Elements of design for studying argumentation: the case of two on-going research lines

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The aim of this paper is to present some ideas in order to construct designs for studying argumentation. Our specific focus is on learning processes involving peer interactions and adult-children activities. We consider argumentation as a context-bounded activity, at the crossroads of different lines of research, such as the neo-piagetian and neo-vygotskian concerns for the socio-cognitive development of higher psychological processes, and the socio-cultural approach of participative interactions within goal-directed activities. In this paper we offer some elements to implement designs around two on-going research lines in order to pay attention to quasi-experimental and observational studies. Firstly we present the task of liquid conservation assuming that a revisitation of this classical study could offer a possibility to consider the argumentation in children's talk beyond Piaget's logicism. The second line concerns an educational situation designed to observe learning through argumentation in classroom contexts; inspired by a piagetian task for studying physics quantities, a sequence is planned to offer students an educational setting to commit into argumentative interactions.

Keywords: design, argumentation, learning, conservation, physics.

Introduction

What is the role of argumentation in learning processes? How and under which circumstances do peer interactions and adult-children activities promote learning through argumentation?

In this paper, we aim to present some elements of designs within two different research lines aiming at highlighting how argumentation can emerge as a context-bounded activity in learning settings. We propose to pay attention to quasi-experimental and observational studies, starting from different perspectives: the neo-piagetian and neo-vygotskian concerns on learning and argumentation; the main approaches of participative interactions within educational activities; and the recent advances of argumentation theories that underline the need of alternative models to consider the argumentative processes emerging from social interactions. We will present some methodological aspects in the implementation of two on-going research designs: the first one concerns the piagetian test of liquid conservation; the second one proposes classroom activities in physics education.

Learning through argumentation: from piagetian tradition to recent advances

The relevance of peer interactions in learning processes is recognized by different theoretical approaches inspired by Vygotskij (1934) and Piaget (1965), and has been developed to understand the socio-cognitive dimensions of thinking processes. In particular, the role of argumentation in learning processes is a very important dimension of the scientific debate.

In this paper, we are specifically interested in the design of experimental or natural settings where participants are invited to argue to learn. The focus is on argumentation as a tool for learning specific contents (Schwarz, 2009). Firstly, we would like to consider the historical background of the piagetian and post-piagetian tradition on this domain. Since the 1920s, argumentation has become an important element in Piaget's work (Piaget, 1924, 1926; Piaget, Szeminska, 1941; Piaget, Inhelder, 1966), as a trace of the child's reasoning. In order to have children expressing their conceptions in an argumentative way, Piaget engaged in «critical» or «clinical» interviews with children, inviting them to react to contrary points of view. The main piagetian hypothesis was that the arguments provided by the children were the signs of their logical thoughts. This exclusive attention to logical structures led Piaget into an underestimation of social and conversational dynamics and strategies involved in argumentation itself (Arcidiacono, Perret-Clermont, 2009).

Over the past decades, numerous studies have been devoted to the role of social interactions in learning and

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arguing. In the early stages of the post-piagetian tradition (Doise, Mugny, Perret-Clermont, 1975, 1976; Perret-Clermont, Mugny, Doise, 1976; Mugny, Doise, Perret-Clermont, 1981; Perret-Clermont, Nicolet, 1988), the experimental evidences have suggested that socio-cognitive conflicts can bring along notable cognitive restructuration in children's thoughts: their levels of reasoning and arguing can be affected by different dimensions, such as task demands, institutional contracts, and educational settings (Schubauer-Leoni, Perret-Clermont, 1997; Cesar, Perret-Clermont, Benavente, 2000). Other studies have contributed to this line of research with a close attention to the argumentation as a specific component of socio-cognitive activities (Perret-Clermont, Carugati, Oates, 2004), in order to understand how the meaning-making activity of participants within an experimental setting is simultaneously social and cognitive.

Other studies have investigated argumentation by developmental and social perspectives (Kuhn, Shaw, Felton, 1997; Buchs, Butera, 2004), providing an analysis of the competencies involved in argumentation. In particular, the focus has been the understanding of the main difficulties that children meet when they engage in argumentation, and the requirements of their competencies to argue.

Marro Clement (1999) and Trognon, Saint-Dizier de Almeida, Grossen (1999) have shown how argumentative conversations display but also support the mutual scaffolding of partners' ideas and their articulation, allowing for the co-construction of new learning. Baker (2003) has underlined how the dialectical dimension of argumentation provides an additional advantage to mere peer cooperation, enabling the objectification of participants' perspectives and representations. Asterhan and Schwarz (2007) have identified some characteristics of dialogues during dyadic interactions that can predict conceptual learning, such as the expression of different arguments, the fact that arguments are distributed among participants, and that discussants co-construct the solution.

In the following part of the paper we intend to highlight some methodological dimensions related to the above-mentioned aspects, in order to consider the construction of designs fostering argumentation.

The design for studying argumentation in two on-ongoing research lines

Several recent studies have contributed to the understanding of the role of argumentation as a specific form of dialogical social interaction (Muller Mirza, Perret-Clermont, 2009; Rigotti, Greco Morasso, 2009). The advances in argumentation theories underline how arguments are nested in communication processes, as a collective construction of discourses, constrained by different dimensions of the communicative context (Perret-Clermont, 2006; Rigotti, Rocci, 2006; Arcidiacono, Pontecorvo, Greco Morasso, 2009). As argumentation is an activity in which interlocutors attempt to decrease or increase the acceptability of one or more ideas by reasoning (Baker, 2002; Walton, 2006), argumentation is often characterized by sudden shifts in contents, references to previous statements, and simultaneous development of different discussion threads.

On the ground of these results, in the following part of the paper we will offer two examples of how learning through argumentation can be considered within a research design. In the first one, we will consider the piagetian test of liquid conservation, assuming that a revisitation of this classical study could offer a possibility to consider the argumentation in children's talk beyond Piaget's reductionistic logicism on these matters. The second line will concern an educational situation designed to observe learning through argumentation in the classroom context, inspired by a piagetian task for studying ideas about the physical world.

Argumentation within the laboratory setting: the design of a piagetian test

In order to understand how argumentation can be a tool for learning in the laboratory setting, we assume that in the liquid conservation test Piaget did not really study the quality of children's argumentations, but the result of types of specific conversations between the experimenter and the child. How can we implement a quasi-experimental design for the study of learning through argumentation inspired by the piagetian test of liquid conservation?

Previous studies have underlined the existence of different paths to cognitive development through the establishment of different conversation types during the liquid conservation test (Psaltis, Duveen, 2006). The collaborative problem solving, being a form of social relation that sustains different types of identities and cognitive activities, it is anyway difficult to predict which pathway a particular conversation will follow, and consequently it is not easy to implement a design that could consider all the concerned elements. In order to contribute to this problem in quasi-experimental situations, in the following part of the paper we will describe the test of liquid conservation, some analytical dimensions and possible outcomes.

The test of liquid conservation

The liquid conservation is one of the most used tests in the study of cognitive and social development of children (typically 4- to 7 years-olds). We consider here an experimental procedure (Perret-Clermont, 1979) that includes a pre-test between the experimenter and one child, a second session between the experimenter and two children, and a post-test similar to the pre-test. During the first phase, the task requires that two identical glasses (A and A') are filled to the same level and the child is asked whether they each contain the same amount. When the child has established that it is the case, the content of one (A') is poured into another (taller and thinner) glass (B). The child is then asked whether the two glasses (A and B) still contain the same amount of liquid. In the second phase each child who failed to conserve at pre-test is allocated to an interaction session with another child (conserving) in order to play together an activity involving sharing out liquid equally. The experimenter gives one child a glass (B), which is taller and thinner than the other child's (glass A) and tells the non-conserving child to pour out equal shares. A third glass (A'), identical to the glass A, is available for their use. Children are invited to discuss and argue about the amount of liquid in the glasses. The activity ends when children agree that they both have the same amount of liquid. Finally, a post-test session follows the same procedure of the pre-test for all participants, in order to verify the individual progress of children.

In the design of the setting (see Figure 1), the goal is to assign more relevance to the argumentative processes children use during the test, in order to create the proper conditions in which the children and the experimenter can co-construct their argumentation.

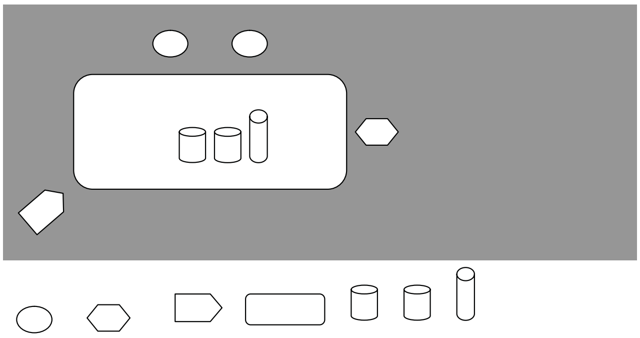

Figure 1. The setting of the test of liquid conservation

Child experimenter video-camera table glass A glass A' glass B

Dimensions of analysis

To promote the analysis of learning through argumentation, we suggest to account the following dimensions in the implementation of a design: social and material conditions that could influence the course of the task (such as the gender of the experimenter and of the children, the status of participants, the composition of the dyads, the position of the materials, the participants' possibility to manipulate the objects, the location, the instructions about the task); the possibility to video-record the experiment (in order to be able to pay attention to verbal and non verbal aspects of the interactions); the opportunity to transcribe the interactions or to transcribe a selection of representative samples (in order to identify specific situations in which the use of argumentative moves is a relevant tool for the learning process).

Concerning the analysis of argumentation we suggest, among others, two different levels*.

The first one concerns a macro-level of analysis used by Felton and Kuhn (2001). The authors have identified two potential forms of development in argumentation: the enhanced understanding of discursive goals and the application of effective strategies to meet these goals. In particular, they have predicted that initial argumentative dialogues would consist of an exposition that is an articulation and clarification of one's own perspective, in contrast of challenges that seek to identify weaknesses in claims. Another possibility to discover how argumentation can play a main role in the liquid conservation test is to examine the quality of the argumentative process. In this sense, a useful possibility is the model of the critical discussion elaborated by van Eemeren and Grootendorst (2004), in order to identify the different discursive moves that participants can use. This kind of analysis assumes that generally the development of a discussion is characterized by the following sequential steps: the *confrontation stage* (in which participants understand that they have different points of views), the *opening stage* (it is the beginning of the critical discussion, when two different standing points conflict between them), the *argumentation stage* (when the interactants really engage in argumentative and rhetoric moves), and the concluding stage (when the discussion is concluded and a solution is established). Within this analytical model it is possible to recognize the logic structure of argumentative moves, and the link between the construction of these moves and the «power» (in terms of persuasive force) of the intervention sustained by a speaker (Rigotti, 2006). This model is useful because it focuses on different elements, such as the communicative context of the argumentative intervention (in terms of institutionalized or interpersonal dimensions) and its relevant factors; the argumentative strategies used by participants (e.g. critical or relational dimensions of the strategic manoeuvring); the communicative instrumentation that concerns the argumentative strategy (for example, the stylistic choices at the linguistic level); and the critical reflection after performing the argumentative intervention. As suggested by Hundeide (1992) *«the difficulty of a task as experienced by the individual, coping with it in a particular situation, cannot be assessed from an analysis of the logical structure of the problem or question such as. We have instead to uncover the nesting of premises through microanalysis of message structure»* (p. 144).

In the assessment of argumentation in testing conversations, we need techniques able to capture also the dynamic nature of the dialog. In this sense a useful proposal is the coding scheme elaborated by Asterhan and Schwarz (2009) in order to capture collaborative argumentative reasoning as it happens. In the presen-

* The goal of this proposal is not to present specifically the models, but just to offer possible examples to examine the argumentation, by the integration of different approaches.

tation of this micro-level of coding dialog protocols, authors suggest a preliminary distinction between two types of argumentative moves: the non-dialectical moves that intend to strengthen and validate the epistemic status of a certain thesis (such as supports and agreements), and the dialectical moves that intend to dispute the validity and strength of a certain thesis or reason (such as challenges and rebuttals). The coding scheme comprises a number of mutually exclusive categories including both types of argumentative moves (claims, request for claims, simple agreements, support, challenges, rebuttals, simple oppositions and concessions, elaborations, requests for information, and information providing). Authors also suggest coding repetitions, corrections and incomprehensible units separately. Another possible method is the interlocutory analysis (Trognon, 1999) that permits to link a conversational move with an illocutionary act. In this sense, conversation is assumed as the sequential accomplishment of an extension of illocutory logic*. This method is useful to trace the evolution of the child's reasoning through the course of the conversation. It can retrace how participants display their states of mind, at every step of the interaction, adopting specific conversational moves.

We underline that it is always necessary for the researcher to recognize that argumentation produced by participants is also a *result* of the design. As the setting is crucial, a major attention in the definition of the design can open new modalities of interdisciplinary studies, integrating different methods that permit to analyze in which contexts and at what psychosocial conditions argumentation emerges and is interpreted by the researchers.

Possible outcomes

In our view, this kind of design will be useful to point out, during the interaction, how partners tend to verbalize part of their thinking allowing some kind of access to their states of mind. A detailed argumentative analysis can permit to understand how participants perceive and manage the relationship among themselves, as well as their understanding of experimenter's intentions. From a cognitive perspective, it will be also interesting to explore the immediate and differed learning processes through the argumentation in the designed situation. For example, cognitive changes from pre-test to post-test in a study of Levin and Druyan (1993) have been related to the way children reason independently on the problem during the pre-test and the way they reason during the transaction. Authors have suggested that in the case of progression from pre-test to post-test a deeper reasoning of a particular response carried out in an attempt to persuade the other of its correctness can increase the child's own confidence in that response; alternatively, in the case of regression, being more convinced of a particular response can lead the child to explore more arguments in its favour.

In our idea, this kind of research design and analyses can be extended to other data collection based on conservation with other similar tasks (e.g. the conservation of different discrete quantities). The design can vary different contextual dimensions, such as the relationship (attribution of the glasses to experimenter and child), and the goals (competition *versus* cooperation).

Argumentation in the classroom: the case of problem solving in physics

Using argumentative practices at school is commonly accepted as a worthwhile objective, and the benefit of argumentation for learning has been well supported (Schwarz, Neuman, Biezuner, 2000). However, a crucial difficulty relies in the implementation of argumentative practices in the classroom (Viennot, 1989), or even more generally in the implementation of any new educational activity in a school context (Garduno, 1997). How to make students commit themselves into an argumentative exchange with their peers, or even more difficult, with their teacher?

We make the hypothesis that many micro situations can be defined within a teaching sequence, where different actors thinking around a common object could develop various meanings, not similar neither compatible to what actors themselves assume they are following conversational rules (Grice, 1979). The fundamental problems of these situations lay in the fact actors do not take the modest attitude of ignorance («*I don't understand her/him*»). Rather, they actively make sense of what has been told (Bruner, 1996) and understand something else than expected by the interlocutor. Most often, the «*something else*» has something to do with the original intended meaning, even if it is somehow transformed. We think that our on-going research line can exploit this particularity of human communication to foster the verbal interaction in the classroom, and ultimately promote argumentative structures of dialogue through the design of relevant activities.

Argumentation in physics

To study argumentation in physics can seem irrelevant at first, as for many countries school activities mainly focus on calculating a solution according to a mathematical formal language. However, over the past decade, argumentation in science education has seen a growing interest (for instance, Baker, 1996; Buty, Plantin, 2009; Driver, Newton, Osborne, 2000; Leitao, 2000; Schwarz, Neuman, Gil, Ilya, 2003; Von Aufschnaiter, Erduran, Osborne, Simon, 2007). This interest comes from at least two important findings: firstly, researchers have shown that children start their

* The interlocutory logic is based on the fact that any production of an utterance in a conversation is the realization of an action (or illocutionary act).

education with existing ideas about the topics addressed by science curriculum (Driver, Guesne, Tiberghien, 1985; Giordan, Girault, Clement, 1994; Johsua, Dupin, 1989); secondly, case studies on students' ideas of science before and after school education show that they are far from a realistic understanding of the social enterprise and the epistemological foundation of science (Driver, Leach, Millar, Scott, 1996). The introduction of argumentative practices in the classroom is therefore twofold: it can be a mean for making students' ideas emerging and including them in classroom activities; and it can play an important role in teaching students a scientific literacy where argumentation is essential both in the way scientific knowledge is elaborated in a community of researchers (e.g. scientific debates among experts) and in the epistemological nature of the scientific knowledge (e.g. claims must be justified and/or related to evidence).

Why are the students' ideas so important in science education? Looking upon the results of education, a study of Viennot (1979) shows that most well educated young adults are not performing better on problem-solving tasks than before their classes, when those tasks are related to their everyday experiences instead of requiring a quantitative answer. These results show that students' ideas that exist previously to school education remain mostly the same and are not transformed by the instruction. In physics, these results suggest that building strong competences of formal language might enable students to perform complex calculation, but do not promote the deep understanding of science necessary to transform their ideas about the physical world. However, this change of idea is crucial to analyze a concrete problem through the concepts of physics. Argumentation — and more generally social interactions — in the classroom can be explored as complementary activities to the formal language and calculation training, from which scholars expect more in-dept understanding of physics.

On the ground of the above-mentioned reasons, we present here general issues concerning a design of research on learning through argumentation in the classroom context. This example of design consists in a sequence planned to offer students the most encouraging educational setting to commit into argumentative interactions. This teaching sequence is not designed in order to make the most efficient lesson for learning relevant physics knowledge: it is rather created to provide rich data for a better understanding of learning processes, through the analysis of the qualities and the roles of argumentation.

Designing a teaching sequence

The first step in the implementation of argumentative practices in the classroom consists in the design of a teaching sequence. In most cases, this design would benefit from a close collaboration with the teacher(s) of the classroom(s). Indeed, the teachers' understanding of the objectives is fundamental for a successful implementation, as well as his/her advice concerning the students' background, their usual way of working and the local challenge and policies. Even if the teacher role is defined in the sequence, we cannot assume before the analysis of data that the teacher role will correspond to the sequence.

Beside this particular aspect, other elements could play an important role and stay out of the researcher's control: for example, the theoretical lessons given before and/or in parallel to the experimental sequence, the evaluation and assessment practices, and different aspects influencing the students' motivation. The teaching sequence will consist in a description of the global frame (e.g. the time at disposal, the objectives of learning, the content of knowledge) and a more precise description of specific activities focusing on argumentation. In order to do so, they should be planned at the critical moment in the sequence where students have elements of knowledge about the questions or problems at stake. A classical way to organize the sequence for having such a critical moment consists in providing students with inquiry-based activities, and fostering argumentative discussions through a collaborative social setting made of small groups of students working together (Osborne, Erduran, Simon, 2004). A small group setting enhances the need of expressing and discussing conceptions. Typically, students are set in groups of three to four and are given a common task involving the need to exchange their ideas to achieve a shared answer. The social setting can also be implemented through computer-mediated interactions among distant individuals or groups, which provide an opportunity for learners to discuss their ideas through written language. The teacher scaffolding and/or the use of computer tools to mediate inquiries or argumentative discussions fit into the global design as resources to engage into activities with a real possibility for students to express their conceptions, test them through an experimental procedure and defend them in a discussion with their peers.

An example of a teaching sequence

In this part of the paper we will present an example of a teaching sequence implemented within the international project Escalate* about argumentation and inquiry learning in science education. In this teaching sequence, the learning objectives are defined in terms of transformation of the students' everyday ideas. In order to evaluate these ideas, a questionnaire is made with six questions known in science education literature as triggering erroneous answers related to common ideas about the physical world (Lemeignan, Weil-Barais, 1993). Figure 2 presents one of these questions.

* *Enhancing Science Appeal in Learning through Argumentative interaction* (ESCALATE) is a project co-funded by the European Commission within the Sixth Framework Programme (2002—2006) — project number: 020790 (SAS6). For further details: http://www.escalate.org.il.

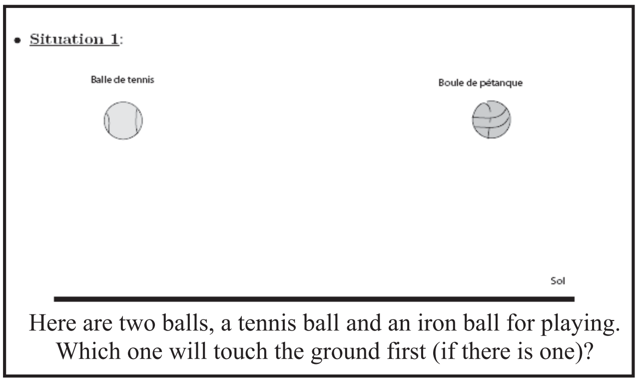

Figure 2. Example of question from the questionnaire

All students fill the questionnaire individually before the teaching sequence, and a similar questionnaire is given after the teaching sequence. Both questionnaires are used in similar classrooms to compare the results with the ones of the students having the designed teaching sequence.

The teaching sequence itself is composed of three activities. First, students have an inquiry-based session with a piagetian task (Piaget, 1974) adapted for the classroom. The task provides students with marbles of various weights and a slide with a moveable inclination. The play with marbles rolling down the slope, accelerating and eventually hitting each others allows interesting experiments about several physics concepts. An instruction sheet guides students trough several steps: the systematic observation of the phenomenon; the description of the marbles movement in conceptual terms, such as «increase and decrease of velocity»; and the description of physics quantities (velocity, acceleration and forces) in formal language (drawing vectors).

Alternatively, a microworld simulating the same task is used in the same type of activity in order to provide students both with the real situation and an idealistic behaviour of the marbles (see Figure 3). The microworld «Marbles Move» (Kynigos, 2007) offers a simulation window, where the marbles' movement can be visually played, stopped or paused. The velocity is displayed during the movement. On the right side, many parameters can be enabled in order to let students inquire the way they influence the marbles movement, the velocity, and the acceleration.

This task offers the possibility for students to discuss their observations in an argumentative way: various inquiries can be performed with the microworld and used as a reference point of the discourse, and as an interpretative space for students' critical judgements.

The second activity invites students' groups to find a shared answer to situations presented in the questionnaire. As preconceptions are very often emerging from these situations, the instructions to the groups are to discuss their previous individual answers before they set an official consensus. In a group of three to four, students always had to handle different ideas about the questionnaire items and to decide which one is the most convincing. For this activity, each group can be equipped with a computer software called Digalo*, in order to construct an argumentative map (see Figure 4). Using this software, all the different groups of the classroom produce a shared map with their answers about the six questionnaire's

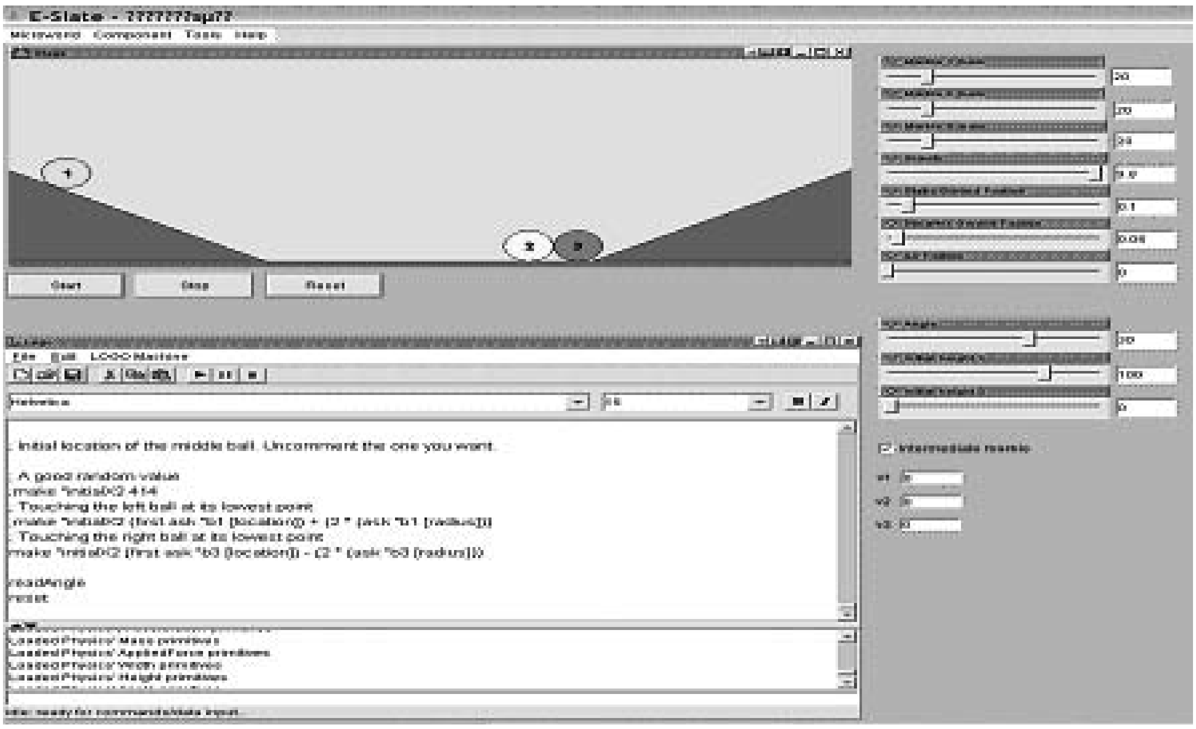

Figure 3. The microworld «Marbles Move»

* Digalo is a software for the acquisition of argumentative competencies. It has been developed within the European Union (5th Framework) Project *Dialogic & Argumentative Negotiation Educational Software* (cf. http://www.dunes.gr). For a full description of the use of this tool, see Muller Mirza, Tartas, Perret-Clermont, de Pietro (2007).

items, including questions addressed to other groups, counter-arguments or supportive contributions. Each time a group is writing on the map, the group makes a choice about the argumentative function (claim, argument) of their own contribution and how it relates to the previous ones (through a system of arrows). Alternatively to the software, a similar argumentative map can be collectively built up on the blackboard.

The third activity sets students in a laboratory work with all the necessary objects (balls, timer) where they have to make experiments about the questionnaire items. Results are written in a report, in which groups are invited to put down their observations, their answers to the initial question and how experimental data can support their conclusion.

Possible data analysis and perspectives

In this research design, besides written data including exercise sheets, experimental reports and argumentative maps, we recommend for the analysis of argumentation to audio-record each group during the whole sequence duration. In addition, video recording of the computer screen is necessary if the research focuses on the use of the computer by students. Other data about context can provide useful information: content of the theoretical course in physics, students' marks, observation of general classroom dynamics and eventually unexpected events.

Data analyses can be performed interrelating different elements of the complex reality that emerges from the sequence. For example, the individual progress can be examined for each student by questionnaires' results or, within group conversations, using the written data compared to the group level progression. However, the main entry into the complexity is based on analyses of groups' verbal interactions, identifying the argumentative structures during the conversation. This approach relies on the assumption, presented earlier in this paper, that argumentation can be used as a trace of learning processes: for example, one can consider if an evidence is used by students in order to argue and to defend their conceptions, or if they interpret their observations in a way that make them match with their previous ideas of the physical world.

Figure 5 presents a picture of the whole research situation, in order to illustrate different aspects possibly recalled in students' argumentative discourses that emerge during the designed situation.

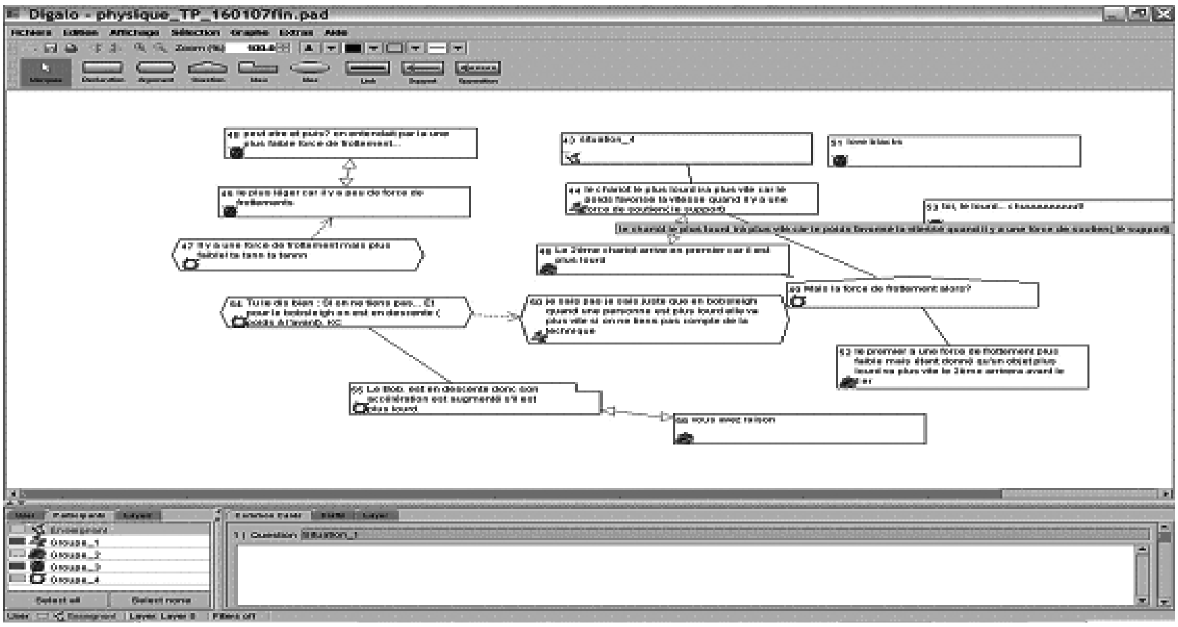

Figure 4. An example of argumentative map

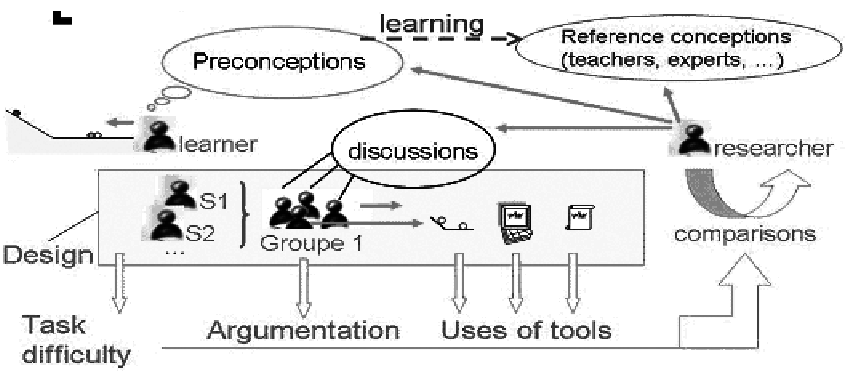

Figure 5. The research process

An important aspect of Figure 5 is the students' previous cognitive and cultural background, mostly referred to as their ideas previous to the school education. However, these ideas are only providing an indicator of this cultural background that is not exhausting the reality it refers to. Taking such an indicator for the cultural background is only justified by the deliberate focus of this particular research on cognitive and social aspects of learning, leaving emotional and other dimensions aside. Later in the sequence, data provide information at a group level about the general difficulty of the task for students, as well as the knowledge and procedures developed, the use of resources, such as the computer and material devices, and finally the production made in order to satisfy educational demands. More precise results about learning processes can be also reconstructed through certain types of dialogue and discourse stimulated within groups.

When argumentation occurs, the analysis can draw indicators of how students cognitively engage themselves into the task, by pointing out when students share their points of view, elaborate concepts, or find productive procedures to achieve the goals of the task. The arrow at the bottom of Figure 5 represents the links that the researcher can draw between various aspects of the argumentative situation: these links include notably the researcher hypotheses about the design (which is represented by a reflective arrow in the illustration), the teacher's expectations, the models of the right acquisition, and the representations of students.

Through the triangulation of data articulated within argumentative discourses, this design can allow the researcher to create an understanding of how learning processes emerge from the whole complexity in which students are immersed. For instance, using the analysis through «knowledge elements» (Tiberghien, Malkoun, 2007), one can identify precise elements of the knowledge to be taught, trace their occurrence through the different activities of the teaching sequence, and describe how they are worked out throughout group interactions, and experimental activities. Another possible analysis, focusing on the verbal content of the group interaction, consists in gathering all references through the transcribed discourse (Blanche-Benveniste, 1997) that refers to a particular concept (e.g. weight) and in describing the progressive elaboration of this concept at the individual or group level as a successive construction of meaning.

Conclusion and perspectives

The research lines we have proposed in this paper are two possible ways to explore how the argumentation emerges as a context-bounded activity and as a tool for learning.

In the first research design we underlined on the need to observe in great detail the activities organized by the researcher in a laboratory context, in order to make possible the understanding of argumentative interactions in quasi-experimental situations. Besides, piagetian conservation tests have also inspired school curricula and different educational activities, but not always successfully for reasons that are interesting to explore more in depth. In this sense, it would be useful to see how children interpret the same situation and argue around a task when it is given to them not in a laboratory setting, but, for example, in a classroom activity like in our second research line. Combining the two lines of research presented around the same argumentative activities, firstly in laboratory and secondly integrating them in the context of the classroom, can be very instructive about the emergence of argumentation in a given social setting, and on how it relates to learning processes.

The second research design can be easily developed or adapted to various classroom contexts and activities. Two conditions must be respected: the case design should provide the best possibility for argumentation to emerge, and the natural situation should be documented through sufficient data sources for a rich crossing of content in the analysis. More detailed research focusing on particular aspects of the design can be very interesting as well: for example, one could take some activities presented above out of the classroom (like the microworld) to conduct clinical interviews with students in a piagetian tradition. It will be high relevant to look at the argumentation produced in this dialogue with the researcher on the same task implemented into an ordinary lesson, as we assume they will considerably differ from peer interactions during the lesson. It is through the understanding of these complex interactions occurring in real life situations that our understanding of learning processes can be developed.

In conclusion, we think that the observation of argumentative activities organized in laboratory settings and in classroom situations could contribute to many psychological research on learning processes, involving different dimensions in the field of education for a better understanding of argumentation in interactive situations.

References

1. *Arcidiacono F., Perret-Clermont A.-N.* (2009). Revisiting the piagetian test of conservation of quantities of liquid: argumentation within the adult-child interaction // Cultural-Historical Psychology. 3 (in press).
2. *Arcidiacono F., Pontecorvo C., Greco Morasso S.* (2009) Family conversations: the relevance of context in evaluating argumentation // Studies in Communication Sciences. 9 (2).
3. *Asterhan C. S. C., Schwarz B. B.* (2007). The effects of dialogical and monological argumentation on concept learning in evolutionary theory // The Journal of Educational Psychology. 99 (3).
4. *Asterhan C. S. C., Schwarz B. B.* (2009). Argumentation and explanation in conceptual change: indications from protocol analyses of peer-to-peer dialog // Cognitive Science, 33.
5. *Baker M.* (1996) Argumentation et co-construction des connaissances // Interaction et Cognitions. 1 (2—3).
6. *Baker M.* (2002). Argumentative interactions, discursive operations and learning to model in science // P. Brna, M. Baker, K. Stenning, A. Tiberghien (eds.) The role of communication in learning to model. Mahwah: Erlbaum.
7. *Baker M.* (2003). Computer-mediated interactions for the co-elaboration of scientific notions // J. Andriessens, M. Baker, D. Suthers (eds.) Arguing to Learn: Confronting Cognitions in Computer-Supported Collaborative Learning Environments. Utrecht: Kluwer.
8. *Blanche-Benveniste C.* (1997). Approches de la langue parlee en francais. Paris: Ophrys.
9. *Bruner J.* (1996). Frames for thinking: ways of making meaning // D. Olson, N. Torrance (eds.) Modes of thought: exploration in culture and cognition. N. Y.: Cambridge University Press.
10. *Buchs C., Butera F.* (2004). Socio-cognitive conflict and the role of student interaction in learning. New Review of Social Psychology. 3 (1—2).
11. *Buty C., Plantin C.* (eds.) (2009). Argumenter en classe de sciences. Lyon: INRP.
12. *César M., Perret-Clermont A.-N., Benavente A.* (2000). Modalités de travail en dyades et conduites à des taches d'algèbre chez des èléves portugais // Revue suisse des sciences de l'éducation. 3.
13. *Doise W., Mugny G., Perret-Clermont A.-N.* (1975). Social interaction and the development of cognitive operations // European Journal of Social Psychology, 5.
14. *Doise W., Mugny G., Perret-Clermont A.-N.* (1976). Social interaction and cognitive development: further evidence // European Journal of Social Psychology. 6.
15. *Driver R., Guesne E., Tiberghien A.* (eds.) (1985). Children's ideas in science. Philadelphia: Open University Press.
16. *Driver R., Leach J., Millar R., Scott P.* (1996). Young people's images of science. Buckingham: Open University Press.
17. *Driver R., Newton P., Osborne J.* (2000). Establishing the norms of scientific argumentation in classrooms // Science Education. 84 (3).
18. *Eemeren van F. H., Grootendorst R.* (2004). A Systematic Theory of Argumentation: The Pragma-Dialectical Account. Cambridge: Cambridge University Press.
19. *Felton M., Kuhn D.* (2001). The development of argumentative discourse skills // Discourse Processes. 32.
20. *Garduño T.* (1997). La genèse d'une innovation pé - dagogique // Dossiers de Psychologie. 51.
21. *Giordan A., Girault Y., Clément P.* (Eds.) (1994). Conceptions et connaissances. Bern: Lang.
22. *Grice H. P.* (1979). Logique et conversation // Communications. 30 (1).
23. *Hundeide K.* (1992). The message structure of some Piagetian experiments // A. H. Wold (ed.) The Dialogical Alternative. Towards a Theory of Language and Mind. Oslo: Scandinavian University Press.
24. *Johsua S., Dupin J.-J.* (eds.) (1989). Représentations et modelisations: le «débat scientifique» dans la classe et l'apprentissage de la physique. Bern: Lang.
25. *Kuhn D., Shaw V., Felton M.* (1997). Effects of dyadic interaction on argumentative reasoning // Cognition and Instruction. 15 (3).
26. *Kynigos C.* (2007). Half-baked logo microworlds as boundary objects in integrated design // Informatics in Education. 6 (2).
27. *Leitão S.* (2000). The potential of argument in knowledge building // Human Development, 43.
28. *Lemeignan G., Weil-Barais A.* (eds.) (1993). Construire des concepts en physique: l'enseignement de la mécanique. Paris: Hachette.
29. *Levin I., Druyan S.* (1993). When sociocognitive transaction among peers fails: the case of misconceptions in science // Child Development. 64.
30. *Marro Clément P.* (1999). Deux enfants, un problème technique, une solution: analyse interlocutoire de la construction interactive d'un raisonnement. Verbum. 21 (2).
31. *Mugny G., Doise W., Perret-Clermont A.-N.* (1981). Interpersonal coordinations and sociological differences in the construction of the intellect // G. M. Stephenson, J. M. David (eds.) Progress in Applied Social Psychology. N. Y.: Wiley.
32. *Muller Mirza N., Perret-Clermont A.-N.* (eds.) (2009). Argumentation and Education. Theoretical Foundations and Practices. N. Y.: Springer.
33. *Muller Mirza N., Tartas V., Perret-Clermont A.-N., de Pietro J.-F.* (2007). Using graphical tools in a phased activity for enhancing dialogical skills: an example with Digalo // Computer-Supported Collaborative Learning. 2.
34. *Osborne J., Erduran S., Simon S.* (2004). Ideas, Evidence & Argument in Science. L.: King's College London.
35. *Perret-Clermont A.-N.* (1979). La construction de l'intelligence dans l'interaction sociale. Bern: Lang (Eng. tr. Social interaction and cognitive development in children. L.: Academic Press, 1980).
36. *Perret-Clermont A.-N.* (2006). Comments on Rigotti and Rocci // Studies in Communication Sciences, 6 (2).
37. *Perret-Clermont A.-N., Carugati F., Oates J.* (2004). A socio-cognitive perspective on learning and cognitive development // J. Oates, A. Grayson (eds.) Cognitive and language development in children. Oxford: Blackwell.
38. *Perret-Clermont A.-N., Mugny G., Doise W.* (1976). Une approche psychosociologique du développement cognitif // Archives de Psychologie. 171.
39. *Perret-Clermont A.-N., Nicolet M.* (1988). Interagir et connaitre. Enjeux et régulations sociales dans le développement cognitif. Cousset: Del Val.
40. *Piaget J.* (1924). Le jugement et le raisonnement chez l'enfant. Neuchatel: Delachaux et Nietstlé.
41. *Piaget J.* (1926). La représentation du monde chez l'enfant. Paris: PUF.
42. *Piaget J.* (1965). Etudes sociologiques. Geneva: Droz.
43. *Piaget J.* (1974). Histoire et développement de la causalité. Raison Présente, 30, 5—20.
44. *Piaget J., Inhelder B.* (1966). La psychologie de l'enfant. Paris: PUF.
45. *Piaget J., Szeminska A.* (1941). La genèse du nombre. Neuchatel: Delachaux et Nietstlé.

46. *Psaltis C., Duveen G.* (2006). Social relations and cognitive development: The influence of conversation type and representations of gender // European Journal of Social Psychology. 36.

47. *Rigotti E.* (2006). Relevance of context-bound loci to topical potential in the argumentation stage // Argumentation. 20.

48. *Rigotti E., Greco Morasso S.* (2009). Argumentation as an object of interest and as a social and cultural resource // N. Muller Mirza, A.-N. Perret-Clermont (Eds.) Argumentation and Education. Theoretical Foundations and Practices. N. Y.: Springer.

49. *Rigotti E., Rocci E.* (2006). Towards a definition of communication context. Foundations of an interdisciplinary approach to communication // Studies in Communication Sciences. 6 (2).

50. *Schubauer-Leoni M. L., Perret-Clermont A.-N.* (1997). Social interactions and mathematics learning // P. Bryant, T. Nunes (eds.). Learning and teaching mathematics. An international perspective. Hove: Psychology Press.

51. *Schwarz B. B.* (2009). Argumentation and learning. In N. Muller Mirza, A.-N. Perret-Clermont (eds.) Argumentation and Education. Theoretical Foundations and Practices. N. Y.: Springer.

52. *Schwarz B. B., Neuman Y., Biezuner S.* (2000). Two wrongs may make a right...if they argue together! // Cognition and Instruction. 18 (4).

53. *Schwarz B. B., Neuman Y., Gil J., Ilya M.* (2003). Construction of collective and individual knowledge in argumentative activity // The Journal of the Learning Sciences. 12 (2).

54. *Tiberghien A., Malkoun L.* (2007). Différenciation des pratiques d'enseignement et acquisitions des eleves du point de vue du savoir // Education et Didactique. 1.

55. *Trognon A.* (1999). Eléments d'analyse interlocutoire // M. Gilly, J-P. Roux, A. Trognon (eds.). Apprendre dans l'interaction: analyse des mediations semiotiques. Nancy: Presses Universitaires.

56. *Trognon A., Saint-Dizier de Almeida V., Grossen M.* (1999). Résolution conjointe d'un problème arithmétique // M. Gilly, J.-P. Roux, A. Trognon (eds.). Apprendre dans l'interaction: analyse des médiations sémiotiques. Nancy: Presses Universitaires.

57. *Viennot L.* (ed.) (1979). Le raisonnement spontane en dynamique élémentaire. Paris: Hermann.

58. *Viennot L.* (1989). Obstacle épistémologique et raisonnement en physique: tendance au contournement des conflits chez les enseignants // N. Bednarz, C. Garnier (eds.). Construction des savoirs. Ottawa: ARC.

59. *Von Aufschnaiter C., Erduran S., Osborne J., Simon S.* (2007). Arguing to learn and learning to argue: case studies of how students' argumentation relates to their scientific knowledge // Journal of Research in Science Teaching. 45 (1).

60. *Vygotskij L. S.* (1934). Myslenie i rec. Psichologiceskie issledovanija. Moskva-Leningrad: Gosudarstvennoe Social'no-Ekonomiceskoe Izdatel'stvo (Engl. tr. Thought and Language. Cambridge: MIT Press, 1962).

61. *Walton D.* (2006). Fundamentals of critical argumentation: critical reasoning and argumentation. N. Y.: Cambridge University Press.