and descriptive method for understanding argumentative discourse (van Eemeren *et al*., 1993) or designing argumentation situations, even for the purposes of learning (see Jackson, 1998).

In fact, – and without playing on words – the previous models of argumentation meet their limits when dialogue is not yet or no longer argumentative. In other terms, when argumentation is too much considered as a verbal activity *per se* (with its own rules and own moves) there are some difficulties in taking into account cognitive continuum underlying the dialogue, for example rational commitments or problem-solving goals. Krabbe (1988) in an answer to Lorenz (Ibid.) stated that argumentative commitments can obtain in non-argumentative phases (e.g. theses), and thus some argumentative rules could prevail outside argumentative phases. In a later paper with Walton (1995), he tried to provide a logical framework for keeping trace of commitments across different dialogue phases, but that approach cannot be considered as a cognitive model. Another difficulty concerns the definition of a set of argumentative moves for the sake of describing argumentation processes. These moves cannot relate to the general process of dialogue, since they concentrate on purely argumentative objects of discourse: theses and arguments. Therefore, argumentation is disconnected from the pragmatic context of the dialogue from which it emerged, like a dialectical game interrupting a collaborative action. In fact, collaborative action (or the general goal of the dialogue) underlies the argumentation, and may change at any time (for example a conflict dissolution because they need to carry on to another topic). Nevertheless, it is clear that providing two separate sets of speech acts for analysing both parallel processes independently (argumentation and general dialogue) is not a satisfactory solution either since at least for cognitive reasons, these processes are very much linked with each other.

Therefore, a solution would be to derive argumentation moves from general dialogue categories, allowing a unique cognitive action to achieve several functions at a time. The multi-functionality of utterances has been already used in many cases to explain the quantity of things one can do with so few words. Authors like Allwood (1995) or Bunt (1994) have used it to distinguish task-oriented speech acts to dialogue control ones (for interaction management). Our main idea is based on the very pragmatic conception of dialogue from Morris or Clark, who considered dialogue as a verbal problem-solving activity (people use language for collaborating with respect to a given problem). The key point for our

concern is to consider argumentation as a specific case of problem-solving, where the problem is the "conflict of avowed opinions" (Barth & Krabbe, op. cit.).

In this framework, three basic and independent components (universe of reference, interlocutory orientation and critical thinking operation) are necessary for identifying the problem-solving functions of utterances, i.e. the way the locutor intends the problem situation to be transformed or improved. Two supplementary components are required to describe the dialectical function of the same utterance: the proponent of the thesis and the argumentative polarity of the argument. Since the independence of these components can be shown, a systematic classification of dialectical functions of utterances can be elaborated, giving rise to eighteen mutually exclusive categories covering the classical dialectical moves and other argumentation moves that contribute to conflict resolution in a non-orthodox manner (such as clarification or ratification moves in dialectics).

This systematic decomposition of argumentation moves provides a powerful analytic method since the identification of five independent criteria allows us to choose within the large set of the resulting categories. Another benefit of such a method is to provide a schematic representation of dialogical argumentation, that can be used either by participants to externalise and reflect on their opinions or to analyse argumentative activities (dialogues or texts).

In the following sections we present our collaborative model of argumentation in problem-solving dialogues and its graphical extension. We illustrate the theoretical and the graphical model by extracts from corpus of argumentative interactions between students. Finally we provides some critiques of these models and suggest some improvement for further research.

### *2. A Collaborative Model of Argumentation in Dyadic Problem-Solving Interactions*

Our model for analysing argumentation follows the pragmatic and collaborative view of language, whose function is to coordinate actions and cognitions of participants for solving a common problem (Clark & Schaefer, 1989). We postulate that a problem is always at the origin of a dialogue even if it is not explicitly defined. The dialogic activity is thus oriented toward the realisation of a certain goal, which can be a concrete, practical result or a pure social or even phatic role. With respect to this conception of dialogue, speech acts are by

definition the basic actions that take part to the resolution of this particular problem, and thus cannot be intrinsically defined inside language**(i)**.

Analysing dialogues consists thus in the identification of problem-solving functions of utterances, i.e. the manner each utterance contributes to the resolution of the various problems met along the dialogue**(ii)**. These problems can be of course the original problem that triggered the interaction and its correlated questions, but also dialogal, interactional problems irrupting in conversation (perception, turn management, time management, understanding difficulties), due to the dialogue activity itself (see the feedback functions of Allwood, 1995, or dialogue control from Bunt's work, 1994). In this framework, utterances are already multi-functional since they can contribute at any time to the main problem (we call it *dialogic*) and to the control of *dialogue* (we call such problems dialogal). These basic functions are analysed according to the following criteria:

– *Universe of reference*: this first criteron denotes the problem the utterance focuses on and can be further developed when we specify which particular aspect of the problem the participant would like to address. If the universe of reference is the problem-solving task (a learning exercise), we can identify whether the participants focuses on a particular solution, a rule, a notion, etc. For dialogal problems, we can specify whether the utterance concerns the dialogue structure (opening, topic management, closing), mutual understanding, time or turn management, etc.
– *Critical thinking operation*: this criterion defines the cognitive action expected by the speaker to locally improve the problematic situation. We distinguish two kinds of operations: evaluations (axiological contributions) whose function is to judge, appreciate or evaluate a situation or a particular point of the problem (EVAL) and explicitation (epistemic contributions) which transforms the state of knowledge by some conceptual operations such as explanation, reformulation, inference…
– *Interlocutory orientation*: in the utterance, the speaker expects one particular participant to perform the cognitive action on the problem. Speakers set their contribution in the interlocutory space of the interaction. The expected *agent* can be speakers themselves in a case of a direct contribution or other participants if they request someone else to do it.

Each utterance is then analysed at least on the basis of what problem(s) is (are) to be solved, by whom and by which cognitive operation(s). Each triplet of

<referent, critical thinking operation, interlocutory orientation> defines one problem-solving function, allowing a single utterance to be multifunctional. This framework may be easily developed to make the analysis more accurate, depending on which particular aspect of dialogue the analyst is interested in.

In the framework of an argumentative phase, – that is in a dialectical sense a situation in the dialogue where someone is defending one of his/her previous statements -, all statements automatically refer to theses. The argumentative problem is thus a "conflict" to be solved, or at least an agreement to be reached with respect to one or several theses. Argumentation is thus to be analysed as a particular case of dialogal problem solving (the highest stage of Allwood's model of communication: determine attitudes towards an agreement). Universe of reference in argumentation is thus composed of the conflicting theses that we identify by their *proponents* (my thesis, MT, or your thesis, YT). Another criterion is also needed to understand the argumentative function of utterances: the *argumentative orientation* of the contribution in favour (PRO) or not (CONTRA) with respect to the thesis. We retain the typology of critical thinking operations (evaluations and elicitation) even if they are called differently in an argumentative context: evaluations have functions of *taking dialectical positions* (TDP) and explicitations of *providing arguments* (ARG).

The combination of these 4 independent criteria gives rise to a large set of 18 dialectical functions, listed and explained in the following table (Table 1). Here are some of them:
– ARG-PRO-MT: the speaker provides an argument in favour of his own thesis
– REQ-ARG-PRO-YT: the speaker asks his opponent to provide an argument in favour of her thesis (ask for justification)
– TDP-CONTRA-MT: this is a case of a retraction of a thesis up to here defended by the speaker
– REQ-TDP-MT: the speaker asks his opponent to take a position with respect to his thesis.

We note that concession is not present in the table. It is actually a conjunction of an argument and a dialectical position with opposing dialectical orientation (for example ARG-CONTRA-MT + TDP-PRO-MT).

The main interest of this classification is to cover the classical categories of dialectical systems and to propose new categories whose function is to clarify the

dialectical situation. Despite these categories are not provided in formal models, they are quite often used in natural dialogues. For example ARG-CONTRA-MT justifies a retraction, REQ-TDP-PRO-MT and REQ-ARG-PRO-MT respectively ask to confirm the acceptation of the opponent's thesis and to justify it…

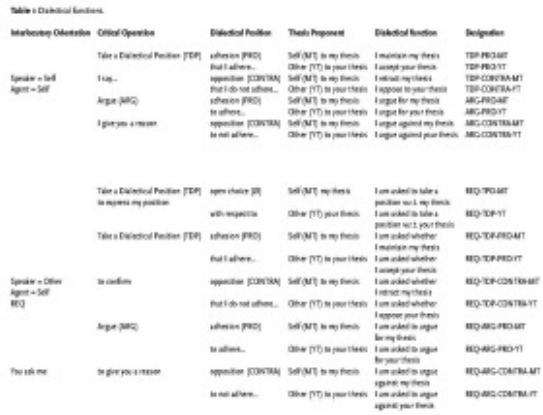


Table 1

Another useful aspect is more practical than theoretical. The systematisation based on the independence of four criteria guarantees the sets of functions will cover all the cases with mutually exclusive categories and provides a practical and powerful method for analysing argumentation, since 4 categorisations are sufficient to identify without any doubt the right category amongst the others.

*3. Corpus sample 1: a chat interaction analysis*

In Table 2 we present the argumentative phase of a problem-solving dialogue between two students. These two 16 years old girls discussed in physics exercise via synchronous typewritten computer-mediated communication (cf. CHAT): modelling energy flows in an electrical circuit composed by a battery and a bulb connected to each other with two wires**(iii)**. The main difficulty of this exercise is to bypass the habitual electrical model and to understand that the electrical work transfers the energy from the battery (initial *reservoir*) to the bulb, which transforms it into light and heat that are transferred to the environment (final *reservoir*). Note how the graphical solution is different from the electrical circuit diagram.

The names of the two students have been changed to preserve anonymity and their dialogue has been translated into English from the original French, without rendering the original orthographic or typographic mistakes (but we kept the capitalised words and most of the punctuation). This dialogue contained an

important closure phase that has not been reported here.

Their dialogue immediately begins with a dialectical phase on a mixed conflict where each participant upholds her thesis (TDP-PRO-MT) against her opponent's thesis (TDP-CONTRA-TT). Anna's argumentation (A5) leads Daisy to retract her thesis (It is "true" that there must be only one transfer) even if she maintains her critique with respect to Daisy's thesis (it would be "logical" to have two wires). In the remainder of the dialogue, Daisy requires the help of Anna to dissipate her doubts (D8) and to be convinced with respect to her solution (D20).

An important episode happens between utterances D10 and A17 when, after the reformulation of her thesis by her opponent (D10), Anna retracts her thesis (AA3) and Daisy asks her to uphold her role of proponent (D14, D16). This reformulation in fact hides a new solution (the correct one), built as a compromise between Anna's solution (one transfer) and Daisy's solution (two wires). But when Anna seems to be convinced by this solution (A17), she comes back to her initial thesis in which there was only the positive wire as a transfer. Daisy asks Anna to take a clear position between her two theses and follows Anna's final choice: the transfer is achieved by the positive wire only.

Table 2

The dialectical analysis shown on the last column of the table shows the dissymmetry of collaboration in this problem-solving and conflict resolution:
1. *Theses (dialectical referents)*: only 4 argumentative moves refer to Daisy's thesis (utterances 2 to 5) whereas 19 referring to Anna's all along the dialogue. The major part of argumentation (8 to 20) is thus organised like a simple conflict where Daisy critiques what Anna proposes.

2. *Interlocutory orientation*: Anna performs only direct contributions. She gets from Daisy the charge to provide answers to Daisy questioning.
3. *Critical thinking operations:* the cognitive activity of the participants is for the essential axiological and rarely epistemic (17 vs. 6). This argumentation is thus very much deliberative and very few arguments have been produced.

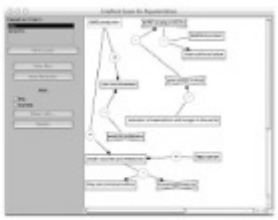
These briefly presented results reveal a quite original form of argumentation that classical models of dialectics would have some difficulties to apprehend. It is a case of a simple conflict won by the proponent whose resolution does not come by the means of convincing arguments but rather *by the expression of a convinced opinion:* Daisy accepted Anna's thesis as soon as the latter seemed to be convinced. The rare arguments provided in the dialogue and even a reformulation leave few opportunities for co-constructing a new solution. The agreement is met on Anna's initial solution by eradication of Daisy's one (too close to the electrical circuit diagram to integrate the constraints of the energetical model).

*4. A Graphical Representation of Dialogical Argumentation*
As argumentation moves can be decomposed into four basic sub-components, we may use the model for providing a graphical language for describing argumentation. Boxes will represent the epistemic part of arguments, directed arrows will make explicit the reference of the argument to the thesis. On this link we put a node with a label for the argumentative orientation (the symbol "+" for PRO and "–" for CONTRA). Attitudes are made manifest by the state of checkboxes situated in the margin of the graphical zone, and are displayed when the corresponding object (box or node) is selected.

This graphical language is recursive: argumentative relations represented by the nodes can be attacked, defended by second-order arguments. There are thus two ways of defeating an argument: either by attacking its backing boxes (undercut) or its node (rebuttal).

Colours are another graphical feature used in this framework for showing which participants are committed to which potential thesis. Each participant has a coloured signature, and every time s/he evaluates a box or a node (either PRO or CONTRA) the border of the object is surrounded with his/her colour. When two opposite attitudes have been expressed, the shape of the object changes to show that a conflict has arisen.

Figure 1 is a screen dump of the implementation of this graphical system in a Java applet, running in the collaborative environment DREW**(iv)**. In this simulated example, two participants (Matthieu in blue and Bill in orange) discuss about the pros and cons of Internet. The main thesis is “Internet is good”. Participants disagree on this thesis as shown by the shape of the box. An argument against Internet is provided, denoted by the negative node: “Big Brother is watching you” (Internet is a means to control users communication and interfere with individual liberties). Both participants agree on this argument because the shape of the node is a circle. It becomes a lozenge when participants disagree. This is the case of the argument “Free speech” that supports Internet (positive node). Bill attacked this argument in its relation to the thesis: free speech is not necessary a good argument for Internet since pornographic messages could not be controlled anymore.



This representation shares this common point with the Toulminian graphical structure of argument (Toulmin, 1958; Suthers & Weiner, 1995) to propose a distributed vision of argument as networked subcomponents. Nevertheless our graphical framework differs radically from the former on two main points:
1. There is no typology of boxes in data, claims, warrants, backings, etc. and therefore no epistemological discrimination between the components of arguments. We are closer to a dialectical representation of argumentation than a representation of reasoning.
2. This is a *dialogical* representation of argumentation, whereas Toulminian graphs are a monological representation of an argumentative discourse structure. Different points of view can be simultaneously represented and related to each other, giving rise to expression of agreements or disagreements.

Two implementations of this system have been carried out, both in Java. One called JigaDREW**(v)** is used as a means of collaboration in the collaborative environment DREW, and thus enable participants to argue through the production of an argumentation graph and the use of other communication modules (a chat for example). Another one can be used as a standalone applet for analysis purpose**(vi)**. The analyst simulates the presence of several protagonists to represent polyphonic aspects of ar*gumentative text or naturally dialogues.*

*5. Corpus sample 2: a graphical argumentative interaction*

The following figure (Figure 2) represents the final stage of a multimodal discussion on the topic "Should we authorise the production of Genetically Modified Organisms (GMOs)?". This example is taken from an experiment carried out in France for the SCALE European project**(vii)**. As before, the graph has been translated from French into English and the names of the participants have been changed. This was the first time that we evaluate this kind of representation in a pedagogical debate activity (see Baker, Quignard, Lund & van Amelsvoort, this volume). One should be aware that this is only a snapshot of a moving graph, interactively modified by the participants.

Evaluating a graph is not an easy thing to do, especially if we neglect the historical process of its generation**(viii)** (that is, argumentation). If we temporarily only look at the boxes omitting the relations between them, we must admit that these two participants succeeded in exploring many parts of the debate: medical developments, ethics questions, food quality issues (taste and nutritive value) and geopolitics issues for GMOs against malnutrition. Participants generally agree on the expressed arguments. They only disagree on food issues and the ability for GMOs to resist to antibiotics. This example shows the interest of such a tool to express ideas (at least) and to elaborate a common ground.

If we take into account the argumentative relationships (arrows and nodes), we have some difficulties to understand the argumentative structure. Of course, one can easily observe that the debate consists in two connected sets of arguments (two subdebates), one on the medical issues and the other on alimentation issues. Participants actually confused argumentative orientation and causality relationship. For example, "GMOs can cure diseases" and "create vaccines" are two arguments in favour of GMOs, thus should have arrows in the opposite direction.

*6. Discussion*

The collaborative model of argumentation in problem-solving dialogue provides an open framework for analysing the role of argumentation in problem-solving dialogues. This model derives from a more general model of dialogue as a collaborative verbal problem solving activity, in which argumentation appears as a specific phase focussed on the resolution of a disagreement. This embedded approach to argumentation enables argumentative utterances to have others functions than argumentative, and to avoid an exclusive/reductive dialectical

analysis of some parts of the dialogue. With the multi-functionality of speech acts, this model thus provides free opportunities to refine categories or to entail further aspects of communication (for example, the co-construction of the social relationship between participants), whilst the model remains cognitively consistent (to the extent that all functions are based on the same set of critical thinking operations).

We provide a set of non *ad hoc* argumentative functions, generated systematically on the basis of clear and simple theoretical principles. These categories cover a larger set of moves than classical dialectical systems and reveal the use of dialectical clarification moves in natural dialogues. But the organisation of dialectical functions on the basis of 4 independent criteria provides a means to analyse the collaborative roles of participants and the different colours of dialectics in learning situations. Unfortunately what we gain in coverage is lost in accuracy. The reduction of argumentative moves to basic functions break down reasoning processes or strategies. Reasoning features such as *reductio ad absurdam*, concessions, etc. need to be recomposed to be effective. Non-adversarial argumentative moves are difficult to be analysed as well. Hypothetical thesis, or collaboratively supported thesis may be discussed, defended or attacked, without being necessarily the thesis of one or the other participant. The proponent role should not be restricted to a particular participant and be supported by a set of persons or for a hypothetical one by no one in particular.

This model gives the theoretical foundations for a graphical representation of dialogic argumentation. As opposed to Toulminian graphs and the Belvedere environment, this graphical representation takes into account dialogic features of argumentation, since several voices can be represented and confronted. The representation focuses on argumentative relationships between propositions, with the recursive possibility to argue on arguments as well as on argumentative relationships. This model can be used for analysing argumentation or for interacting with other people by co-constructing an argumentation graph. The latter usage of this tool has been tested with a class of 18 years old students. The results are divided: although JigaDREW offers a good means for externalising opinions and arguments, the graphical meaning of arrows are not very well understood, and need probably an intensive teaching sequence to stress on the difference between an argumentative graph and a conceptual map. An important difference with the analytical model it is based on, is that only direct

contributions are graphically represented. When participants request some information or some particular action, they are forced to use another means of communication. Therefore, as a communicative tool, JigaDREW cannot be used alone. Further developments are planned for improving features of JigaDREW, within the framework of the SCALE European project, for example an automatic layout algorithm, a intelligent tutoring system giving feedback to participants in specific configuration of the graph, etc. But the most important work is planned for the integration of this tool (either for producting or for analysing argumentation) in pedagogical situations, within collaborative work with teachers.

*7. Conclusions*

We have presented a collaborative model of argumentation in problem-solving dialogues. This model aims to provide an analytical framework for describing the cognitive processes of argumentation and their potential roles in problem solving. To preserve cognitive coherence and continuity of the dialogue, argumentation has been considered as a specific case of problem solving, where a "conflict" is to be solved. We show the way in which we can derive argumentation moves from general functions of problem solving; those we use for analysing various aspect of communication management. A large set of dialectical functions has been generated on the basis of four simple criteria: *thesis proponent, argumentative orientation*, *interlocutory orientation* and the *critical thinking operation*. This model has shown to be relevant for analysing collaboration and cognitive roles of participants and quite easy to apply despite the number of categories.

This model is also at the foundations of a graphical representation of dialogic argumentation, providing at least a tool for representing the structure and the evolution of argumentation dialogues. This graphical system has been implemented in a standalone Java applet for analysis purpose and in a communication module for interaction purpose, fitting into an existing collaborative environment, DREW. This interface is currently under development and aims to support argumentation learning and debate through Internet for pedagogical purpose. A deep collaboration between researcher and teachers, in the framework of the SCALE European project, will undoubtly be beneficial in improving the functionality of this interface and its pedagogical utility.

*Acknowledgements*

I would like to thank gratefully my thesis supervisor and colleague Dr. Michael

Baker for his guidance in my doctoral and postdoctoral research. The development of the JigaDrew interface could not have been possible without the support of the SCALE project consortium, the Ecole des Mines de St-Etienne, and especially the help of Philippe Jaillon, the core designer of DREW and also the brilliant network engineer that help us to carry out the first experimentation of the interface. Finally, I would like to thank warmly all participants of the experiments related here, students from Bron and La Mulatière and their teachers, and all colleagues that helped me in their organisation.

NOTES

**[i]** Vernant (1997) claims that the use of language is governed by extrinsic rules, outside language.

**[ii]** We meet there a "problematologic" view of dialogue from Meyer (1982), where the meaning of utterances stays in their relation to a particular problem that they locally transform.

**[iii]** More information on the conditions under which this data has been collected can be found in Quignard & Baker (1998).

**[iv]** Dialogical Reasoning Educational Web tools. The DREW environment is a development of the RIM research team of the Ecole des Mines de St-Etienne (http://drew.emse.fr). It is available under GPL in different european languages (French, English, Finnish, Dutch, Hungarian and Portuguese).

**[v]** Java Interface for Graphical Argumentation in DREW. This interface has been implemented by Matthieu Quignard in 2001 under contract with the Ecole des Mines de St-Etienne, with the help of Philippe Jaillon, the main designer of the DREW environment.

**[vi]** More information on this applet on http://levant.univ-lyon2.fr/SCALE/DREW/GrapheurAlone/index.html

**[vii]** The SCALE project (Internet-based intelligent tool to Support Collaborative Argumentation-based LEarning in secondary schools, March 2001–February 2004) is funded by the European Community under the Information Societies Technology (IST) Programme. Information on the project can be found at: http://www.euroscale.net/

**[viii]** The interested reader is invited to replay on demand of this interaction on http://levant.univ-lyon2.fr/SCALE/ samples/index.html

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