Collaboration in collaborative learning

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This paper presents a theorisation of collaborative activity that was developed in the research field known as "collaborative learning", in order to understand the processes of co-elaboration of meaning and knowledge. Collaboration, as distinguished from cooperation, coordination and collective activity, is defined as a continued and conjoined effort towards elaborating a "joint problem space" of shared representations of the problem to be solved. An approach to analysing the processes of co-construction of a joint problem space is outlined, in terms of inter-discursive operations, together with approaches to defining different forms of cooperative activity. In conclusion, the specificity of this approach to defining collaboration is discussed in relation to other fields of research.

Keywords: collaboration; cooperation; coordination; collective activity; dialogue; learning; knowledge elaboration; argumentation

1. Introduction

Collaborative activities have been studied across many scientific disciplines, for a diversity of reasons. These include understanding human social and cognitive development from early infancy (Vygotsky, 1978), analysing shared problem solving (Roschelle & Teasley, 1995), analysing collective work (Schmidt, 1994), studying specific psychological processes such as collaborative remembering (Edwards & Middleton, 1986), and trying to understand what differentiates humans from other primates (Hamann, et al., 2011). In computer science, models of collaborative action and communication have been developed as a basis for designing more effective human-machine interaction systems (Grosz & Sidner, 1990) and computer-based shared workspaces (e.g. Dourish & Bellotti, 1992).

Given such a diversity of aims in studying collaboration across disciplines, and the fact that scientific concepts are forged within specific research programmes, the question arises as to whether there could be a coherent and operational trans-disciplinary theory and model of collaboration. In order to contribute to such an investigation, this paper describes a particular theorisation of collaborative activity,

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elaborated in the field known as "collaborative learning" (henceforth abbreviated to "CL") (Dillenbourg, et al., 1996; Dillenbourg, 1999a, 1999b)[1], including the part of that field concerned with the role of technology mediation, called "computer supported collaborative learning" (henceforth abbreviated to "CSCL")[2]. In that context, the motivation for elaborating an operational definition of collaborative activity is to try to understand the types of processes at work in groups of students that (dis)favour learning. This is important for interpreting experimental results, as well as for designing educational situations based on CL and CSCL.

After presenting characteristics of situations studied in CL, and a first definition of collaboration, distinguishing it from cooperation, coordination and collective activity, I describe a particular model of collaboration (Baker, 1994, 1995), situated within an analysis of forms of cooperation (Baker, 2002b), based on interdiscursive transformations of knowledge and understanding. By way of conclusion, I discuss the domain-specificity of the way that collaboration is theorised in CL research.

2. Collaborative learning research: Situations, cooperation and collaboration

Collaborative learning research emerged in the 1970s, for practical reasons (for example, scarce resources such as computers had to be shared between students) and as a reaction to psychological and education approaches centred on the individual learner. Further motivations for focussing on group processes related to changes in society that emphasised the need to learn to work with others in and out of school – especially in an increasingly globalised world, fuelled by Internet technologies – and changes in authority structures on a societal level that allowed the students' voices[3] to be heard in the classroom. This paper focuses very

1. This short paper focuses specifically on the way in which the concept of collaboration has been defined in the domain of collaborative learning research, and therefore does not provide a review of this domain itself, for which references to research syntheses and specific studies are given in the present text.

2. See, for example, the *International Journal of Computer Supported Collaborative Learning*: http://ijcscl.org

3. Throughout this paper, notwithstanding developmental differences, the term "student" will be used in the general sense of "learner", a person acting in a situation that is designed to favour learning, referring without distinction to primary school children, secondary school pupils, university students or even older adults.

specifically on the way that "collaboration" has been defined in the field of CL, and therefore reviews research in the field only to the extent that it contributes to the main focus here. References to general research syntheses and specific research are given throughout the paper.

Early research on CL focussed on trying to identify the conditions under which working together (e.g. in pairs) was most effective, for example in comparison with working alone: when are 'two heads better than one' (e.g. Azmitia, 1988; Mullins, Rummel & Spada, 2011)? As might be predicted, whether working together is more effective, in terms of quality of problem solutions and learning outcomes, depends on other variables, such as the type of task, the age of participants, the number of members in the group, differences in prior knowledge and gender (e.g. Joiner & Littleton, 2013). Thus, it became recognised that results were difficult to generalise beyond specific tasks (Dillenbourg, et al., 1996). What has become known as the "interactions paradigm" addressed this problem by searching for dominant frequencies of 'types' of interactions between students (e.g. more or less explanatory, conflictual, argumentative, task-focussed, etc.), treated as intermediary variables that could explain why some groups functioned and learned better than others. All this required a theoretical model of collaboration, in order to avoid choosing interaction categories in an *ad hoc* manner, and also as a basis for designing collaborative educational technologies.

3. General characteristics of group work in learning situations

Before proceeding, it is necessary to state a few assumptions about what (potentially) collaborative *situations* are considered to be in CL research, that are so widely assumed that they are rarely made explicit (but cf. Dillenbourg, 1999b), but which need to be stated here in order to clarify the scope of the theorisation of collaboration in CL research.

Firstly, students working together are assumed to be *equals*, in terms of their *statuses* and *rights* to intervene in the interaction, although they are rarely equals in terms of prior knowledge and other relevant social and cognitive characteristics. Each has the social status of "student". This apparently simple condition effectively excludes from consideration as "collaboration" many interactions between teacher and student. For example, in classroom interactions, teachers have the right to make negative evaluations of high-school students' responses to questions posed to them, and routinely do so (Sinclair & Coulthard, 1975); however, students rarely have the right to criticise teachers' ways of interacting with them, at least in

face-to-face interactions[4]. Similarly, according to the definitions proposed here, in work situations, most face-to-face interactions between manager and employee cannot be characterised as cases of collaboration (although managers may often speak of their "collaborators", employees do not usually describe their managers in the same way) given asymmetry of rights between participants. Collaboration, here, therefore refers to an interaction between persons having equal statuses and rights in the interaction, who are not necessarily equals in other respects.

Secondly, group work is usually organised by requiring the groups to work on, and hand in to the teacher, *a single shared production or solution* to the problem they are set. This is a means for 'engineering' the need to work together, although the design of effective collaboration situations requires developing tasks whose achievement makes it actually *necessary* to work together, given that the problem can not be solved alone. Reasons for organising situations of group work are not only related to supposed efficiency in learning, in comparison to working alone. From a developmental point of view, it is social action in groups that is primary, with working alone being a particular and derivative case. Going further in this direction, Crook (2013) has argued that the desire to 'share', to achieve 'mutuality' is a basic and defining drive of human beings; being motivated to 'share' our experiences with others, and sometimes taking pleasure in this for its own sake, is part of what it means to be human, and not only a more or less efficient strategy for achieving a task. Indeed, the outcomes that students report of having engaged in cooperative work go beyond considerations of learning of taught content, to include increased self-esteem and liking of school (Slavin, 1989).

Thirdly, not all 'group work' is either cooperative or collaborative. This point requires further definition of cooperation and collaboration (see below); but what it basically means is that when students are in a 'group work' situation, they are assumed to share the goal of arriving at a shared solution (see point two above), i.e. one on which they all agree (although this may turn out to be impossible). However, when students are in a group work situation (either face to face or at a distance), for a given duration (say, more or less one hour), there will be periods during which they are not attending to each other or to a joint task focus, with each student working individually on a related subtask; in which case, the students can not be said to be collaborating during those periods. This means that the term collaboration will most likely only be applicable to certain specific phases of group work; and identifying such phases – that, by hypothesis, relate to learning

4. In many contemporary universities, students are given the right to criticise their teachers' actions, but this is usually done outside classroom social interaction, using questionnaires. I am grateful to a reviewer for having reminded me of this point.

outcomes – requires a strong theory of collaborative activity. An important corollary of this point is that collaboration presupposes a high degree of *joint attention* (e.g. to a shared tangible object relating to the task, to an aspect of the problem) and *a mostly synchronous interaction*. I shall return to this point later.

Fourthly, an important characteristic of collaborative learning situations is the extent to which a known procedure exists for solving the problem. For example, in the case of a school mathematics problem, the solution procedure may be commonly known, and collaboration could therefore concern the way the procedure is applied. But the most 'collaborative' situations are those that are largely *exploratory*, where no clear plan or procedure exists for solving the problem (or, indeed, for organising collaboration). In such situations, the aim will be for students to explore the problem space and in so doing gain deeper conceptual understanding. This is collaboration as "co-elaboration" of knowledge and understanding of the joint problem space (again, see below).

Fifthly, and in relation to the previous point, the aim of group work situations in education – at least from the point of their designers (e.g. the teacher) – is often that the students learn, in the sense of co-elaborating and appropriating task-related conceptual understanding, and not only that they reach the correct answer to the given problem. For example, in a task where students are asked to draw diagrams to represent transfers and transformations of energy in simple experimental situations (Tiberghien & Megalakaki, 1995), the main aim was not that students should learn to draw such diagrams for themselves, but rather that, in trying to draw them together, they should gain deeper understanding of the concept of energy. This will mean that collaboration, in CL, is intimately related to *the processes of co-elaboration of conceptual understanding and knowledge* relating to the task domain.

Finally, in most CL situations in the classroom, or via Internet, the role of the teacher obviously differs from one-to-one or whole class situations. The teachers' roles are principally to create students' working groups, to organise their work by providing task instructions and educational materials or supports, and to evaluate the students' work, handed in at the end of the working session. Teachers do not usually intervene in a continuous manner during the work of the groups themselves, because this would be practically difficult (for example with 24 students organised in 8 groups of 3), although they usually do monitor groups occasionally, and intervene to provide help on students' requests. This contrasts with whole-class work, where teachers are of course usually the "classroom orchestrators"; and real-time teacher monitoring of student groups becomes more possible (although it is not without its difficulties) in the case of online CL (Baker, 2008; Dillenbourg, 2013). In the case where teachers do provide tutoring for groups, this is often proposed and studied in terms of the Vygotskian notion of "scaffolding",

where a more capable person provides indirect support for a less capable person's problem-solving (Woods, Bruner & Ross, 1978), within the latter's "zone of proximal development" (Vygotsky, 1978).

Each of the possible and usual roles for the teacher in CL just mentioned – *creating*, *organising* and *evaluating* student groups – has given rise to extensive research, which can only be mentioned briefly here. Theoretically, at least, teachers could create groups of students on the basis of any of the conditions that are known to influence CL mentioned above (e.g. differences in individual participants' prior knowledge or competence, gender differences, group size, interpersonal relationships, etc.). But in educational practice, this is difficult to put into effect: in the 21st century, in Europe, teachers usually allow students who want to sit near each other to do so[5], carrying out 'fine-tuning' of seating arrangements during the year; thus groups are usually organised simply in terms of spatial proximity (students work with others sitting next to them). Another common approach is to create "friendship pairs" (Jones & Issroff, 2005), on the basis that students who already know each other will devote less effort to regulating the interpersonal relationship, and thus be able to expend more effort on achieving the task. Quignard (2000) has demonstrated mathematically that optimising the creation of sets of groups within a class (e.g. 6 groups of 2, from 12 students) according to criteria such as differences between students' task-related conceptualisations, is a complex optimisation problem, for which there is not necessarily a single good solution. In practice, therefore, creating optimal groups for CL is a difficult and practice-based matter.

Turning to the question of the organisation of how students' group work should proceed, this is often left open in educational practice: students are given instructions on a problem to be solved, together; and how they should work together is not defined by the teacher. Some experimental work has, however, led to proposals for both organising collaborative work into specific phases and for prescribing how collaborative dialogue should be performed. In the former category, for example, the "jigsaw method" (Aronson et al., 1987) aims to create positive interdependence between students, by dividing up responsibilities for achieving elements of a task (cf. the discussion of cooperation, below), and asking students to then present and pool the knowledge they have acquired individually. Computer interfaces provide concrete means for organising how collaboration will proceed; and, in CSCL research, this has given rise to a subfield of research on "scripting" collaboration (Fischer et al., 2007; see below in this paper) for favouring learning.

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5. According to the author's personal experience, in England and in France, at least 40 years ago, students in class were organised in ranks of rows of desks, according to academic ability, with the 'good students' at the front of the class near the teacher.

With respect to the organisation of collaborative dialogue itself (see the discussion of forms of cooperation, below), proposals have been made for defining a set of "ground rules" for effective CL (Mercer, Wegerif & Dawes, 1999): for example, students should listen to each others' proposals, be fair in their criticisms, etc.

How to evaluate students' collaborative work, in a way that encourages productive collaboration, is a thorny issue in educational research and practice. Providing feedback to students on their progress is an integral part of teaching; but there is a paradox here: on the one hand, teachers need to evaluate individual students' abilities (that is a societal choice), but this can not be done if evaluation concerns only the product of collaboration; on the other hand, evaluating individual contributions to collaborative work emphasises individual contributions, possibly to the detriment of collaboration itself (see below). Collaboration is not a mere juxtaposition or collation of individual efforts, so, if collaboration has occurred, then it will be difficult to evaluate individual contributions from the joint output. Teachers usually opt for a combination of individual and group evaluation (evaluating individual progress, on the basis of individual tests following collaboration, as well as the quality of the collaborative product). On the basis of extensive meta-reviews of CL research (Slavin, 1983), a clear result emerged: cooperative learning is most effective when the task to be achieved is *not* subdivided into sub-tasks distributed across participants (i.e. as in the case of "cooperation", as defined below) and when evaluation (feedback) is given to the group as a whole on the basis of (the average of) the cognitive progress of individual group members.

The main points made above are not absolute definitions of group work, cooperation and collaboration in every type of situation: they are defining characteristics of such situations as they are studied in CL research, and as such the limit the scope of the model of collaboration sketched out here.

4. Collaboration, cooperation, collective activity and coordination

The definition of collaboration proposed by Roschelle and Teasley (1995) has become generally accepted in the field of CL (e.g. Dillenbourg, 1999b), and has given rise to several extensions that will be discussed forthwith. The initial definition given by Roschelle and Teasley (*ibid.*) is as follows:

> Collaboration is a coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem. We make a distinction between 'collaborative' versus 'cooperative' problem solving. Cooperative work is accomplished by the division of labour among participants, as an activity where each person is responsible for a portion of the problem solving. We focus on collaboration as the mutual engagement of participants in a coordinated effort to solve the problem together. (p. 70)

To *cooperate* means at least to share a common goal (or one that is assumed to be shared, such as building a model of the Eiffel Tower with Lego™), towards whose achievement each participant in the group will strive. But this is compatible with dividing up the task into subtasks and assigning individual (or subgroup) responsibilities for achieving each of them (e.g. "you make the plan, you others select the bricks, and I'll build the tower"). To *collaborate* means at least to cooperate (in the sense of pursuing a goal that is assumed to be shared), but also to go further than this, in working together in a more or less synchronous way, in order to gain a *shared understanding* of the task. In this sense, cooperation is a more general concept and phenomenon than collaboration. *Collaboration is a specific form of cooperation*: *cooperation works on the level of tasks and actions, collaboration works on the plane of ideas, understanding, representations.*

The (invented) example of three students (X, Y and Z) writing a short joint project report on flora and fauna in their local park will help to clarify this distinction between cooperation and collaboration. Students could *cooperate* on this joint task, in the sense of working towards the shared goal of producing the report by dividing up responsibilities for achieving subtasks: for example, "you, Y, write up the data; you, Z write the references and describe the park; I, X, will write the introduction and conclusion". Or they could *collaborate*, in the sense of studying the park, analysing data, writing the report together, side by side, from beginning to end, discussing as they go along, with respect to what they are trying to do, how they should do it and what is meant by elements of the task (such as "flora", "the park", "the report").

It should be noted that this distinction between cooperation and collaboration corresponds broadly to ordinary usage (although the nuance between the meanings of the two words in the English language is often slight). This does not mean that these definitions are universally correct, and in any case the aim here is to develop precise scientific meanings for these terms. Rather, it gives some indication that the definitions are not completely spurious. Consider the tragic example of country Alpha invaded and occupied by the armies of country Beta. People from Alpha who 'work with' the enemy Beta in some way are not usually accused using the pejorative term "cooperator!", but are rather decried using the term "collaborator!". This confirms that what people see as reprehensible is not so much that others have "cooperated", in the sense of having performed certain actions corresponding to the enemy's goals or orders, probably under duress; but rather that they had "collaborated" with the enemy, in the sense of having actively shared and participated in developing the enemy's system of *ideas* and *values* (ideology), thereby going beyond what is minimally necessary (i.e. cooperation). This is in alignment with the definition of collaboration as an active and joint process of elaboration on an ideational plane. Notwithstanding the negative example of

collaboration mentioned above, it is probably true to say that collaboration is usually connoted positively, as a 'good thing', despite well-known problems that can occur in students' group work, such as demotivation, exclusion and even interpersonal aggression (Baker, Bernard & Dumez-Féroc, 2012).

Figure 1 shows an example of collaboration, taken from a corpus of interactions recorded in a high school physics classroom[6], where the students (each 17 years old), working in pairs, had been asked to identify the forces acting on a stone, which has been suspended by a string on a support (in the photograph taken from a video recording reproduced in Figure 1, student A is to the left and student B to the right).

Figure 1. Example of joint focus and collaboration in the physics classroom

The dialogue (of 16 seconds' duration) shown in Table 1 was produced by the students beginning at the photograph shown in Figure 1 (it was taken at the point where student A says, in line 223 of Table 1, "what are the objects that act on the stone(?)").

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6. I am grateful to Asuman Küçüközer (see Küçüközer, 2005) for permission to reproduce this image and corpus extract.

Table 1. Extract from a physics problem-solving dialogue in the classroom*

Line Num.	Speaker	Dialogue	
		English translation	**Original French version**
223	B	what are the objects that act on the stone	quels sont les objets qui agissent sur la pierre
224	A	– *laughs, indicates the stone with his pen* – what does it mean, "to act"(?)	– *il rit, indique la pierre avec son stylo* – ça veut dire quoi « agir » (?)
225	B	errrm(:::) that make it(:::) – *A and B laugh together* –	bein(:::) qui font que(:::) – *A et B rient ensemble* –
226	A	you see(!)	tu vois(!)
227	B	Dunno know how to explain, but well … that act	je sais pas comment expliquer, mais bon … qui agissent
228	A	that that hold(?)	qui qui tiennent(?)
229	B	given that, that notion of interaction	vu que, que cette notion d'interaction

*The original French transcription has been translated into English by the author, whilst attempting to retain the informal character of the students' speech. In the transcription, "(:::)" indicates prolongation at the end of a word; "(?)" indicates interrogative intonation; "(!)" indicates exclamatory intonation; behaviours and paraverbal aspects are thus, in italics "– behaviour –".

In the interaction sequence represented by Figure 1 and Table 1, the two students are collaborating because: (a) their faces, bodies, hands are jointly oriented towards the same objects (alternately, the stone, the string, the stand, the exercise book) and (b) in their synchronous interaction, linguistic uptake and reformulation occurs *between* the discourses of each student: [verb] "to act on" (line 223) ~>"to act" (line 224) ~>"to do [*faire*]" (line 225) ~>"to act" (line 227) ~>"to hold"(line 228), "to interact" (line 229)[7], (c) the students share the sub-goal of trying to elaborate a shared understanding of the expression "to act on", found in the problem statement, with respect forces and stone suspended by a string.

It is necessary to go further in these definitions, with respect to several points, in order to situate the concepts of cooperation and collaboration as defined so far with respect to others related concepts, such as collective activity and coordination.

Firstly, in real situations, cooperation and collaboration are closely linked. *Cooperation will usually require at least some collaboration*, if only to agree initially on an understanding of what the task is and how it is to be divided up amongst participants, as well as to integrate individual contributions in the final joint prob-

7. The symbol "~>" in expressions such as "x ~> y" is here used to mean "x is transformed into y".

lem solution. In general, the longer the duration of individual cooperative work, the more each contribution will 'drift' away from the others, and the harder it will be to achieve final integration. It is an empirical question as to the best balance between cooperation and collaboration in specific situations.

Secondly, the concept of *collective activity* can be defined in relation to cooperation and collaboration. Collective activity is a much more general concept than even cooperation. In terms of cultural-historical activity theory (Leont'ev, 1979), an activity is defined on the level of society – and is thus 'collective' by definition – as a concerted effort that requires some degree of coordination (see below), and is oriented towards the satisfaction of a human basic need. For example, hunting and education are collective activities on a societal level, responding to the needs of hunger (amongst other cultural needs) and cultural transmission of skills. Another example of a collective activity would be the writing of a Wikipedia article. Here, the background societal need, in the 21st century, might be "to share knowledge on a global level"; and this can be carried out by individual persons all working on a given object – the Wiki text – without their necessarily engaging in cooperation – in the sense of agreeing who will work on what – or indeed in collaboration – in the sense of elaborating, within the group of writers, a shared understanding of what is to be expressed in the text. There could, however, occur 'zones' or phases of cooperation within such collective activity (such as when participants agree to work on different subtasks, or parts of the article) and zones of collaboration, such as when disagreements occur, and it is necessary to discuss what the article is about, as well as for whom it is destined (e.g. Détienne et al., 2012).

Thirdly, the term *coordination* refers to the process of *ordering* of entities (events, behaviours, actions) in *time*, simultaneously or sequentially. Members of a string quartet are coordinated when they play notes of chords together that should be played together, and when they each play in an order defined by the score and in reaction to each other. In terms of the definitions presented above, coordination is required in socially organised collective activity, such as hunting, on the level of specialised activities, such as making weapons, beating the prey in a particular direction, stalking, killing, bringing the meat home, skinning, cooking, etc. It is also required on the level of actions and behaviours within these specialised sub-activities. With respect to cooperation, coordination applies the individual work on subtasks carried out by different persons, and most probably involves a more or less precise plan, that says who will do what in what order. But it is in mostly synchronous collaboration that coordination is most salient, for example on the level of non-verbal behaviours, posture, facial expressions and turn-taking (overlapping, interruption, sequentiality). It would be possible to extend the notion of coordination to individual representations of the task, in which case the notion of *coordination of representations* would approach the above definition

of collaboration itself. But it is not clear that greater conceptual clarity would be thereby achieved. Coordination is thus a phenomenon that is transversal to that of collective, cooperative and collaborative activity, but works on different objects and timescales in each case.

Fourthly, collaboration and "coordination of representations", as defined in CL research, relate closely to the phenomenon of *grounding* (Clark & Schaefer, 1989) and to *interactive alignment* (Garrod & Pickering, 2004). But there are important differences between these concepts (see Baker, Hansen, Joiner & Traum, 1999), and it is not true to say that 'collaboration is interaction' or 'collaboration is grounding'. Firstly, collaboration in CL research concerns particularly the *meanings of important concepts* underlying the task domain (e.g. in a debate or collaborative problem solving session on Genetically-Modified Organisms, collaboration would relate to the meaning of key notions such as "Nature" and "modification"), and not the shared meanings of all physical or communicative actions that are objects of grounding and alignment (e.g. "stop interrupting me!" or "the answer is 2.5"), although it is possible, a priori, that any behaviour could have indirect bearing on conceptual issues. Secondly, collaboration in CL, should, if it is to bear potential for learning, go beyond the minimalistic "grounding criterion", which states that: "… the contributor and the partners mutually believe that the partners have understood what the contributor meant *to a criterion sufficient for current purposes*" (Clark & Schaefer, *ibid*, p. 262; my italics). For collaborative learning, for one student to simply understand that another student meant to say "you use makeup, and that's not natural either" (see Baker, 2009) is not enough: for collaboration and learning it would be necessary for students to go beyond minimal understanding of the meanings of their utterances (*qua* the grounding criterion), to attempt to negotiate the underlying meanings of important concepts expressed in those utterances (for example, concerning the concept of Nature). The phenomenon of grounding in CL is related to, but distinct from, that of "intersubjectivity", that is important in developmental and cultural psychology (Rommetveit, 1979, 1985; Forman, 1992). However, whilst the "common ground" refers to shared, and often agreed, meanings of utterances in dialogue, intersubjectivity is a much broader concept. It refers to the ability of persons (and the processes by which they exercise this ability) to understand others' minds (i.e. to have a "theory of mind"; Flavell, 2004) and emotions (empathy), without necessarily implying agreement (Matusov, 1996).

Finally, it was stated above that collaboration is a quasi-synchronous process. But if it is defined as a process of co-elaboration of conceptual representations in a problem solving situation, could not this also occur in an asynchronous exchange, for example by emails sent over a period of a year, at one-week intervals? The answer would seem to be, yes, it possibly could. But in that case, the cognitive and

discursive processes would not be the same as in quasi-synchronous interaction, since in the spaced-out email example, the participants would have much more time to reflect on others' and their own contributions (Clark & Brennan, 1991), leading to co-production of a discursive object more akin to a joint distributed text, serving as an external memory support. But in a face-to-face synchronous interaction, utterances can be collaboratively co-constructed in a process of interactive thinking where there is often little or no external memory support for the verbatim of the interaction itself (cf. commonly visible interaction histories in computer-mediated communication). At bottom, the focus on synchronous interaction as a defining characteristic of collaboration in CL comes down to a theoretical and methodological choice.

If, as I have said, collaboration in CL is basically a joint, active and quasi-synchronous process of co-elaborating conceptual representations of problem solving domains, how can such processes be analysed in a tractable way, notwithstanding the highly contentious nature of the very idea of "mental representations" in cognitive science?

5. Collaboration processes and forms of cooperation

The approach to understanding the processes of joint elaboration of shared "representations" (i.e. collaboration) that I propose in my own work (Baker 1994, 1995, 2004) is to treat them in terms of *(inter-)discursive operations* performed on interactively negotiated *discursive objects* (Sitri, 2003). This does not amount to a denial of the existence of mental representations or of unshared private thoughts. Rather, it amounts to an epistemological and methodological standpoint (akin to discursive psychology of Edwards, 1993, Harré & Gillett, 1994, and broadly inspired by Wittgenstein, 1953) according to which dialogue is viewed as (one) accountable manifestation of collective thinking (Allwood, 1997). The thoughts of individuals during dialogue surely exist, but are only relevant to its analysis to the extent that they are made publicly manifest in some way, are mutually perceived and influence the on-going dialogue process. A further theoretical choice is to model dialogue as a multidimensional *negotiation* (Baker, 1994, 1995), on the levels of meanings, dialogue structure and the interplay of projected self/other images (Goffman, 1956). In this case, the primary communicative acts are not assertives, with underlying beliefs, but rather commissives, *conditional* offers and acceptances, of the type "I will accept p if you will accept it". Cohen (1992) distinguishes acceptance from belief, where the former is understood as a joint policy for joint reasoning, a gloss of which might be "I will accept what you say for the purposes of this dialogue, and reason with that, as far as it goes". There are two corollaries to this. Firstly,

collaborative learning is then defined in terms of the relation between acceptance and belief (i.e. between meanings negotiated in dialogue and their appropriation in the individual). Secondly, the "joint problem space" of "shared representations of the problem", as a defining element of collaboration (Roschelle and Teasley, ibid.) is modelled as *a set of jointly accepted discursive objects, co-constructed in dialogue*. Thus, joint conditional acceptance can be seen as the 'cement' of dialogue and collaboration.

6. Knowledge co-elaboration processes

Discursive operations, as described in the "natural logic" of Grize (1982) and Vignaux (1988, 1990), are the means by which language does work on representations. Examples would be predication and justification. In previous work (e.g. Baker, 1994, 1995) I proposed that collaboration processes in problem solving situations could be analysed in terms of *four classes of inter-discursive operations*: elaborative, conceptual, foundational and linguistic. In some sense, these are akin to rhetorical relations (Mann & Thompson, 1984); but the aim here is to represent dynamic transformations of discourse exchanged in dialogue, rather than structures of texts. In this short paper it is only possible to provide a brief outline of this approach (see Baker 1994, 1995), within the general aim of explicating a particular view of collaborative knowledge co-elaboration processes.

The first of the four classes of inter-discursive operations, termed "elaborative", encapsulates the way in which an initial discourse is either extended by addition of further elements, or else 'contracted'. Extensions can include drawing inferences, completing partial solutions, adding additional predicates, and so on; contraction is the inverse of this (e.g. A: "that green snake is escaping" ~> B: "the green reptile is escaping" [agreed that it's green and a reptile, but not necessarily that it is a snake]). Elaborative operations work on the level of co-construction of joint problem solution elements. The second class, "conceptual", functions in terms of redefinition or categorisation of key discursive objects. Examples of such operations are shown in Figure 1 above (operations on the concepts of action, doing, holding, interaction); they can involve stating a more specific category (e.g. A: "it's the energy" ~> B. "it's the kinetic energy"), or inversely, moving to a more general category (e.g. A: "It's the kinetic energy" ~> B: "the energy …" [but not of the kinetic kind]), or introducing new conceptual distinctions, often using "argument by dissociation" (Perelman & Olbrechts-Tyteca, 1957; Baker, 2002a)[8]. The third

8. For example, in a debate on "anti-semitism", a proponent could attempt to defend a standpoint against criticism by introducing a dissociation between the notions "anti-semitism" and

class, "foundational", includes operations that neither extend nor redefine discursive objects, but that function on the 'vertical' dimension of supporting, justifying, explaining or arguing for or against them. Finally, "linguistic" operations transform, restructure or reformulate discourse, without manifestly changing the ongoing joint problem solution, in epistemic, argumentative, or conceptual terms.

Combinations of discursive operations can be performed within the interventions of a single speaker (auto-operations) or with respect to interventions of others (hetero-operations). The interaction will be more collaborative to the extent that students build on others' ideas (predominance of hetero-operations) rather than on their own. The utility of such fine-grained analyses of collaborative interaction, in terms of inter-discursive operations, is thus that it provides a precise picture of the way in which problem solutions are co-elaborated or, in other terms, the *degree of collaboration*. Clearly, such a discursive and epistemic analysis does not take into account all that is relevant. For example, a burgeoning area of research in CL concerns how regulation of the interpersonal relation, going hand in hand with the interactive circulation and regulation of affect, interacts with processes of co-elaboration of meaning and knowledge (Andriessen, Baker & van der Puil, 2011; Baker, Andriessen & Järvelä, 2013). But, I would claim, it represents the 'core' analysis of collaboration in CL research, since it bears directly on the processes of learning *qua* knowledge elaboration.

7. Forms of cooperation

As discussed above, collaboration is a specific "form" of cooperation, or one way in which it can be achieved. In CL research, there have been several proposals for the identification of a broader set of forms of cooperation, motivated by the study of their relations with learning outcomes (i.e. which forms, under which conditions, favour learning?).

In early research, carried out within the socio-cognitive conflict paradigm (Doise, Mugny & Perret-Clermont, 1975), Gilly and colleagues (Gilly, Fraise & Roux, 1988) identified three main forms of cooperation, which they termed types of "interactive dynamics": (1) "co-construction" (more or less equal contribution to co-constructing a solution), (2) "acquiescent co-elaboration" (unequal contributions, one student elaborates a solution element, with feedback from others) and (3) "contradictory confrontation" (a proposed solution is refused by another

"anti-judaism". Such a dissociation can of course be claimed to be fallacious (Grootendorst, 1998).

student, with the former attempting to support the proposal). Three main gradual dimensions of interaction can be seen to be underlying these three forms (Baker, 2002): (1) degree of symmetry (in terms of interactive roles), (2) degree of alignment (of problem solving solution stages, of representations of the problem, etc.) and (3) degree of (dis-)agreement. Combining the three dimensions gives eight main forms of cooperation, within which "collaboration" can be defined as an interaction that tends towards symmetry and fluid alternation of roles (e.g. proposer of solutions, critic, scribe, etc.), a high degree of alignment, and either agreement or disagreement (cf. the remarks on intersubjectivity without agreement, above). The latter is an important point: *collaboration does not mean agreement*, or absence of disagreement and argumentation. To the contrary, certain types of argumentation dialogue can be seen as highly collaborative in that students are therein obliged to genuinely engage with each other's conceptualisations of the problem (Baker, 1999, 2003, 2009). In fact, the study of the variety of forms that the main form of cooperation called "argumentation dialogue" can take, in relation to the evolution of beliefs and conceptualisations, has become a subfield of CL research (see, for example, the collective works: Andriessen & Coirier, 1999; Andriessen, Baker & Suthers, 2003; Muller Mirza & Perret-Clermont, 2009).

What motivates the identification of these forms of cooperation rather than others is firstly that they correspond to salient types of sequences in students' interactions, and secondly that they can be linked to collaborative learning processes as described in the research literature. For example, the process of "peer tutoring" (Webb, 1989), whereby the student who spontaneously 'teaches' or explains to another has significantly higher learning gains than others by so doing, can be seen as a particular form of asymmetrical cooperation. Secondly, along the dimension of "alignment", effective grounding processes have been shown to be important conditions for cooperative learning (Baker, Hansen, Joiner & Traum, 1999; Barron, 2003). Researchers have proposed numerous ensembles of forms of cooperation, the most well-known of which is that of Mercer and colleagues (Mercer, Wegerif & Dawes, 1999), which includes forms of "talk" such as "disputational", "exploratory" and "cumulative", derived largely from empirical and learning theoretic considerations. It is important to note that, depending on how they are defined, forms of cooperation may or may not be mutually exclusive. For example, it is possible for given interaction sequences to be both cases of "co-construction" and "argumentation", or all of "disputational", "cumulative" and "exploratory", to greater or lesser degrees.

Research on identifying the forms of cooperation or interaction that are most conducive to learning, in given types of situations, have been applied in reverse, that is to say, situations are designed to more or less "script" the interaction towards precisely those productive forms, often using specifically designed CSCL interfaces (e.g. Baker & Lund, 1997; Fischer, et al., 2007). A difficulty here is to

constrain the students' interactions towards the desired (productive) forms to a degree that does not stifle creative knowledge elaboration (Dillenbourg, 2002).

Finally, an alternative approach to that of identifying forms of cooperation that correlate with learning outcomes has been to develop multi-dimensional methods for analysing and assessing the overall "quality of collaboration" (Spada, Meier, Rummel & Hauser, 2005; Détienne, Baker & Burkhardt, 2012), or, the extent to which collaboration is effective, as a process and in relation to the quality of its outcomes. The dimensions that human analysts are asked to rate include the degree to which conflicts are resolved cooperatively, knowledge sharing and elaboration processes, efficiency of grounding and fluidity of coordination of speech and action.

8. Concluding remarks

The model of collaboration described here is centred on cognitive-linguistic processes of co-elaboration of problem solutions and their conceptual underpinnings. This is revealing of the extent to which the model is specific to collaborative learning situations, given that it focuses precisely on interactive processes by which (epistemic) learning outcomes are produced. As I mentioned above, this is not to say that these epistemic processes can be understood in isolation from aspects of social interaction such as the negotiation or regulation of self-images, identities and affects. And although dialogical thinking is, I claim, inherently cognitive, communicative and discursive, it is also necessary to take into account the 'total utterance', including aspects of non-verbal communication such as bodily posture and movement, gesture and prosody, in order to understand the evolution of negotiated meanings.

Such an inter-discursive vision of collaboration between human beings, conceived as operating essentially on an ideational and linguistic plane, contrasts with tasks that have been termed "collaborative" in other research fields. For example, in research on comparing how children and chimpanzees behave with respect to "collaboration" (Hamann, et al., 2011), what is at stake is the sharing of tangible resources, such as food or toys, which may or may not have been acquired by previous "cooperation". In terms of the definitions described above, this would not be described as collaboration, but rather as behavioural coordination, since there is no active drive towards co-constructing (cognitive-linguistic) representations of a problem-solving situation. In the sense that it is defined above, the concept of collaboration elaborated in CL research involving human students, obviously presupposes linguistic ability. In a sense, the conceptualisation of these phenomena in the case of non-human primates comes closer to a sociological or activity-theory vision of collective activity (such as hunting, or child rearing), as organised within

groups or societies, driven by societal needs or motives, such as nourishment, shelter and reproduction (cf. Leont'ev, 1979). Turning to artificial intelligence conceptions of collaboration (e.g. Grosz & Sidner, 1990; Chu-Carroll & Carberry, 2000), the model we have sketched above is not incompatible with the aims of this discipline, but runs up against the bottleneck of automatically understanding the processes of co-constructing meaning in human-machine language-based dialogues.

Of course, there is no question of trying to legislate with respect to definitions of scientific concepts, such as those discussed here – cooperation, collaboration, coordination, collective activity – since each discipline and domain elaborates operational concepts within its own research programmes and paradigms. But it is possible that a model for collaboration in collaborative learning situations could provide an example, originating in one of the most complex cases of human joint activity (co-learning), which might be of some interest as a 'yardstick' for understanding joint activities in other domains. Complexity is not a simple concept. But in collaborative learning situations, what is at stake is not only to solve the problem together, but also to learn how to solve such problems more efficiently in the future, either together or alone, and to be able to do so in virtue of deeper conceptual understanding in the problem domain.

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