TRANSFORMATION OF ROBUST MISCONCEPTIONS THROUGH PEER ARGUMENTATION

Christa S. C. Asterhan, Baruch B. Schwarz

RESEARCH ON ARGUMENTATION AND THE TRANSFORMATION OF DECLARATIVE KNOWLEDGE

Argumentation has become an increasingly popular topic of investigation within the psycho-educational research community, especially so in the last decade and a half. Based on distinctions made by leading theorists (Baker 2003; van Eemeren, Grootendorst, Henkenmans, Blair, Johnson, Krabb, Plantin, Walton, Willard, Woods, & Zarefsky 1996; Walton 2006), argumentation is defined in this paper as a social activity in which interlocutors attempt to strengthen or weaken the acceptability of one or more ideas. This goal is achieved by engagement in reasoning.

Research on argumentation as an instigator of learning can be roughly divided in two different but intrinsically related venues: The first concerns the effect of argumentation on thinking and reasoning. A number of studies have shown that peer argumentation improves subsequent individual or collective thinking and leads to more balanced or elaborate standpoints on the particular topic of discussion. (e.g., Baker( this volume); Goldberg, Schwarz & Porat 2008; Kuhn, Shaw & Felton 1997; Schwarz in press; Schwarz, Neuman, Gil & Ilya 2003; Voss & Means 1991; Wegerif, Mercer & Dawes 1999; Zohar & Nemet 2002). The second concerns the effect of argumentation on the transformation of declarative knowledge. However, although argumentation is often associated with the activity of knowledge construction (e.g., Andriessen, Baker & Suthers 2003; Duschl & Osborne 2002), empirical research on the benefits of argumentation on learning has commenced only recently.

First indications that argumentative dialogue may improve declarative knowledge were reported by Teasley (1995) and Jimenez-Aleixandre (1992). This claim was
further supported by evidence from qualitative analyses and field studies (e.g., Baker 2003; Fernandez, Wegerif, Mercer & Rojas-Drummond 2001; Mason 2001; Schwarz & Linchevski 2007; Schwarz, Neuman, & Biezuner 2000; de Vries, Lund & Baker 2002). Whereas descriptive data may provide insights into processes of emergent learning, they cannot provide conclusive answers to questions concerning causes for improvement. Does argumentation, for example, lead to better understanding or are individual differences in intelligence, skill, knowledge, or experience responsible for both the engagement in argumentation and for better understanding, as suggested by Means and Voss (1996)? To answer such questions experimental designs are needed.

This approach presupposes that argumentation can be isolated and manipulated as an independent variable in order to study its effect on learning. As with the majority of psychological constructs, argumentation cannot be *directly* manipulated. Therefore, one can only compare the effects of designs that are thought to foster argumentation. This is justified if there is a way to make sure that these designs actually foster more argumentative activity than comparable settings without such elicitation. Another possibility is to adopt a correlational approach and to compare conceptual change and quality of talk; that is, to correlate between kinds of dialogue characteristics and learning. Recently, we combined both approaches with a set of experimental and non-experimental investigations into the role of argumentation in knowledge transformation in the topic of evolutionary theory (Asterhan & Schwarz 2007a; 2007b; 2008a, 2008b). The type of knowledge transformation we chose to focus on concerns conceptual change.

CONCEPTUAL CHANGE: A PARTICULAR FORM OF KNOWLEDGE TRANSFORMATION

Domain-specific theories of cognitive development propose that innate mental structures guide learning in early childhood by actively seeking and assimilating different inputs (Carey & Spelke 1994, 1996; Gelman & Brenneman 2004). Whereas some of these structures foster the accumulation of more sophisticated knowledge in a domain, early learning can also interfere with the understanding of complex scientific constructs that children are confronted with in formal instruction. Extensive research has shown that children’s (and adults’) naïve theories concerning constructs such as evolution, force and astronomy are not only different, but incommensurable with the
scientifically accepted ones (e.g., Carey, 1992; Chi, 2008). The radical reorganization (Vosniadou, 1999) that is required in these knowledge representations has traditionally been referred to as conceptual change (e.g., Carey & Spelke, 1996; Chi, 2005). Some of these misconceptions, also referred to as naïve theories, everyday concepts or intuitive concepts, are difficult to uproot even with extensive formal instruction (e.g., Limon 2001). They are often very adaptive in and compatible with everyday experience and are sustained by ambiguous language use. In addition, Chi (2005; 2008) has suggested that the robustness of certain misconceptions can be attributed to the fact that students often misinterpret one kind of process, the emergent type, for another, namely direct processes. A direct process is, among others, characterized by the fact that it has a clear beginning and end, a sequence of distinct actions that are contingent and causal, and an identifiable, explicit goal. Emergent processes, on the other hand, are uniform, simultaneous and ongoing and have no clear goal (Chi 2005; Ferrari & Chi 1998). According to Chi, conceptual change in these instances requires a lateral re-categorization to an ontologically different and often lacking conceptual category, that of emergent processes.

Natural selection is an example of an emergent process (Ferrari & Chi 1998). However, most students frame evolution as a direct process: For instance, it is often regarded as a process that serves a certain purpose or goal (e.g., becoming better adapted). Moreover, all individual members within a population are considered to develop new characteristics as a result of and in response to changes in the living environment. Similar to other robust misconceptions, naïve theories of natural selection have consistently been found to be extremely difficult to uproot, even following extensive formal instruction on the subject (e.g., Bishop & Anderson 1990; Brumby 1984; Jensen & Finley 1995).

The set of studies that we discuss in this paper focus on whether, when and how peer argumentation may foster conceptual change on scientific topics that have been known to be notoriously difficult to teach. The topic we chose for these studies concerns natural selection. The learning tasks in these studies were designed within to the socio-cognitive conflict paradigm, according to which collaborating peers are either confronted with anomalous data or contradicting views and/or are paired with peers who have different views (Limon 2001; Mugny & Doise 1978). Elsewhere we
have argued that peer argumentation combines a number of social and cognitive processes that have either been identified or proven to foster concept learning within such task settings (Schwarz & Asterhan in press). However, a causal relation between peer argumentation and conceptual change had not been established yet. This was the goal of our first experimental study.

A DYADIC STUDY: CONSOLIDATING PEER COLLABORATION GAINS THROUGH ARGUMENTATION

The first experimental study tested the effects of instructions to conduct an argumentative discussion on different measures of conceptual understanding in a dyadic setting. Seventy-six undergraduates from the Social Sciences and Humanities each watched a 20 minute excerpt of an instructional movie on evolutionary theory. In the excerpt several examples of animal evolution were described. It also contained a detailed explanation of how Darwinian’s theory accounts for evolutionary change in the particular case of a bird species called "Darwin’s finches". Following, students were randomly assigned to dyads and were instructed to collaboratively explain a newly presented case of evolutionary change (i.e., the evolution of webbed feet of ducks). Half of the dyads were instructed to engage in peer argumentation on their respective explanations. After at least 30 s into the discussion, they were also shown a short excerpt of a critical discussion of four turns between two (hypothetical) subjects which, they were told, had participated in the experiment a year earlier:

X: Then the ducks had to change their feet so that they could swim. The area was flooded with water, and because of the new environment webbed feet developed.

Y: What do you mean “developed”? How did that happen?

X: Hmmm. In the beginning they did not know how to swim. But slowly they learned to do it and that caused some sort of development in their feet. I mean, webs developed between their fingers. And that’s how it was passed on to the next generation.

Y: Well if that were true, then Olympic swimmers should also develop webbed feet, since they also swim all day long!!
The discussion in the excerpt modelled a critical discussion on the ducks item without actually revealing or hinting at the correct solution. Control dyads were merely instructed to collaborate. Individual evolutionary understanding was assessed as the quality of the explanatory schemas they used to explain newly introduced evolutionary phenomena on three separate test occasions: Prior to, immediately after and a week following the dyadic collaboration phase. In addition to this measure of conceptual understanding, we also assessed the number of discrete Darwinian principles that students explicitly mentioned in their written responses.

When controlled for pre-test performance and other variables, delayed post-test explanations of individuals in the argumentative condition reflected superior conceptual understanding compared to those of control students. Furthermore, the pattern through which this advantage was attained revealed that students in both conditions improved their conceptual understanding immediately following the intervention. However, students who were merely instructed to collaborate lost this temporary gain, whereas students in the argumentative condition retained the same level of performance at the delayed post-test. The improvement in conceptual understanding as seen in the explanatory schemas that students applied could not be attributed to an increase in the number of discrete Darwinian principles they produced in their explanations: Students in both conditions showed immediate gains on this measure which disappeared on the delayed post-test a week later. Potential intervening variables, such as whether students arrived at the Darwinian solution during the interaction and the length of their discussions, were not found to be dependent on condition.

Taken together, these findings seem to suggest that the differences in conceptual understanding may be the result of different levels of processing during or after the intervention phase. The conjecture that the difference between the two conditions may be attributed to superior processing in argumentation was further explored in two different ways: First of all, we analyzed the dyadic dialogues in an attempt to identify the characteristics that distinguished between dialogues that were followed by conceptual change and those that were not. Secondly, we examined whether the patterns of change could be replicated in a follow-up experiment in a more rigorously controlled design that further isolated the engagement in dialectical argumentation.
Manipulation checks showed that all the experimental dyads engaged in argumentation. However, some of the dialogues were characterized by one-sided argumentation, in which students only produced reasoned arguments that strengthened the acceptability of a certain explanation. In dialectical argumentation, on the other hand, both weakening and strengthening arguments are proposed (Asterhan & Schwarz 2007a). We will first present the second experimental study and then discuss the findings from the dialogue analyses.

SCRIPTED ARGUMENTATION DIRECTED AT A CONFEDERATE

The design and procedure of the second experiment were almost identical to the first one, except for the fact that in both conditions a confederate played the role of one of the participants. Participants in the experimental condition were prompted to engage in dialectical argumentation on their own and the confederate's solution, by answering structured questions read aloud by the confederate, who chose a piece of paper from an urn and invariantly picked up the role of the 'reader'. In the control condition, the subject and the confederate only read aloud their solutions to each other, without discussing them further and performed a filler task to control for time-on-task. Thus, students in both conditions were prevented from conducting a natural dialogue and were exposed to the same naive theories of evolution.

So as to ensure uniformity of exposure to another explanatory schema (i.e., the confederate's), while preserving a minimum difference between that and the student's explanatory schema, two different answer sheets were prepared for the confederate. Each contained a solution according to an explanatory schema that was qualitatively different, but belonged to the same schema category. The solution that was read by the confederate as her own was thus contingent on the participant's explanatory schema (see Asterhan & Schwarz 2007a, for further details).

The task scenario in the experimental condition was designed to ensure that participants engaged in dialectical argumentation in a controlled design, while preserving the perceived equal-status, peer-collaborative nature of the first study. First, participants were requested to read aloud their answer to the 'webbed duck feet' question. They were then asked to discuss the strengths of that solution, to criticize it, and to discuss whether it explained the change that occurred to the ducks' feet. Then
the confederate was requested to read 'her' solution aloud, after which the participants were asked to discuss that solution according to the previous steps. In both conditions, students interacted with the confederate and the additional solution was always presented as being the confederate's, who personally read it to a student. In sum, the conditions were identical on factors such as social facilitation, actual exposure to an alternative view, the nature of this alternative solution and the personification of viewpoints. They differed only in engagement of dialectical argumentation.

The results showed that students who were instructed to engage in scripted dialectical argumentation on their own and another person's solution showed greater conceptual gains than control students. They were also more likely to have attained conceptual change (Asterhan & Schwarz 2007b). Thus, the advantage of elicitation of argumentation observed in collaborative dyadic situations was replicated in a situation of scripted argumentation directed at and prompted by a peer, a design that isolated dialectical argumentation from the interactional features of the collaboration.

Similar to the findings from the first (dyadic) experiment, students in the argumentative condition preserved the conceptual gains obtained during the intervention. However, students in the control condition did not show improvement on any of the tests. This suggests that control subjects' temporary gains in the dyadic study derived from the peer interaction *per se*, and not from the movie they saw. When students were not allowed to discuss each others' solutions and were exposed to the same misconception, such temporary gains disappeared. Instances of post-intervention reflection and deliberation were equally distributed among experimental and control students.

The combined results of the two experimental studies first and foremost provide important experimental support for the assertion that eliciting argumentation promotes conceptual understanding in Science in a socio-cognitive conflict learning paradigm. Even a meticulously designed task meant to cause cognitive conflict did not lead to lasting cognitive gains, unless the students were specifically instructed (dyadic study) or scripted (confederate study) to engage in dialectical argumentation. Secondly, our findings particularly emphasize the importance of delayed assessment, especially in the case of dialogical argumentation, since its potential benefits may not become
apparent at immediate test occasions. Whereas peer collaboration by itself was found to have a positive effect on conceptual understanding, these gains proved to be merely temporary and disappeared at delayed post-tests.

Dialectical argumentation requires explaining oneself and justifying one's standpoints, as well as considering and evaluating alternative solutions. We suggested that the advantage of argumentation for concept learning is achieved through superior cognitive processing. This interpretation was indirectly supported by two findings from our experimental studies: (1) mentioning the Darwinian account during the discussion was not related to learning gains; and (2) the particular pattern in which the advantage of argumentative conditions was achieved in both experiments (preserved gains versus loss of temporary gains or no gains). To further progress in the understanding of the role of dialectical argumentation in concept learning, we then analyzed the dialogues from the dyadic study to identify characteristics of the dialogues responsible for concept learning.

EXPLANATION DEVELOPMENT AND DIALECTICAL ARGUMENTATION AS TWO ACTIVITIES WITH A DIFFERENT IMPACT ON LEARNING
In spite of the mean effects of instruction for dyadic argumentation on conceptual understanding, not for all experimental subjects conceptual gains were identified and not all experimental dyads engaged in a dialectical argumentative discussion, as they were instructed to (Asterhan & Schwarz 2007a). This difficulty was expected since arguing about scientific issues is difficult to sustain (Baker 2003; de Vries, et al 2002). On the other hand, the results of this dyadic study indicate that proper instruction often yields "productive" dialogs, in the sense that these dialogs were more likely to be followed by a resilient change in conceptual understanding by at least one of the dyadic partners.

Following, we subjected the conversations of the first study's experimental dyads to detailed dialogue analyses, in an attempt to identify dialogue and interaction characteristics that predict learning from interaction. Two complementary analysis of different granularity were developed (Asterhan & Schwarz 2008a): The micro-level scheme assessed the nature of students' dialogical moves within the interaction and focused on moves that referred to the epistemic status of an idea (i.e., different
argumentative interlocutory moves) and those that developed ideas (i.e., different moves that introduced new information to the discussion, such as those that develop or expand on preceding contributions). Dialogical moves that were assessed included, among others, claims, reasoned challenges, reasoned rebuttals, reasoned supports, simple agreements, concessions, elaborations, and requests for information.

The complementary macro-level coding scheme was intended to capture interpersonal and socio-cognitive features of the interaction as a whole that could distinguish between gaining and non-gaining dyads. The following characteristics of dyadic collaboration were assessed: (1) *Interpersonal repartition* of the different solutions that were mentioned during the interaction; (2) whether the discussants reached *closure* by the end of the discussion; (3) whether they discussed the *central and crucial issue* of how the change occurred; (4) whether they *equally contributed* to the discussion; and (5) whether the argumentative structure of the interaction as a whole was *dialectical* (students proposed more than one solution which Ss feel obliged to choose from, or the dialogue contains a single proposed solution that is both contested as well as defended) or *one-sided* (students only discussed why a proposed solution is correct).

The dialogue features of gaining dyads (i.e., at least one student achieved conceptual change) were compared with those of non-gaining dyads (i.e., none of the students achieved conceptual change) and revealed the following (Asterhan & Schwarz 2008a): The dialogues of gaining dyads contained a larger number of dialogical moves that reflect dialectical reasoning (i.e., reasoned challenges, simple oppositions, concessions and reasoned rebuttals) than those of non-gaining dyads. In contrast, gaining and non-gaining dyads equally engaged in consensual processes of explanation development and validation (i.e., providing reasoned support for solutions, simple agreements, elaborations of explanations). The importance of dialectical engagement for conceptual change was further emphasized by the macro-analyses: The dialogues of all gaining dyads were characterized by interpersonal repartition of solutions within the dialogue (i.e., the different solutions proposed during the interaction were represented by different persons) and by a dialectical argumentative structure.
In light of the experimental findings discussed earlier, the finding that engagement in dialectical argumentation predicted conceptual change was expected. However, the fact that engagement in consensual processes of knowledge construction did not relate with learning gains is surprising. In fact, the literature on explanation- and elaboration-based dialogue has extensively shown its benefits on learning (e.g., Coleman 1998; King & Rosenshine 1993; Neuman & Schwarz 1998; Van Boxtel, van der Linden & Kanselaar 2000; Webb, Troper & Fall 1995). We therefore continued to explore the relation between engagement in consensual explanation development and learning gains on the individual (instead of the dyadic) level.

Even though collaborators often commonly construct and sustain a shared problem-solving space, it does not inevitably follow that the knowledge that has been constructed during the interaction is perceived in the same manner by all participants, nor that individual ideas are more similar following collaboration. Likewise, it is possible that different dyadic partners benefited differently from the interaction. For example, whereas analyses on the dyadic level did not detect a relation between consensual processes of explanation development and conceptual change, self-generated engagement in processes of consensual explanation development may be beneficial to individual learning (Chi, deLeeuw, Chiu & Lavancher et al 1994). Observing a collaboration partner doing the same thing, on the other hand, may not lead to gains (Webb, et al, 1995). To disentangle self-generated dialogue moves from the partner's, we then conducted several regression analyses in which a single person's learning gains were predicted by the frequency of each dialogue move enacted by this person him/herself, as well as those by his/her collaboration partner. However, the analyses mirrored the previous ones: Individual learning gains were solely predicted by the extent to which that particular person actively engaged in dialectical argumentation him/herself.

These intriguing findings open a new venue of research into the potentially different roles of consensual development of explanations and of critical-dialectical argumentation in learning through peer dialogue. It is possible that processes of consensual explanation and elaboration are only beneficial for learning that involve assimilation and conceptual learning of the enriching type. However, they may not be sufficient for the radical reorganization in knowledge structures that is required for
certain particularly robust misconceptions. Needless to say, these directions should be further explored in future research.

THE DOUBLE-EDGED SWORD OF SOCIO-COGNITIVE CONFLICT: DIALECTICAL ARGUMENTATION OR INTERPERSONAL HARMONY?

Taken together, the combined findings of the previously presented three studies emphasize the importance of dialectical argumentation in knowledge transformation of the conceptual change type. To some extent, this reflects the literature on cognitive conflict (Piaget 1985) and socio-cognitive conflict theory (Mugny & Doise 1978). According to these, the confrontation of different cognitions in combination with the equality in status are what make peer collaboration settings particularly powerful, since this is assumed to induce high levels of cognitive conflict which, in turn, are thought to be crucial for conceptual change to occur.

However, the match between these landmarks of developmental theories and the studies described here is far from perfect. First of all, a distinction should be made between cognitive conflict as a description of a learning mechanism and as a paradigm of instructional design. As shown in the experimental studies, designing learning tasks according to a socio-cognitive paradigm by presenting students with anomalous or contradicting information did not prove to be sufficient. Even when the exposure to another view was controlled for (i.e., in the confederate study), only those students that were elicited to engage in dialectical argumentation gained from the intervention. Thus, contrary to common assumptions, this seems to suggest that it is not the interpersonal pressure of the peer settings, nor the contradicting views that the learner is exposed to, but the actual engagement in dialectical argumentation that is responsible for deep conceptual gains. This may in turn be facilitated by the social settings of peer collaboration.

Secondly, in alignment with socio-cognitive conflict theory (see also Baker, 2003), the interaction of all the gaining dyads was characterized by interpersonal repartition of explanations, that is: each discussant proposed at least one explanation that differed from his/her partner's. However, such a characterization still needs further clarification. Does the 'confrontations of cognitions', as suggested by socio-cognitive conflict theory, imply a confrontation between persons or only between the ideas
represented by them? Results from our dialogue analyses provide some first suggestions: Whereas gaining dyads posed a larger number of dialectical moves, dialogues of gaining and non-gaining dyads contained an equal number of moves that reflect consensual explanation construction and validation. Moreover, further qualitative analyses (Asterhan & Schwarz 2008b) showed that when the interaction was only characterized by critical-dialectical argumentation in a competitive, non-constructive atmosphere, students did not gain from the interaction either. Vice versa, when learners only engaged in consensual co-construction, they merely developed and consolidated their misconceptions. Even the meticulous design of this task -in which the students' conceptions were confronted with the scientifically-accepted concept -in which students were instructed to engage in critical, argumentative dialogue and were shown a dialogue excerpt of a critical discussion- failed to cause some dyads to take a critical stance (Asterhan & Schwarz 2008a).

This seems to indicate that dialogue that combines dialectical-critical argumentation and consensual construction of knowledge is a particularly powerful one. The question is however: How is or can this be accomplished? They may easily be perceived as two extremes of the same continuum. Being critical towards the ideas that have been proposed by another person may easily be interpreted as a personal attack on that person or as threatening group harmony, even if the intentions were neutral. In fact, peer collaboration literature has a long history of contrasting these as two opposing accounts of learning: On the one end, Piagetian theory that emphasizes the elicitation of cognitive conflict by peer disagreement (e.g., Piaget 1985) and at the other, Vygotskian theory that conceptualize learning as a process of internalizing socially constructed, consensual products (e.g., Vygotsky 1978).

In a recent study, we explored how some dyads managed to maintain the delicate balance between engaging in critical-dialectical argumentation while preserving interpersonal harmony (Asterhan & Schwarz 2008b). The protocols of these dyads showed that the episodes of dialectical argumentation were characterized by a pleasant and constructive atmosphere, not by interpersonal conflict or antagonism. Some students employed sophisticated techniques, such as spontaneous role-playing, in order to critically challenge different ideas without explicitly attacking the other or his/her views. Arguably, this would have allowed them to critically explore different
perspectives, but preserve a productive and constructive atmosphere of collaborative problem-solving and reach a better understanding therefore.

In the following section, we will present two excerpts from one particular dialogue between two females (A and B) to illustrate how students can engage in co-constructive, yet dialectical argumentation on each others' explanations.

AN EXAMPLE OF DIALECTICAL, YET CO-CONSTRUCTIVE ARGUMENTATION IN PEER DIALOGUE

Prior to the instructional intervention, both students explained evolution in Lamarckian terms, according to which individual members of a species developed new traits and passed these on to the next generation. During the first part of their interaction (i.e., on the warming-up item in which they were required to explain a phenomenon that was also explained in the movie), student A attempted to construct a Darwinian explanation. At the start of their conversation on the target item (the evolution of the webbed feet of ducks), A and B each present their respective solutions for the phenomena. Whereas A's explanation for the evolution of webbed feet includes several clear Darwinian characteristics, the explanation proposed by B is of the Lamarckian type. However, this incongruence does not surface to the conversation; rather, A and B even overtly express agreement. The introduction of the modeling dialogue by the experimenter then leads these two discussants to juxtapose their two different explanations and engage in dialectical argumentation:

[The experimenter gives them the excerpt and they read it aloud]

A 8 Difficult….I think that-

B 9.1 -If it is a matter of survival, then, ehhh, evolution will not occur, because swimmers, they do not need it for their survival.

9.2 It is something that nature feels that something has to happen, or the creature feels that something has to change for it to survive, only then will the change take place. That's amazing!

A 10 The question is, ehh, whether the change is biological or not? I mean, one survives and the rest does not, so one develops-

B 11 - You mean like a mutation?
A 12 Cause there are all kinds of animals. By chance one kind is well adapted to the new situation and that kind survives and continues itself.

B 13 Yes

A 14 I do not understand how he understood that- suddenly he says that they developed webbed feet

B 15 So how do you think it happened, that it happened overnight?

A 16 That one by chance had something similar to webs. He survived, and…the webs just developed [evolved], became more sophisticated.

B 17 And what if-

A 18 -Not something out of nothing!

B 19 And what if no one had it?

A 20.1 Then they would not have survived.

20.2 How could they have survived?

B 21 Maybe they just developed it somehow?

In this excerpt, the two discussants overtly discuss the incongruence between their respective views and challenge each others' ideas. What is striking, however, is the fact that, the conversation is not antagonistic in nature and that we did not detect any expressions or signs of discomfort throughout the entire protocol. Rather, the respective explanations are challenged 'from within', by exploring the validity and explanatory strength of the proposed explanation, and not by head-on confrontations. Disagreements are settled by requesting clarifications rather than by expressing opposition: For example in turn 10, A does not openly disagree with B's explanation, but instead asks her whether an account of intentional change can also account for 'biological' changes, such as the change in webbed feet. In turn 14, she formulates her doubts as a lack of understanding from her part ('I don’t understand how he understood that- suddenly he says that they developed webbed feet …'). Then in turn 15 discussant B requests A to clarify her viewpoint ('So how do you think it happened, that it happened overnight?'). She attempts to follow the line of reasoning proposed by A and asks her local questions that test the limitations of A's explanatory schema (see turn 19). This "what if…" stratagem is also adopted later on in the conversation, as shown in the next excerpt:
B 36  Do you think that if there was a person that had a bit of webs between his fingers, a human creature, then, ehhmm, and if we were to let this human being reproduce, then he would continue this, or that it would come off in the next generations?

A 37  No. Of course, when all the rest of the people would not have it and he would be the only one to exist, he is the basis for the reproduction, so obviously it, ehhh, his offspring would be like him. He is made of the same materials in fact.

B 38  But maybe these things, when they are at the start of their development, say something like, theoretically, a man with webs between his fingers, maybe they will develop only when they are needed for survival. And when they are not needed then they will go extinct with the following generations.

A 39  Development [evolution] just like that-

B 40  -By accident, by accident, mutation. Like, haven't you ever seen someone with a problem, say something a bit different-

The “what if…” scenario presented by B in turn 36, once more tests the limitations and implications of A's explanatory schema. This pushes A to explicitly refer to an important aspect of evolutionary theory that had not been introduced in the conversation until then: heredity. Whereas B seems to have accepted some aspects of the variability principle (turn 38), she continues to try and convince A of the possibility that evolution is an intentional, teleological process ('they will develop only when they are needed for survival'). A's reaction in turn 39 refers to the fact that traits cannot simply develop 'just like that', an issue that they had resolved and agreed upon earlier on in the conversation. This, in turn, causes student B to introduce yet another important concept, that of random mutations.

Their constant challenging in a gentle manner pushed them to articulate the different principles of evolutionary theory. These short excerpts show how B challenges the Darwinian-type explanation that is initiated by A in a non-antagonistic manner, whereas B seems to be able to consolidate and articulate this new explanation exactly as a result of B's critical questions. The students juxtaposed their explanations and, in spite of their disagreements, attempted to understand their respective lines of
reasoning and were open to each others' comments. The conversation is characterized by a pleasant communicational style that avoided overt personal confrontations which may have led to social inhibition and premature closure of the discussion. The interlocutors created a shared space in which they could critically reason on the arguments and articulate new arguments without denying the authors of the replaced arguments: ideas seemed to be perceived as a common property to be explored collaboratively.

CONCLUDING REMARKS
The studies we reviewed here and the protocol excerpt we presented illustrate the potentiality of dialectical, yet co-constructive argumentation for triggering conceptual change. The occurrence of dialectical, co-constructive argumentation in the AB dyad was certainly influenced by the instructions, task design and script they had been given. But it did not occur in all dyadic interactions. For this type of peer-to-peer dialogue to occur, it is important that students (and educators) understand that when they are invited to be dialectical and to discuss their (or others') differences, this does not necessarily imply that they have to persuade each other in a debate-type 'win-lose' competition. When the situation is perceived as competitive and its participants as opponents, learners are likely to merely engage in attempts to refute the other's explanation and to prove the superiority of one's own explanation over others. Insights from qualitative protocol analyses reveal that learning gains should be expected to be less substantive in this case (Asterhan & Schwarz 2008b). One may argue that in order to convey more clearly that being dialectical does not imply interpersonal competition, collaboration scripts should be more explicit and clearer on this issue. However, the two experiments we have conducted suggest that the effect of argumentative design is often difficult to predict. More generally, the studies we reviewed suggest the variability of behaviours in peer argumentation.

Finally, in addition to its potential benefits for conceptual change, encouraging dialectical, co-constructive argumentation is important in its own right. From an educational point of view, we would like students to engage in collaborative endeavours in which they critically consider and integrate different perspectives. For teachers, the more prevalent reason for implementing argumentative discussions in their classroom may in fact be the expectation that these activities will teach their
students to become civilized, rational and empathic discussants. So, even though argumentative design may not cause all people to transform their misconceptions, it may turn them into better citizens.

REFERENCES


