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# ARGUMENTATION AND CONSTRUCTIVE INTERACTION

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## ABSTRACT

Research on collaborative learning currently emphasises the need to understand the processes at work in communicative interactions between learners, as a means of discovering interactive learning mechanisms. Within this general research programme, we concentrate on the specific case of argumentative interactions, with the aim of describing how they can be *constructive*. A constructive interaction is defined as one in which new meanings or knowledge are co-elaborated, and/or one that fulfils some specific (constructive) function with respect to cooperative activity. Our main proposal is that in order to address this research problem we need to combine analyses of argumentative interactions along five theoretically separable dimensions: dialectical, rhetorical, epistemological, conceptual and interactive. Respectively, these consider argumentative interactions in terms of rational criticism, cognitive effects on participants, the nature of knowledge involved, the form of cognitive representations and co-elaboration of meaning and knowledge. We present a detailed analysis of an extended interaction sequence, taken from a corpus that was collected in a physics classroom. The analysis reveals how the interactive pressure imposed by the necessity to resolve interpersonal conflicts forces meanings and knowledge to evolve, and the basic function of argumentation in this context: filtering flawed proposals.

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*"Der Konflict löst sich etwa, wie die Spannung einer Feder in einem Mechanismus, den man schmilzt (oder in Salpetersäure auflöst). In dieser Lösung gibt es keine Spannungen mehr."*

"Conflict is dissipated in much the same way as is the tension of a spring when you melt the mechanism (or dissolve it in nitric acid). This dissolution eliminates all tensions."

(Wittgenstein, 1980, pp. 9/9e)

## 1. INTRODUCTION

Researchers working on collaborative learning have recently turned their attention to the interdisciplinary study of the dynamics of communicative interactions (e.g. Resnick, Levine & Teasley, 1991; Pontecorvo, 1993). In one sense, this shift of emphasis is linked to the recognition that, without powerful theories and specific models of cooperative learning, the search for interactive learning mechanisms will be essentially blind (see e.g. Mandl & Renkl, 1992; Dillenbourg, Baker, Blaye & O'Malley, 1995). In a wider sense, it is motivated by the emergence of new paradigms in cognitive science — such as "situated learning" (Lave, 1988) or "cognitive interactionism" (Suchman, 1987) — that emphasise the role of interactions in learning (i.e., both communicative interactions within groups of persons, and interactions between persons and the socially constituted material world).

Within this general research programme we focus on the specific case of *argumentative interactions* produced in collaborative problem-solving situations. Our aim is to understand the cognitive-interactional processes that operate within these interactions, and to describe some ways in which they can be considered to be *constructive* interactions[1].

The term "constructive interaction" was coined by Miyake (1986), to describe the way in which the conceptual points of view of people who are trying to understand a complex physical device (a sewing machine) go through successive iterations, between understanding and non-understanding. In our sense, an interaction can be "constructive" in at least two ways.

Firstly, an interaction is constructive if it literally leads to the (co-)construction or building of something — meaning, understanding, solutions to problems and sometimes knowledge. Constructive interaction in this sense relates to the problem of *emergence* from communicative interaction: how can it be that new knowledge or understanding arises from interaction with others, that is not easily reducible to a simple function of the participants' knowledge and contributions ? Note that in this case we are not directly concerned with "*C*onstructive" interaction, with a capital "C", i.e. the construction of representations that are accepted as correct from a normative point of view. Rather, our aim is to describe the

[1] The terms *interaction*, *communicative interaction*, *argumentative interaction* and *constructive interaction* will be discussed in more detail below. For the present, we assume an intuitive understanding on the part of the reader.

potentially productive transformations that are manifest throughout the of students' interaction, some of which may turn out to be Constructive.

Secondly, an interaction can be constructive to the extent that it generally contributes in some way to cooperative goal-oriented activity. In the case of collaborative problem-solving, an example would be when one student points out something that enables the students to realise that they do not in fact understand their current joint solution, which leads to its *deconstruction* to leave the part of it that is useful. To ask to what extent an argumentative interaction is constructive in this second sense is to inquire as to its *function* with respect to collaborative problem-solving: does it lead to addition of new knowledge to the common ground (Clark & Schaefer, 1989), or is it rather a means of eliminating solutions; does it lead to better mutual understanding or simply to confusion ?

Our main proposal is that understanding how argumentative interactions can be constructive in these two senses requires combining analyses along five theoretically separable dimensions: *dialectical*, *rhetorical*, *epistemological*, *conceptual*, and *interactive*. We illustrate these analytical dimensions with respect to an interaction sequence drawn from a corpus of collaborative problem-solving dialogues collected in a physics classroom.

## 2. COMMUNICATIVE, ARGUMENTATIVE AND CONSTRUCTIVE INTERACTIONS: SOME WORKING DEFINITIONS

Our aim here is to propose an approach to analysing *interactions* that are both *communicative* and *argumentative*, in order to understand how they may be *constructive*. We therefore need to provide working definitions of these key terms[2].

### 2.1 Inter-action and communicative interaction

We use the term *interaction* (or "inter-action", literally "action between") to distinguish situations in which *actions* of *agents* are *mutually dependent* (c.f. Kerbrat-Orecchioni, 1990, p. 17 ff.). Classically, action is distinguished from behaviour in that the former presupposes the operation of the will — of intentionality — whether the agent is conscious of this or not at the time of acting, whereas the latter does not necessarily. An agent is an entity that is, at least, capable of acting intentionally on the basis of cognition. Actions are mutually dependent when they are each set off or caused by others, and when they are related in a certain way. Usually this means that the interdependent actions are directed towards the achievement of a common goal, possibly in relation to a common plan. An example of interaction involving interdependent physical actions would be the case where two people attempt to transport a piano up a staircase — one person pushes to the right so that another

[2] Our brief discussion necessarily touches upon fundamental and contentious issues in cognitive science concerning the nature of cognition and action, that we can of course not resolve: our aim is simply to clarify our own position with respect to these matters.

can lift the piano up a step, the raising of the piano causes the first to push again, and thus they can both advance in achieving the common goal of moving the piano upwards.

This definition of interaction, as essentially *interpersonal*, would therefore exclude the case where agents act on their physical environment, the *reaction* of which then leads to a modification in the agents' actions. For example, people using hammers to strike in nails successively modify their hammering actions as a function of the reaction of the nails and wood. Thus, theorists of situated learning, such as Lave & Wenger (1991), speak of people "interacting", "negotiating" or even "conversing" with their environment. In our terms, such phenomena would be described as "action/reaction" rather than "interaction" since one of the parties (the physical environment) is not an agent, capable of intentional action. As we define them, what interaction and action/reaction have in common, is interdependency[3], and the fact that at least one human agent is involved in the situation described.

*Communicative interaction* is therefore interaction that involves communication, i.e. sequences of mutually dependent *communicative* actions. In our terms, an action is communicative if — minimally — it is performed by a speaker with the intention of producing a more or less specific cognitive effect in a hearer, by means of the hearer's recognition of the speaker's intention to produce that effect (Grice, 1957)[4]. Although communicative actions can be non-verbal[5], we are concerned here primarily with *verbal* actions, i.e. with the utterance of interconnected sequences of speech acts, whose aim is to enable interlocutors to share their mental states. The actions will be interdependent to the extent that speakers actions and thoughts mutually influence each other. The piano-moving example described above involves non-verbal and non-communicative interaction. In reality, such cases usually involve (verbal and non-verbal) communicative interaction to some extent — for example, when the piano is stuck, and a discussion arises concerning how to unblock it. In what follows, when we refer to communicative interactions, we mean *verbal* communicative interactions.

## 2.2 Argumentative interaction

We view *argumentative interaction* as a specific type of communicative interaction. Although non-verbal communicative acts (such as banging one's fist on the table) can be used in argumentative interactions, we do not deal with them here. Within the literature, many

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[3] C.f. Lave (1991), p. 67: "[situated social practice] emphasizes the relational interdependency of agent and world, activity, meaning, cognition, learning and knowing."

4 For example, if a speaker S, in a certain context, makes the utterance "The door!", directed towards a hearer H, this counts as a communicative action to the extent that S intends to produce the cognitive effect in H "H understands that S wants H to shut the door", by means of H's recognition of S's intention "S intends me, H, to understand that S wants me to shut the door". If S had no such intention (e.g. S had no intention that H should recognise his intention; S knew that H intended to shut the door in any case), then this does not count as a communicative action. In this case S would have made a locutionary act (the uttering of words having a linguistic meaning), but not an illocutionary, or communicative, act (Austin, 1962; Searle, 1969).

[5] For example, X could push Y towards a door with the communicative intention that Y understand that X wants Y to leave.

different views exist on what argumentation is (see e.g. Plantin, 1990; van Eemeren, Grootendorst & Henkemans, 1996), not all of which view it as a form of communicative interaction, as defined above (e.g. argumentation as a text, argumentation as a type of speech act, argumentation as a form of logical proof). For our purposes here, an argumentative interaction is a communicative interaction that satisfies just two minimal conditions (to be described shortly). These conditions correspond to a minimal definition of a *dialectical* approach to argumentative interactions (see §3.1 below). To that extent, *an argumentative interaction is simply a verbal communicative interaction in which the dialectical dimension is present.*

The two characteristics that a communicative interaction must minimally possess in order to be viewed as an argumentative interaction are as follows.

Minimal conditions for argumentative interactions

1. *Opening phase*. A verbal conflict must be mutually recognised by the participants, with respect to one or more views[6] attributed to one or more of the participants; a verbal conflict is an expressed difference of positions[7] (for/against, pro/contra) or attitudes (e.g. belief/non-belief) with respect to the view(s).

2. *Argumentation phase*. Following the opening phase, participants must each make at least one communicative act that is globally in accordance with the positions expressed in the opening phase; these communicative acts reveal some degree of stability in the positions with respect to the view(s) expressed in the opening phase; communicative acts produced in an argumentative interaction that are in accordance with a for/pro position are termed *defences*, and those that correspond to the against/contra position are termed *attacks* .

Normative theories of argumentation may adopt very much more strict criteria (e.g. van Eemeren & Grootendorst, 1984). We are not claiming that these two conditions are necessary and sufficient for all that has been termed argumentation, but simply that they constitute a useful working definition that can be used for analysing argumentative interactions produced in collaborative problem-solving situations.

In an idealised case, the opening phase, would be as follows:

Opening phase

- [Move 1] X: "The battery is a transformer of energy" ((expression of a view))
- [Move 2] Y: "No it isn't, it doesn't receive energy !". ((attack on X's view))
- [Move 3] X: "Yes it is, it makes electricity from chemicals" ((defence of own view))

At the end of the opening phase, both X and Y have expressed their different positions (pro and contra) with respect to X's view by attacking or defending that view at least once. There

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[6] In this quite general definition we use the term "view" in order to avoid theoretical commitments with respect to the public or private nature of argumentation. A view could be interpreted as a proposition, a propositional attitude, a (public) statement, or even a speech act. In terms of a dialectical model of argumentative interactions, the view with respect to which participants adopt opposed positions is termed a *thesis*.

[7] In Barth & Krabbe's (1982) dialectical theory, such positions are termed "dialectical roles", and can be either "proponent" or "opponent".

are several ways in which this idealised schema can be modified, whilst nevertheless preserving its essential structure, for example:

- X's view in move 1 need not necessarily be expressed — it could already be part of the common ground (Clark & Schaefer, 1989) concerning what X believes; however, in this case, once attacked, X could try to avoid verbal conflict by saying "I didn't say that".
- Y's attack, corresponding to a contra position in move 2 could be expressed in several different ways — for example, by a simple denial ("no it isn't !"), by saying something that is mutually understood to be an attack on X's proposal or belief (e.g. "But it doesn't take in energy !"), or by proposing a different view concerning the matter at hand (e.g. the common problem to be solved) where the two views are mutually believed to be contradictory (i.e. proposing a counter-thesis).
- In move 3, X could attempt to defend his view by making a counter-attack, such as one that attempts to invert the "burden of proof" (e.g. "could you tell me why not ?").

At the end of the opening phase, although opposed positions have been expressed, the participants could then let the matter drop, in which case argumentative interaction would have been initiated, but not pursued. According to the second condition, therefore, the participants must make at least one further communicative act that confirms the relative stability of these positions, i.e. willingness to engage in argumentative interaction. Once positions are initially established, they can of course shift. The point is that at any give stage, positions must be established and mutually recognised.

In most cases, a third phase will occur, in which the participants discuss how the verbal conflict should be *closed* — who is right or wrong ? who has won or lost ? what should be done/believed ? However, we have found that in many cases, students simply move on to something else, and leave the closure (e.g. resolution) implicit. For this reason, the closing phase is not strictly essential to analysis of real argumentative interactions. What is basically required is that participants take opposed positions with respect to a view, and act communicatively in order to give reasons for and against the view in a way that is coherent with their positions and a minimal commitment to them. This minimal argumentative interaction schema is summarised in Table 1. Parts that are enclosed in square brackets "[]" are optional[8]; "…" indicates that further moves of this type may be made. From Table 1 it can be seen that just four moves (2 to 5) are required for argumentative interactions.

TABLE 1. MINIMAL IDEALISED SCHEMA FOR ANALYSIS OF ARGUMENTATIVE INTERACTIONS.

| *Phase* | *Moves* |
|---|---|
| (1) *Opening phase* | [Move 1 — X: expression of view(s) ν] |
| (initial expression of views and mutual recognition of opposed | Move 2 — Y: attack on ν (contra position) |

[8] The three phases can be compared with the stages for rational discussions described by van Eemeren & Grootendorst (1984).

| | |
|---|---|
| positions with respect to them) | Move 3 — X: defence of ν (pro position) |
| (2) *Argumentation phase* | Move 4 — Y: attack on ν (confirmation of relative stability of contra position) |
| (communicative acts in accordance with positions) | Move 5 — X: defence of ν (confirmation of relative stability of pro position) |
| | […] |
| [ (3) *Closing phase* | [Move 6 — Y: clarification of position with respect to ν and outcome of argumentation phase |
| (discussion of outcome) ] | Move 7 — X: clarification of position with respect to ν and outcome of argumentation phase] |

Most theoretical approaches to the study of argumentation specify the *goals* of arguers (e.g. Walton, 1989). Thus, as we shall discuss below, rhetorical approaches (Perelman & Olbrechts-Tyteca, 1958/88) see argumentation as an attempt to persuade, whereas dialectical approaches (Barth & Krabbe, 1982) see it as an attempt to play and win a verbal game. Given our aim of analysing collaborative problem-solving interactions, we do not consider that specific goals are necessary to a minimal and operational definition of argumentative interactions, for two reasons. Firstly, students may have various different goals in engaging in argumentative interactions — e.g. attempting to persuade, to convince, to appear reasonable, to cooperatively search for a common solution, to avoid losing face, … — and we do not want to restrict our definition to a single goal, since this would exclude much of what is manifestly argumentative interaction in the situations that we study. Secondly, in practice it is very difficult to infer students' goals in argumentative interactions.

## 2.3 Constructive interaction

Whilst any communicative interaction could be constructive, our concern here is with the specific case of argumentative interactions.

As mentioned in introduction, the first sense in which a communicative interaction can be constructive is when leads to the (co-)construction of something — a problem-solution, meaning, knowledge, … . This aspect is addressed by the epistemological, conceptual and interactive dimensions of argumentative interactions described below. The epistemological dimension is intended to encapsulate the way in which students who argue in terms of different types of reference knowledge can come to a common point of view with respect to the problem to be solved, as a result of confronting their knowledge in argumentative interaction. The conceptual dimension concerns the way that students divide up their understanding of what is being discussed. It enables us to understand how some forms of conceptual change could result from engaging in argumentative interactions. Finally, the interactive dimension describes the interdependencies between students' communicative

actions (see §2.1 above), how the way on which they build on each other's contributions can lead to co-construction of knowledge.

The second sense in which a communicative interaction — and an argumentative interaction in particular — can be constructive is when it fulfils some specific function with respect to the cooperative problem-solving task. Our aim in this case is to ask what that function might be. For example, clarification of some concept that relates to something that is discussed, contributing a new element to the problem-solution, enabling the students to recognise that their previous solution is unacceptable, and so on. An argumentative interaction which is *not* constructive in this second sense would be one that had no incidence at all on the students' subsequent cooperative problem-solving (e.g. 'arguing for the sake of it').

In summary, therefore, a constructive argumentative interaction is one that serves some specific purpose or function with respect to the activity in which the participants are engaged (e.g. cooperative problem-solving), and/or which leads to (co-)construction of knowledge or understanding. Knowledge co-construction during argumentative interaction can be viewed as a specific function with respect to the participants' broader activity. In general terms, our inquiry is therefore directed towards understanding the function of argumentative interaction in task-based communicative interactions, or, to answering the question "why argue, what difference does it make ?".

## 3. DIMENSIONS OF ARGUMENTATIVE INTERACTIONS

Relatively little research has hitherto been carried out specifically on the role of argumentative *interactions* in cooperative learning. Most has concentrated on studying production and understanding of argumentative discourse[9] (e.g. Voss *et. al.,* 1986, 1991; Golder, 1996) rather than interaction, or else on studying argumentative interactions in situations that were not designed to promote learning (e.g. Resnick et. al., 1993). However, in both cases, researchers have often applied models of argumentation that were designed for analysing texts rather than interactions. For example, Resnick and colleagues (*op. cit.*) applied Toulmin's (1958) argument graphs to analysing discussions between university students of contentious issues (such as "nuclear power"). The argument graphs were extended to include the different types of reasoning underlying supports, backings, etc., as well as thematic links, reformulations of utterances, and implicit claims, conclusions and premises.

We argue that, firstly, in order to understand how argumentative interactions can be constructive, we need to use models of argumentation that are inherently dialogical and pragmatic. Secondly, analysis of argumentational dimensions (dialectical and rhetorical) needs to be supplemented by analysis of other dimensions (epistemological, conceptual, interactive) if we are to understand the nature of constructive argumentative interactions (and, ultimately, how they relate to collaborative learning). Thirdly, nevertheless, the different

[9] By "discourse" we mean a spoken or written linguistic product (e.g. a speech, a text) that is not produced in a communicative interaction.

dimensions need to be analytically separate, precisely so that we can study how they function with respect to each other (see §3.6 below).

From our theoretical point of view, the only dimension that is *strictly* argumentational — that defines argumentative interactions as such — is the *dialectical* dimension (see §2.2 above). The approach to analysing argumentative interactions that we have described above is thus derived from a more general dialectical model (§3.1 below). What we term the rhetorical dimension here is concerned with the cognitive effects on speakers and hearers that result from engaging in an argumentative interaction. Clearly, cognitive effects could be produced by engaging in any type of communicative interaction since their production is a defining characteristic of communication itself (see §2.1 above). The term "rhetorical" is therefore used here simply to refer to the specific case of cognitive effects produced in argumentative interactions, and also to indicate the relations between this dimension, as we define it, and other areas of argumentation theory (see Van Eemeren, Grootendorst & Henkemans, 1996). The other three dimensions — epistemological, conceptual, interactive — could also be present, to a greater or lesser extent, in any communicative interaction that is produced within the context of a knowledge-based activity (i.e. involving the communication, acquisition, co-construction, discovery, etc., of knowledge). Our aim here is thus to study how these dimensions operate in the specific case of argumentative interactions.

We discuss each dimension below and indicate in each case how their study is relevant to our objectives as stated in introduction.

## 3.1 The dialectical dimension

Along the dialectical dimension, argumentation is viewed as a sort of interactive game, a "verbal jousting tournament", the objective of which is, of course, for someone to emerge as the winner (and someone else the loser). There may be different reasons (goals) why participants play the game, for example desiring personally to win, or else attempting to put different views to a critical examination (Walton, 1989). Our analysis approach is based on the formal dialectics of Barth & Krabbe (1982). We shall only give a brief outline of this approach here, sufficient for understanding the analyses that follow[10].

Dialectics begins from a conflict situation: <A,B,Con,T>. "A" and "B" are the participants in the dialogue, "Con" a set of concessions (statements that are agreed by the participants prior to debating), and T the thesis to be debated. The minimal starting point is that one participant , for example "A", has made a statement U, and the other has raised doubts with respect to U. "A" makes one defensive move with respect to U, which now becomes the thesis, T. The participants have now adopted specific dialectical roles: A becomes the proponent, and B the opponent. These roles condition participants' commitments to theses, concessions, and to making certain types of moves in specific contexts.

The moves in the game are specific speech acts: assertions (U), requests for defensive moves (U ? — "how do you defend U ?"), hypothetical statements ((?)U — "I am prepared to defend

[10] See Van Eemeren, Grootendorst & Henkemans (1996), chapter 9, pp. 246-273, for a general introduction.

U for the purposes of this debate") and a special speech act "U!" that indicates that the interlocutor has made a "foul move". Such foul moves are defined with respect to a set of general rules that govern the debate and that, ideally, are agreed by the participants prior to debating. For example: a participant can not both assert a statement then attack it, since this would correspond to adopting both a pro and a contra position with respect to that statement within the same argumentation sequence. Other rules operate to generally make the debate converge to a determinate outcome (e.g. no repeating moves indefinitely, all attacked statements must be immediately defended) and to decide what that outcome is (e.g. if B has no more legal moves at his disposition with which to reply to an attack, then he has lost). There are of course also specific rules that determine what counts as an attack or a defence of a particular statement (e.g. "A?" and "B?" are attacks on "A ∧ B") that will correspond to a domain model in task-oriented dialogues. There are two basic types of conflicts: "simple", in which a single thesis is debated, and called into doubt by the opponent, and "mixed", in which each participant proposes a thesis (thesis and counter-thesis).

We are not, of course, claiming that such idealised models can, as such, account for all aspects of real argumentative interactions, nor especially those produced by students. For example, van Eemeren & Grootendorst (1984) have pointed out that concessions are not fixed prior to debating, but are continually negotiated throughout argumentative interactions. Rather, we view such abstract dialectical models as providing a basic structure, and functional components, with respect to which we can search for correlates in real interactions: what are the general rules that govern argumentative interactions between students ? what is the range of speech acts that they use ? how are outcomes determined ? With respect to the latter question, Trognon (1990) has shown that the basic predictions of such dialectical models — who has won or lost ? — conform to human intuitions in certain cases. This result is promising for cognitive studies of argumentation since it enables us to address the question of how argumentation outcomes influence the subsequent course of collaborative problem-solving (e.g. does the loser drop belief in his thesis?).

## 3.2 The rhetorical dimension

Traditionally, rhetoric is the art of persuading an auditorium, a group of listeners. The means used do not of course have to be rational, their simple aim is efficacy in persuasion. Significantly, the sophist or rhetor is able to argue both in favour of and against any given opinion (see e.g. Ducrot & Schaeffer, 1995, pp. 140-151).

We generalise use of the term 'rhetoric' firstly to any type of *epistemic effect* that is produced, as a result of argumentative interaction. Epistemic effects are concerned with the status of representations from the point of view of individuals, their attitudes with respect to them — being in a state of knowing, believing, suspecting that something is the case, viewing it as plausible, certain, or as a defensible opinion, etc. In interactions, these attitudes can shift, or be revised[11]. Changes of epistemic status can often be more subtle than revisions of beliefs to non-beliefs. For example, as the result of an argumentative interaction, students may view a

[11] See research on belief revision in artificial intelligence, for example Gardenförs (1992).

proposal that they had hitherto viewed as certain, as uncertain, yet defensible (Nonnon, 1996). Such a change may in fact turn out to be constructive, since, once the students have realised that they do not fully understand something, they may be motivated to seek out the required knowledge.

Secondly, such effects can be produced with respect to *all participants* in the interaction: the uttering of a particular sequence of speech acts in an argumentative discussion can have effects on the speaker as well as on the hearer. This possibility can be compared with the "self-explanation" effect (Chi *et al.*, 1989; Chi & VanLehn, 1991; Webb, 1991): subjects who produce explanations can learn from so doing, as well as those who receive them.

Within a computational approach to speech-act theory (e.g. Cohen, Morgan & Pollack, 1990), certain types of cognitive effects that result from engaging in argumentative interactions can be modelled as relatively stable perlocutionary effects of speech acts (Van Eemeren & Grootendorst, 1984).

## 3.3 The epistemological dimension

The epistemological dimension deals with the *nature* of the knowledge that is involved in argumentative interactions — the knowledge that is appealed to, and which underlies the interaction. We distinguish three aspects: (1) the intrinsic properties of knowledge, (2) the knowledge domain (3) the source of the knowledge.

Properties that are intrinsic to a different types of knowledge include its degree of inherent ambiguity, its complexity, and the existence of alternative solutions or conceptual points of view.

By a domain we mean a body of knowledge as possessed by a recognised social group of experts (such as researchers in psychology or mathematics, or international scientific bodies). There are of course sub-domains: for example, organic and inorganic chemistry.

The source of knowledge can be either considered from the point of view of the individual's capabilities, or in terms of social-institutional positions of individuals or groups. Thus individuals may acquire knowledge through perception (including information acquired from other people), action, or reasoning. The social-institutional status of the person(s) from whom knowledge is acquired are important: knowledge acquired from a teacher, a parent or a friend does not have the same status.

Analysing the nature of the knowledge involved in argumentation is important given that some types of knowledge used as arguments or counter-arguments may be perceived as having more strength or weight. For example, an argument that appeals to an undeniable fact of everyday experience (fire burns) may have more weight than one that depends on individual reasoning. Secondly, in cognitive terms, some types of knowledge may be more firmly anchored (DiSessa, 1988), or "epistemically entrenched" (Gardenförs, 1992), than others.

## 3.4 The conceptual dimension

The conceptual dimension of argumentative interactions is concerned with the *form* of knowledge, the way in which it is *represented*, in the universe of reference (the 'external' task whose achievement is the reason why the communicative interaction takes place). It is thus not the same as the epistemological dimension, that deals with the *nature* of knowledge. An example will perhaps make this clear.

Suppose that the topic of an educational interaction is "living beings", such as plants and animals. In such an interaction, along the epistemological dimension, students may appeal to different types of knowledge — of physiology, palaeontology, botany, … — coming from different sources (what they learned in school, in everyday life during a visit to the zoo, etc.). Now suppose that the teacher asks "what is the main difference between plants and animals ?" Establishing such a difference is a conceptual matter, it requires performing a type of *linguistic-cognitive operation*, termed *differentiation*. Such operations are "the means by which discourse performs … cognitive work on representations" (Vignaux, 1990, p. 307; see also Vignaux, 1988). For example, a student might reply "animals have legs and can move, whereas plants are fixed to the ground by their roots". Such differentiations (the separating out of representations or concepts from each other) are the bases for *determinations*, i.e. characterisations of the object of discourse, e.g. qualifications or properties which are being attributed ("animals have legs"). It is not possible to predicate or to evaluate propositions (predications) unless one can, to some extent, differentiate out concepts from each other.

The conceptual dimension relates directly to two important aspects of argumentative interactions that have already been described by argumentation theorists. The first aspect concerns the fact that in order to argue effectively, participants are often obliged to *clarify* their interpretations of utterances (Naess, 1966). The second relates to the fact that debates often shift towards 'deeper', more fundamental, or *general* issues (Walton, 1992)[12]. We shall describe how the *interactive pressure* [13] that requires conflicts to be resolved verbally in argumentation triggers such operations, and may in turn lead concepts to evolve (e.g. to the correct differentiation: "the difference between plants and animals lies in the way that they obtain their *energy* — via photosynthesis or by digestion.").

## 3.5 The interactive dimension

In the specific case of argumentative interactions, the interactive dimension encapsulates the processes by which knowledge [epistemological dimension] or concepts/representations

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[12] Walton (1992) gives the example of a debate on the desirability of the institution of tipping in the USA, that becomes a debate on the more fundamental issue of what should be the role of the state in regulating work practices.

[13] Strictly speaking, we should distinguish *interactive* pressure — the obligation to respond in interaction, to think of one's reply in real time — from *interactional* pressure, which concerns social aspects of interaction (see Muntigl & Turnbull, 1998) such as loss or preservation of "face" (the person who is refuted may lose face, resolution of the verbal conflict must be negotiated so that face is preserved).

[conceptual dimension] are transformed, reformulated, refined, elaborated or *negotiated* in communicative interaction.

We adopt Roulet and colleagues' (Roulet *et al.* 1985; Roulet, 1991) distinction between *interactive* and *interactional* completeness (*complétude*) in a model for interactions based on the concept of negotiation. Interactive completeness is a condition for interactional completeness. If someone wants to sell you a carpet, then you can agree to buy it or not. Similarly, if someone provides you with some information, you can agree with it or not. This is *interactional* negotiation, operating on the level of agreement/non-agreement, or acceptance/non-acceptance. However, in order to know whether you agree or not (with buying the carpet, or with the information content), in the first case you have to know the price, the type of carpet, etc., and in the second you have to understand the information. So a subdialogue can be entered into in order to determine the price, the colour, etc., what the information means (explanatory dialogue), which corresponds to *interactive* negotiation.

In the case of collaborative problem-solving dialogues, students are usually required to reach some degree of *agreement* with respect to the solution to the problem (interactional negotiation). However, in order to attain such agreement, they often need to transform initial proposals into some new proposal that is acceptable to each and which satisfies the constraints of the problem (interactive negotiation , driven by the need to reach agreement on the interactional level).

In Baker (1994, 1995) we described a general model of collaborative problem-solving, based on the idea that it is fundamentally a negotiation (interactive) that operates on the "knowledge level"[14] Initial proposals may be *transformed* in interaction in four basic ways: they may be *extended* (e.g. new propositions or predicates conjoined, inferences draw) or *restricted* (e.g. their range of validity, propositions or predicates 'removed' — "I agree with x, but not that it is *F*), their *foundations* may be examined (justification, explanation), or they may be *reformulated*. Usually, repetition (zero reformulation at the knowledge level) serves a specific purpose at another communicative level: checking mutual understanding, summarising the current common solution so that agreement can be decided. In this way, collaborative problem-solving can be described succinctly (Baker, 1995), to give a picture of the extent to which the students are genuinely collaborating, rather than solving the problem in parallel.

The reason why the interactive dimension is important here is perhaps obvious: students may be led to transform initial proposals into more refined concepts and knowledge, which may then be internalised.

In argumentative interactions, there is pressure on individuals to avoid *intrapersonal* conflict, or cognitive dissonance (Festinger, 1957), and special *interactive pressure* (Bunt, 1995) to resolve *interpersonal* conflicts. Argumentative interactions are often emotionally charged. This is not necessarily negative, since there may be an interplay between knowledge-based and socially-based argumentation (debate vs. dispute). We adopt the working hypothesis that *these pressures operating in argumentative interactions may lead meanings and knowledge to evolve*.

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[14] Note that interaction management, rights and obligations, self and other-images, etc. may also be negotiated (see e.g. Moeschler, 1985).

## 3.6 Some relations between the dimensions

*Dialectical* and *rhetorical* dimensions of argumentation are intrinsically related given that the former is intimately associated with attitude formation — the taking of stances, positions, for or against proposals. Once participants engage in an argumentative interaction, they must step back from their proposals, examine their foundations, defend or attack them, and in general *reflect* upon their knowledge. Such reflection may itself be a cause of change in attitudes (see our earlier remarks concerning the self-explanation effect in an interactive context). As mentioned above, argumentation outcomes may also be the causes of attitude shifts.

However, argumentative interactions are not always resolved in a strictly dialectical way, i.e. with refutation or successful defence (and concession), leading to designation of a winner and a loser. This is where *dialectical*, *interactive* and *conceptual* dimensions relate to each other. Thus, some argumentative interactions may be resolved (or rather 'dissolved') by negotiating a compromise (*interactive*) that combines and refines alternative proposals. Others may be 'defused' by differentiating the *conceptual* framework in into two parts, that enables each participant to be 'right', but within a separate framework (e.g. "You are right in the case of elastic impacts and I am right in the case of inelastic impacts" — see Baker, 1991). Clearly, the *conceptual* dimension is related to the *epistemological* one given that the nature of the knowledge involved determines how it can be conceptualised.

Finally, as mentioned above, *dialectical*, *rhetorical* and *epistemological* dimensions interrelate given that the nature of the knowledge involved determines the extent to which participants will be willing to change their minds with respect to it (rhetorical), and that some types of knowledge (epistemological) provide more forceful arguments (dialectical).

# 4. THE TASK AND THE CORPUS

The corpus from which the sequence analysed here was taken, was collected in a physics class of a secondary school (*lycée*) in the Lyon area (France). The class was experimental to the extent that a new teaching sequence, on the theory and model of energy in physics, was being tried out on the students (16-17 years old). The students were not specialising in sciences for their examinations (*baccalauréat*) — this was 'physics for literary students'.

The students' task was designed for learning about modelling in physics, and the theory/model of energy in particular (Tiberghien, 1994, 1996; Devi, Tiberghien, Baker & Brna, 1996). In the part of the energy modelling teaching sequence discussed here, students are asked to produce qualitative models (diagrams) called "energy chains" in order to represent energy storage, transfer and transformation in a series of three simple experimental situations. Figure 1 shows example energy chains (correct, and students' solution) for an experimental situation where a battery is linked to a bulb by two wires.

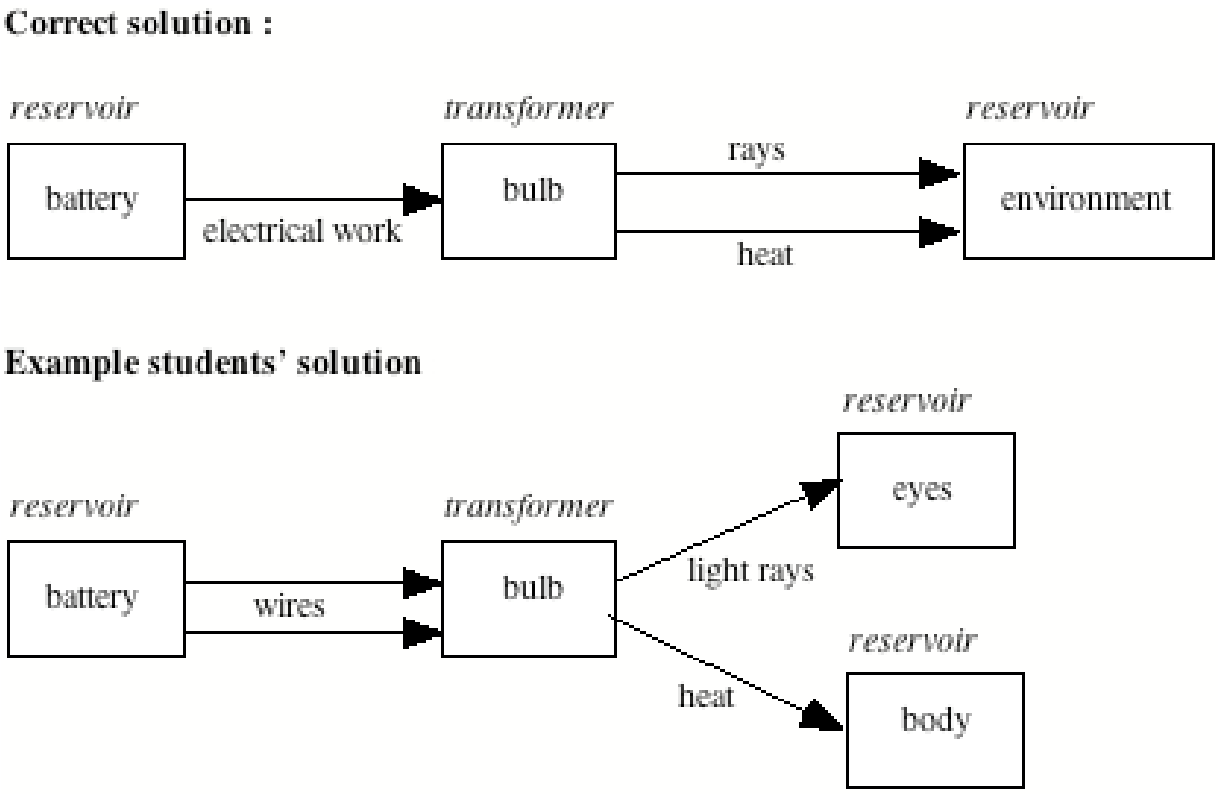


*Figure 1. Energy chains (correct solution, and example students' solution) for an experiment where a bulb is connected to a battery by two wires.*

The didactic rationale of this task is that by attempting to instantiate the simple qualitative model for energy in concrete cases, the students will be led to co-construct an understanding of the concepts of "energy" and "model". This will involve co-elaborating the semantics of the model, given its syntax and lexicon, together with a domain of reference (Tiberghien, 1996).

Students worked together in pairs, with the person whom they normally sat next to (friendship pairs ?). Within the same class, 20 students, 10 pairs, drew the energy chains on paper. The students were given a sheet that expressed simple definitions of elements of the energy chain (e.g. "a reservoir stores energy"), the law of conservation of energy, and a set of syntactic rules to which the diagrams had to conform (e.g. "A complete energy chain must start and end with a reservoir"). They were also given experimental apparatus (battery, wires, bulb; a small motor, a dynamo, a weight and string). Spoken dialogue was tape-recorded, then transcribed, and paper copies were collected.

This task was chosen for the study of argumentative and constructive interactions given that it is exploratory and constructivist, and requires the use of a range of different types of knowledge (see analyses below). Together, these factors lead to a task-situation that provides a wide "negotiation space" (Dillenbourg & Baker, 1996), or which is potentially highly "debatable" (Golder, 1996).

## 5. AN EXAMPLE ARGUMENTATION SEQUENCES AND ITS ANALYSIS

We present and analyse an extract from the corpus described above. The example illustrates many, but not of course all, of the possible interrelations between the analytical dimensions described earlier. Other possible and real (those occurring elsewhere in the corpus) phenomena will be discussed in section 6.

In the analyses we indicate the incidence of different dimensions as follows:

- **D** — dialectical dimension,
- **R** — rhetorical dimension,
- **E** — epistemological dimension,
- **C** — conceptual dimension,
- **I** — interactive dimension.

The extract is divided into subsequences for purposes of exposition, that follow on directly from each other (for reasons of space, short sections that are inessential to the argumentative interaction itself are omitted; this is indicated by "<…>").

This extract is taken from a communicative interaction between a boy and a girl (whom we shall call John and Mary — J and M)[15], who attempted to produce an energy chain for a simple experimental situation in which a battery is linked to a bulb by two wires (the bulb shines when connected to the battery by the wires). Our analysis illustrates the following specific cases of relations between all five dimensions:

- implicit negotiation (**I**) of knowledge as a means of argumentative attack (**D**);
- explicit negotiation (**I**) as a means of argumentative defence and resolution (**D**);
- the role of different types of knowledge (**E**) to which each student appeals within dialectical processes (**D**);
- a specific relation between dialectical outcomes (**D**) and changes in positions or attitudes[16] ®; and
- conceptual differentiation (**C**) as a means of attempting to find a negotiated (**I**) resolution to the argumentative interaction (**D**).

### 5.1 Subsequence 1: John's thesis is proposed and refuted.

Prior to the sequence analysed here, the students had already agreed that the battery was a reservoir of energy, and the bulb a transformer of it. Their problem at this stage was to determine the nature of the transfer(s) [of energy ?] between the two. John's proposal — that becomes his thesis — is shown in Figure 2 (see line 180 in Table 2).

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[15] All students' names have been changed, and all dialogues have been translated from the original French by the author. The complete corpus (in French) is publicly available at: http://sir.univ-lyon2.fr/GRIC-COAST/DRED/

[16] The extract shows a micro-level rhetorical shift (of position, or attitude, with respect to a view) within the argumentative interaction sequence itself. Analysis of more global rhetorical changes would require analysing the students' communicative interaction after the argumentative interaction sequence. For example, if a student continues to propose a thesis that was refuted, then this implies no direct rhetorical change as a function of the dialectical dimension (see Baker 1996a, 1996b for a detailed discussion of this issue).

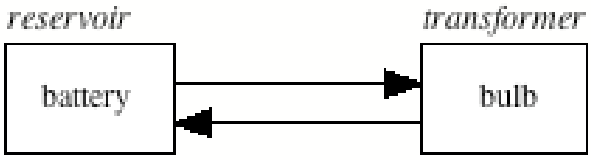


*Figure 2. John's thesis*

TABLE 2: FIRST SUBSEQUENCE

| *Line* | *Loc* | *Dialogue* |
|---|---|---|
| 178 | J: | Right, there, there's the … |
| 179 | M: | … transformer. Do the transfer arrow |
| 180 | J: | There are several of them to be done. One there [battery to bulb]. Should we put another one there ? [bulb to battery] |
| 181 | M: | Pprrrttt! |
| 182 | J: | You see, it leaves from a reservoir and it comes back to a reservoir. |
| 183 | M: | Is that right !? |
| 184 | J: | A reservoir to begin with and a reservoir to end with. |
| 185 | M: | Have we got two batteries John ? |
| 186 | J: | No ! |
| 187 | M: | Have we got two batteries !? |
| 188 | J: | No |
| 189 | M: | Then why do you say such a load of rubbish ! |
| 190 | J: | What have we forgotten then ? |

The dialectical structure of this sequence provides the basic framework within which relations with other analytical dimensions can be shown[17] (Table 3).

[17] We provide such an analysis of this short section simply in order to illustrate the method. For more details see Baker (1996a, 1996b).

TABLE 3: DIALECTICAL STRUCTURE OF FIRST SUBSEQUENCE[†]

| *Transcr. line* | *Dialectical moves* | *Mary* | *John* | *Pragmatic character of dialectical move* |
|---|---|---|---|---|
| 180 | (a) | | **(A ∧ B)** | John's thesis |
| 181 | (b) | **(A ∧ B) ?** | | Expression of doubt; (indirect) request for defence of (a) |
| 182 | (c) | | **C** | Direct defence of (a) |
| 183 | (d) | **C ?** | | Request for defence of (c) |
| 184 | (e) | | **C'** | Direct defence of (a) |
| 185 | (f) | **D** | | Attack on (a) |
| 186 | (g) | | **♦D** | Concession of D |
| 187 | (h) | **D** | | Attack on (a) |
| 188 | (i) | | **♦D** | Concession of D |
| 189 | (j) | **⊗(A ∧ B)** | | Explicitation of argumentation outcome: John's thesis is *refuted* |
| 190 | (k) | | **♦(j)** | Concession of the argumentation outcome: refutation (j) |

[†] *Propositions*: A = "There is a transfer from battery to bulb"; B = "there is a transfer from bulb to battery; C = "there must be an a reservoir at the beginning and the end of an energy chain"; D = there are not two batteries in the experiment". " X' " indicates a reformulation of X.
*Argumentation speech acts*: U = statement; U ? = request for defence: "how do you defend U ?"
*Dialectical moves*: ♦U = statement U conceded; ♦(n) = dialectical move n conceded; ⊗ U = explicitation of argumentation outcome: "U is refuted in this debate".

The analysis shown in Table 3 can be seen as a more detailed instantiation of the general schema for argumentative interactions discussed previously (§2.2, Table 1), using elements of Barth & Krabbe's (1982) dialectical model[18], but without claiming to perform dialogic logic proofs (we are describing real argumentation). Thus, in Table 3, dialectical moves (a)-(c) correspond to the opening phase, moves (d)-(h) to the argumentation phase, and moves (i)-(k) to the closing phase. The analysis is of course highly idealised, and deliberately only takes into account a single dimension (**D**), precisely so that other dimensions can be analysed with respect to it. For example, the idealised dialectical function of Mary's utterance (Table 2, line 181) " Pprrrttt!" is to raise doubts, and indirectly request defence; John's question (Table 2, line 190) "what have we forgotten then ?" is interpreted as a concession of the refutation of his thesis.

With respect to other dimensions, the first important point to be noted here is that John auto-reformulates (**I**) his defence "C" of his thesis (moves (c) and (e) in Table 3). Initially (line 182) he says that his thesis is justified because "it [energy ?, electricity ?] leaves from a reservoir and comes back to a reservoir". He then reformulates this proposal in order to move towards a more direct statement of the energy chain rule, provided by the teacher "A complete energy chain must start and end with a reservoir". This makes clear how a more legitimised form of knowledge (**E**) supports his thesis. In essence, his ingenious proposal is that since the

[18] We add one additional symbol "♦" to indicate moves that have the function of conceding — either a statement, or else a claim concerning the outcome of the argumentation itself — and a second, "⊗", to indicate explicitation of the argumentation outcome.

transfer leaves from a reservoir (battery) and comes back to one (the same battery, the arrows go round in a circle), his thesis satisfies the energy chain rule. From the combination of dialectical and interactive analyses, we can thus see that this reformulation is elicited by the *interactive pressure* of Mary's request for a defence (move (d) in Table 3).

The second important point concerns the nature of Mary's attack ("Have we got two batteries?", glossed as the proposition: "D = there are not two batteries in the experiment") and the underlying reasoning that links it to John's thesis, thus proposing that it is refuted. This is perhaps not obvious, although it appears to be fully understood by the students. Our interpretation is that Mary's refutation depends on an implicit elaboration (**I**) of the energy chain rule cited above, i.e.: "R1': An energy chain must start and end with a reservoir, *and the first and last reservoirs can not correspond to the same physical object*". Her reasoning is basically as follows: since R1', and given the concession that "the battery is a reservoir", then this would imply that there must by *two different batteries*, which is manifestly false (there is only one battery on the table before them !); so John's proposal is refuted (or at least, the energy chain rule is no defence for it).

The third point concerns the different types of knowledge (**E**) to which each student appeals in their dialectical moves (**D**). Mary appeals, in the final analysis, to basic facts of perceptual experience: there is only one battery ! As such, these facts can not be refuted, although the reasoning based on them could be. John appeals to knowledge whose source is the teacher (the energy chain rules). *However*, this is manifestly not the type of knowledge that underlies the solution that he proposes: the energy chain transfers go round in a circle like an electrical circuit, knowledge of electricity in fact underlies his solution. This argumentation is not simply a matter of rendering knowledge and reasoning explicit, but rather may involve *a posteriori* reconstruction, and the use of the most convincing arguments to hand (Baker, 1996a, 1996b; Baker, *to appear*). As we shall see, these basic epistemological stances remain relatively constant throughout the whole sequence.

Finally, we note that factors of interaction management (making sure that the other has received and understood the message) interfere with strict dialectical rules — for example, the repetition of attacks and defences in Table 3, (f)-(i). One basic dialectical rule is however always adhered to: an attack must be followed by a defence.

## 5.2 Subsequence 2:Mary's counter-thesis

In the subsequent subsequence Mary begins by explaining her way of thinking about the problem (a linear causal model — line 191 of Table 4), and proposes a counter-thesis (Figure 3), now that John's thesis has been refuted.

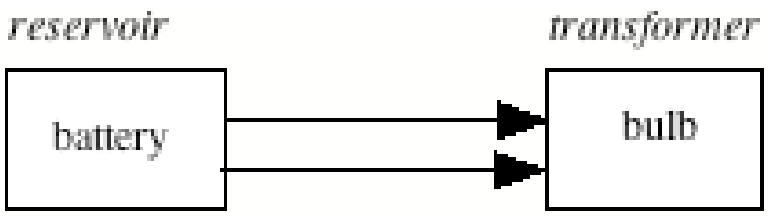

*Figure 3. Mary's counter-thesis*

TABLE 4: SECOND SUBSEQUENCE

| *Line* | *Loc* | *Dialogue* |
|---|---|---|
| 191 | M: | But no. I.....You know there, it's obvious that it's like that [two arrows both from battery to bulb]. I thought that. Look, there's the wire. Wait … Me, I thought it was like that ! That the two wires...You see, the energy goes from there [the battery]. It goes ttssouiii across the two wires and arrives there [the bulb]. You understand. So they're like that the two arrows. You understand what I'm trying to say ? I mean that it goes from there, there's a wire like that from the reservoir, there's a wire that goes from the reservoir and carries it to the battery, you agree ? And it's like that, there's the other wire. Me, I would have done it like that. |
| 192 | J: | Yes, but that's no good ! Look what they say "An energy chain … " |
| 193 | M: | I don't give a damn |
| 194 | J: | What ? |
| 195 | M: | I'm telling you I don't give a damn. For me it's like that. |
| 196 | J: | Yes but a complete energy chain begins and ends with a reservoir. |
| 197 | M: | Yes, but I've got it. But me, I'm telling you, it's not because they wrote that that we have to do that [John's solution] |
| 198 | J: | Uhh, but precisely, we do have to ! |

This subsequence illustrates two main phenomena. Firstly, epistemological stances (**E**) remain constant (see above): Mary appeals to perceptually-based facts, and John to the rules of the model. It is significant that Mary's thesis is based on linear causal reasoning, but which is nevertheless anchored in the perceptual world, since she says that the transfers correspond to the wires[19]. Secondly, the subsequence gives a good illustration of one type of relation between **D** and **R** dimensions: *dialectical refutation of a thesis does not necessarily lead to dropping a pro position with respect to it*. John accepted that his thesis was refuted (**D**) at the end of subsequence 1; however, this has *not* produced the effect that he drops his thesis (**R**). In fact, he uses the same argument (energy rule) that was a defence of his own thesis as an attack on Mary's. Mary's defence in fact appeals to her conception of the logical relations between the two theses debated: it is not because her thesis is not entirely satisfactory that his thesis is right.

## 5.3 Subsequence 3:Mary's finds a compromise, yet hesitates …

The students are now at something of an impasse: John's thesis has been refuted, although he has not, apparently, changed his mind about it; Mary's thesis has been shown to be inadequate, since it does not satisfy the energy chain rule. Mary therefore tries to find a compromise (Table 5) to resolve the conflict (**D**), that combines elements of both solutions (**I**).

[19] Note that this is in fact false. Mary has not understood that in modelling, there is no necessary one to one correspondence between entities to be modelled and elements of the model — it is not because there are two wires that there must be two *transfers* of energy; there should be only one transfer, of electrical work, from the battery to the bulb.

TABLE 5: THIRD SUBSEQUENCE

| *Line* | *Loc* | *Dialogue* |
|---|---|---|
| 199 | M: | In my opinion, in my opinion, it leaves from both sides, so … But you know, there could be two arrows in each direction … I'm going to tell you … |
| 200 | J: | Yeah, it doesn't begin and end with a reservoir, so it's not a complete energy chain |
| 201 | M: | John, John, I'm going to tell you s'mthing |
| 202 | J: | Yes |
| 203 | M: | They put "if there are several modes of transfer, you must have an arrow for each mode of transfer". You understand ? So there are two directions of arrows. There's that one [battery to bulb] and that one [bulb to battery]. It could be that there are two arrows in this direction [battery to bulb] and one in the reverse direction [bulb to battery], you agree ? Well, be logical. Eh ! |
| 204 | J: | That's all we have to put apart from that ? |
| 205 | M: | Uh, well me, I would have put the arrows in the other direction |
| 206 | J: | You put other arrows here ? |
| 207 | M: | It leaves from a reservoir and it goes to the transformer, I don't give a damn if it comes back to the … |
| 208 | J: | … and you take that off ? <silence> You take that off ? |
| 209 | M: | Uh, no ! Dunno about that ! I was just thinking about that. Because you see, me, I say to myself … Look: y've got the battery and y've the two wires, the energy, it goes across the two wires, so, it goes from the reservoir and it does that. You understand ? It's not that it goes through the wire, in my opinion, eh ? , it's not that it leaves in the wire, passes through the transformer and then it comes back to the reservoir in the other wire. You see what I mean ? It's that it goes from there [battery] and across the two wires, it arrives there [bulb], so it's the same direction, the arrows. <…> |
| 224 | J: | We can't put an arrow in that direction like that and in that direction. That doesn't mean anything |
| 225 | M: | [she reads the sheet] "One indicates on each arrow the mode of transfer. If there are several modes of transfer, you must have an arrow for each mode of transfer". Me, that's how I understood it. But we don't give a damn , everyone does it how he wants, we thought about it like that, the others haven't done it like us. |

Mary's proposal begins (lines 199, 203, 225 of Table 5) with the cognitive operation of *determination* (**C**) of the concepts /transfer/mode/: each of the transfers is now to be conceptualised as a different *mode* of transfer (either "energy" or "electricity"). Under our interpretation, this enables Mary to allow both partners to be 'right' and thus to resolve the conflict (**D**) by negotiating a compromise (**I**) that superficially combines the conflicting proposals. When in line 207 she states "I don't give a damn if it comes back …" then (as shown by the later dialogue) she proposes that the common solution could have only arrows from battery to bulb, if their mode is "energy" (her solution), but that this is not incompatible with there being a third transfer, that comes back to the battery, since this could be a different mode of transfer ("electricity"). What she appears to be proposing as a compromise is shown in Figure 4. It can be seen that her proposal combines and reconceptualises elements of the two opposed theses (Figures 2 and 3).

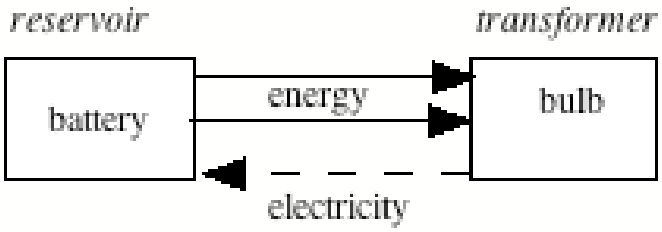


*Figure 4. Mary's compromise solution*

However, Mary hesitates (end of line 209), retracts, and returns to her own thesis, given that John does not accept her proposal (line 224), and perhaps because she has understood the incoherence or superficiality of her compromise.

## 5.4 The final refutation …

The complete sequence is resolved by refutation in the subsequence shown in Table 6.

TABLE 6: FOURTH SUBSEQUENCE

| *Line* | *Loc* | *Dialogue* |
|---|---|---|
| 226 | J: | Ah but, there's no return, that's it, we slipped up. There's no return, they're right [the dyad on the next table] |
| 227 | M: | But that's what I've been trying to tell you. That arrow there [bulb to battery] means that the energy, it passes from the transformer to the reservoir. That's never been seen. Otherwise, that [the bulb] never goes out. You see what I mean ? |
| 228 | J: | Pass me your eraser ? |

Significantly, it is John who refutes his own thesis, but by appealing to information outside this dyad's interaction (the solution of the students on the next table). Mary reformulates (**I**) this refutation (line 227), saying that that is what she had been trying to say all along. The refutation (**D**) is conclusive since it appeals to everyday knowledge (**E**): bulbs never shine forever. John concedes, Mary has won. This does not, however, necessarily mean that Mary's solution will be mutually accepted (**R**).

# 6. DISCUSSION: CONSTRUCTIVE MECHANISMS IN ARGUMENTATIVE INTERACTIONS

For the case of collaborative problem-solving interactions, we have seen how the dialectical framework of argumentative interactions imposes a special *interactive pressure* (to resolve

verbal conflicts) on the participants. This pressure stimulates students to draw on different types of knowledge, to determine and differentiate concepts, to negotiate the meaning of key terms in the domain of reference and to combine elements of solutions as compromises. To paraphrase Wittgenstein's striking expression (Wittgenstein, 1980, pp. 9/9e), verbal conflicts are thus usually *dissipated* or *dissolved* rather than *resolved*, in a strictly dialectical sense. The interactive and interactional phenomena described above thus constitute an answer to our first question in this specific case: how are argumentative interactions constructive, in the sense of leading to co-elaboration or emergence of meaning and knowledge ?

Our second question concerned constructive interaction in the sense of the overall function of argumentative interaction with respect to collaborative problem solving: how might it be seen as contributing to this activity ? It appears that one intuitively plausible possibility can be eliminated in this case: argumentation does not always function as a means of augmenting shared knowledge. It is not primarily a means by which a proposal, when successfully defended, then becomes accepted by all parties involved. Usually, and in the cases described above, its function is to *eliminate* 'flawed' proposals (Baker, 1996a, 1996b), i.e. those with respect to which it is mutually recognised that there is at least one counter-argument. Thus in the above examples, John's solution was eliminated by refutation (example 1); Mary's solution remained as a plausible candidate, yet John still maintained that it was not acceptable since it did not satisfy the energy chain rule. This process may be ultimately constructive in our second sense to the extent that unfruitful problem-solving paths are not taken by the students.

Such elimination can also be constructive in the first sense to the extent that it leads to a joint attempt to understand *why a proposal is not acceptable* (rather than leading to discussion of why a proposal *is* acceptable). In simple terms: if no-one has found anything wrong with a proposal, then why inquire into its foundations ? It is only when something appears to be wrong that the need to explain and understand is felt and acted upon. Therein may lie the real key to understanding the constructive interaction (in both senses) engendered by argumentation. It is true that, when one of two competing proposals is eliminated from consideration, the remaining one may be considered as the 'common' solution. But this does not necessarily mean that it is mutually believed. Rather, it may be mutually *accepted* (Cohen, 1992), 'for the sake of argument', given the basic contract of the interaction that at least some 'common' solution must be proposed at the end of the session (something, although not completely agreed, is better than nothing).

## 7. CONCLUSIONS AND FURTHER WORK

The analyses presented here go some way towards furthering our understanding of how argumentative interactions produced in collaborative problem-solving situations can be constructive, in the sense of leading to co-elaboration of meaning and knowledge, and in the sense of fulfilling a specific role in the collaborative activity. Our main proposal is that analysis of strictly argumentational aspects (i.e. dialectics and rhetoric) can not alone give us the key to these problems, which lies rather in understanding the interrelations between five analytically distinct dimensions. We have seen how argumentative interactions can lead to reconstruction rather than explicitation of knowledge, how the pressures they exert on

participants can lead to co-elaboration of meaning, and how they act as filters of flawed proposals.

For the present, our analysis approach has been applied to corpora of communicative interactions in the domain of learning physics (the present chapter; Baker, 1991, 1996a, 1996b). However, as Golder (1996) points out, one does not argue about anything, with anyone and in any social-institutional situation. The extent to which this approach can lead to insight into constructive processes involved in a wider range of tasks and situations therefore remains to be determined. Although our results are presently limited to domains of school physics that are relatively 'closed' (a determinate set of correct solutions exists), these domains provide a sufficiently wide space of debate given that they require the students — especially in qualitative modelling tasks — to draw on a wide variety of types of knowledge. In more 'open' domains, such as social science and humanities subjects, an even wider space of debate exists since argumentation in terms of different theoretical and methodological approaches is an integral part of these domains from the very outset (Goodyear & Stone, 1992). It is therefore reasonable to conjecture that the approach described here will find application beyond the specific tasks to which it has been applied up to the present, provided that the tasks are 'knowledge-rich', and especially when they are also open-ended. In fact, it is difficult to conceive of an argumentative interaction occurring with respect to a task that was neither 'knowledge rich' nor open-ended: in that case there could be little to argue about. Elaborating a theoretical analysis of the nature of problem-solving situations-tasks that allow the emergence of both argumentative interactions and collaborative learning remains a fascinating goal for future research.

A second specificity of the task analysed here resides in the fact that the students were asked to reach agreement on a single solution to the problem: would similar constructive processes be likely to occur if this constraint was relaxed ? We speculate that, in the case where students simply 'worked together' (spontaneously or by request), and could propose divergent individual solutions, this would in fact alleviate many unproductive aspects of argumentative interactions along the interactive dimension, such as the generation of false or 'too easy' compromises. Once people are engaged in communicative interaction, they can not always avoid addressing conflicting views, adopting positions and justifying themselves, without losing 'face' on a social level. In that case, they become committed to following the driving forces, the interactive dynamics, of argumentative interactions through to the end. This would usually require making the terms of debate more precise, along the conceptual dimension, and eventually seeking a cooperative or constructive resolution to the social and cognitive conflict of views.

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## REFERENCES


Austin, J.L. (1962). *How to do things with words*. Cambridge: Cambridge University Press.

Baker, M.J. & Lund, K. (1997). Promoting reflective interactions in a computer-supported collaborative learning environment. *Journal of Computer Assisted Learning*, 13, 175-193.

Baker, M.J. (1991). The Influence of Dialogue Processes on the Generation of Students' Collaborative Explanations for Simple Physical Phenomena. *Proceedings of the International Conference on the Learning Sciences*, pp. 9-19**.** Evanston Illinois, USA, August 1991.

Baker, M.J. (1994). A Model for Negotiation in Teaching-Learning Dialogues. *Journal of Artificial Intelligence in Education*, 5(2), 199-254.

Baker, M.J. (1995). Negotiation in Collaborative Problem-Solving Dialogues. *Dialogue and Instruction: Modeling Interaction in Intelligent Tutoring Systems*, (eds.) R.-J. Beun, M.J. Baker & M. Reiner, pp. 39-55. Berlin: Springer-Verlag.

Baker, M.J. (1996a). *Argumentation and Cognitive Change in Collaborative Problem-Solving Dialogues*. Research Report N° CR-13/96 of the COAST Research Team, Lyon [http://sir.univ-lyon2.fr/GRIC-COAST/coast.rapports.eng.html].

Baker, M.J. (1996b). Argumentation et co-construction des connaissances. *Interaction et Cognitions*, 1, 2/3, 157-191. Paris: Editions L'Harmattan,.

Baker, M.J. (*to appear*). Argumentative Interactions and Cooperative Learning. *Escritos* [in Spanish translation].

Barth, E.M. & Krabbe, E.C.W. (1982). *From Axiom to Dialogue: A philosophical study of logics and argumentation*. Berlin: Walter de Gruyter.

Bunt, H.C. (1995). Dialogue Control Functions and Interaction Design. R.J. Beun, M.J. Baker & M. Reiner (Eds.), *Dialogue and Instruction, Modeling Interaction in Intelligent Tutoring Systems*, pp. 197-214. Berlin, Springer-Verlag.

Chi, M.T.H. & VanLehn, K.A. (1991). The Content of Physics Self-Explanations. *Journal of the Learning Sciences*, 1(1), 69-105.

Chi, M.T.H., Bassok, M., Lewis, M.W., Reimann, P. & Glaser, R. (1989). Self-Explanations: How Students Study and Use Examples in Learning to Solve Problems. *Cognitive Science* , 13 (2), 145-182.

Clark, H.H. & Schaefer, E.F. (1989). Contributing to Discourse. *Cognitive Science,* 13, 259-294.

Cohen, J., Morgan, J. & Pollack, M. (1990). *Intentions in Communication*. Cambridge Mass.: MIT Press.

Cohen, L.J. (1992). *An Essay on Belief and Acceptance*. Oxford: Clarendon Press.

Devi, R., Tiberghien, A., Baker, M.J. & Brna, P. (1996). Modelling Students' construction of energy models in physics. *Instructional Science*, 24, 259-293.

Dillenbourg, P. & Baker, M.J. (1996). Negotiation Spaces in Human-Computer Collaboration. Proceedings of *COOP'96, International Conference on Design of Cooperative Systems*, Juan-les-Pins, France, June 1996.

Dillenbourg, P., Baker, M.J., Blaye, A. & O'Malley, C. (1995). The evolution of research on collaborative learning. In H. Spada. & P. Reimann (eds.) *Learning in Humans and Machines,* pp. 189-205, London: Pergamon.

DiSessa, A. (1988). Knowledge in Pieces. In G. Forman & P. Pufall (eds.), *Constructivism in the Computer Age*. Hillsdale NJ: Lawrence Erlbaum Associates.

Ducrot, O. & Schaeffer, J.-M. (1995). (eds.) *Nouveau Dictionnaire Encyclopédique des Sciences du Langage*. Paris: Editions du Seuil.

Festinger, L. (1957). *A theory of cognitive dissonance*. Stanford: Stanford University Press.

Gardenförs, P. (ed.) (1992).*Belief Revision* (Cambridge Tracts in Theoretical Computer Science 29), Cambridge: Cambridge University Press.

Golder, C. (1996).*Le développement des discours argumentatifs*. Lausanne: Delachaux & Niestlé.

Goodyear, P. & Stone, C. (1992). Domain Knowledge, Epistemology and Intelligent Tutoring in Social Science. In R. Moyse & M. Elsom-Cook (eds.) *Knowledge Negotiation*, pp. 69-96. London: Academic Press.

Grice, H.P. (1957). Meaning. *The Philosophical Review*, LXVI (3), 377-388.

Kerbrat-Orecchioni, C. (1990). *Les Interactions Verbales (Tome 1)*. Paris: Armand Colin.

Lave, J. & Wenger, E. (1991). *Situated Learning: Legitimate peripheral participation*. Cambridge (UK): Cambridge University Press.

Lave, J. (1988). *Cognition in Practice*. Cambridge: Cambridge University Press.

Lave, J. (1991). Situated Learning. In L.B. Resnick, J.M. Levine & S.D. Teasley (eds.) *Perspectives on Socially Shared Cognition*, pp. 63-82. Washington D.C.: American Psychological Association.

Mandl, H. & Renkl, A. (1992). A plea for 'more local' theories of cooperative learning. *Learning and Instruction*, 2, 281-285.

Miyake, N. (1986). Constructive Interaction and the Iterative Process of Understanding. *Cognitive Science*, 10 (2), 151-177.

Moeschler, J. (1985). *Argumentation et Conversation: Eléments pour une analyse pragmatique du discours*. Paris: Hatier-Crédif.

Muntig, P. & Turnbull, W. (1998). Conversational structure and facework in arguing. *Journal of Pragmatics*, 29, 225-256.

Naess, A. (1966). *Communication and argument. Elements of applied semantics*. London: Allen and Unwin.

Nonnon, E. (1996). Activités argumentatives et élaboration de connaissances nouvelles: le dialogue comme espace d'exploration. *Langue Française, 112* (décembre 1996), 67-87.

Perelman, C. & Olbrechts-Tyteca, L. (1958/1988). *Traité de l'argumentation. La nouvelle rhétorique*. Bruxelles: Editions de l'Université de Bruxelles.

Plantin, C. (1990). *Essais sur l'argumentation: introduction linguistique à l'étude de la parole argumentative*. Paris: Kimé.

Pontecorvo, C. (ed.) (1993). *Cognition and Instruction*, 11 (3 & 4). Special issue: Discourse and Shared Reasoning.

Resnick, L.B., Levine, J.M. & Teasley, S.D. (eds.) (1991). *Perspectives on Socially Shared Cognition*. Washington D.C.: American Psychological Association.

Resnick, L.B., Salmon, M.H., Zeitz, C.M., Wathen, S.H. & Holowchak, M. (1993). Reasoning in conversation. *Cognition and Instruction*, 11 (3 & 4), 347-364.

Roulet, E. (1991). On the structure of conversation as negotiation. *(On) Searle on Conversation* (J.R. Searle et al.), pp. 91-99. Amsterdam: John Benjamins.

Roulet, E. et al. (1985). *L'articulation du discours en français contemporain*. Berne: Peter Lang.

Searle, J. (1969). *Speech Acts*. Cambridge: Cambridge University Press.

Suchman, L. (1987). *Plans and situated actions: The problem of human-machine communication*. Cambridge: Cambridge University Press.

Tiberghien, A. (1994). Modeling as a basis for analyzing teaching-learning situations. *Learning and Instruction* 4, 71-87.

Tiberghien, A. (1996). Construction of prototypical situations in teaching the concept of energy. G. Welford, J. Osborne & P. Scott (Eds.) *Research in Science Education in Europe*, pp. 100-114. London: Falmer Press.

Toulmin, S. (1958). *The Uses of Argument*. Cambridge: Cambridge University Press.

Trognon, A. (1990). Relations Intersubjectives dans les Débats. *L'Interaction Communicative*. A. Berrendonner & H. Parret (eds.). Berne: Peter Lang.

van Eemeren, F. H. & Grootendorst, R. (1984). *Speech Acts in Argumentative Discussions*. Dordrecht-Holland: Foris Publications.

van Eemeren, F.H., Grootendorst, R. & Henkemans, F.S. (1996). *Fundamentals of Argumentation Theory: A Handbook of Historical Backgrounds and Contemporary Developments*. Mahwah New Jersey: Lawrence Erlbaum Associates.

Vignaux, G. (1988). *Le Discours Acteur du Monde: Enonciation, argumentation et cognition.* Paris: Ophrys.

Vignaux, G. (1990). A Cognitive Model of Argumentation. F.H. van Eemeren, R. Grootendorst, J.A. Blair & C.A. Willard (eds.), *Proceedings of the Second International COnference on Argumentation*, Vol.1 (June 19-22), chapter 40, pp. 303-310.

Voss, J.F. & Means, M.L. (1991). Learning to reason via instruction in argumentation. *Learning and Instruction*, 1, 337-350.

Voss, J.F., Blais, J. & Means, M.L. (1986). Informal reasoning and subject matter knowledge in the solving of economics problems by naive and novice individuals. *Cognition and Instruction* , 3(4), 269-302.

Walton, D.N. (1989). *Informal Logic*. Cambridge: Cambridge University Press.

Walton, D.N. (1992). *Plausible argument in everyday conversation*. New York: State University of New York Press.

Webb, N.M. (1991). Task-related verbal interaction and mathematics learning in small groups. *Journal for Research in Mathematics Education*, 22 (5), 366-389.

Wittgenstein, L. (1980). *Culture and Value*. (Ed.) G.H. von Wright. Oxford: Basil Blackwell.