A LINGUISTIC ANALYSIS OF THE DIDACTICAL ENVIRONMENT IN SUPPORT OF THE SCAFFOLDING CONCEPT

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Can the didactical environment be conceptualised as a constant evolving process due to all the protagonists' contributions such as: signs, actions, interactions, and language games? If the didactical environment during mathematical problem solving is without doubt composed of cognitive destabilizing elements, these must be compensated by resources required for supporting the learning process by adaptation. This is particularly important in the context of special needs education. In order to complete our studies of didactical environments, our different observations and analyses of interactions occurring during classroom situations, bring us to reflect on language acts. A linguistic analysis using the syntactic, semantic and pragmatic register is suggested. Its possible contribution to our understanding of didactical environments is discussed.

VERBAL SCAFFOLDING AND THE SEARCH FOR BALANCE

Our research explores various language interactions encountered during mathematical problem solving activities through a didactical dimension related to the notion of "milieu" (Brousseau, 1990). Language phenomena that are responsible for the evolution of an environment suitable for the construction of mathematical knowledge in the specific context of special needs education are investigated. Hence our objective is to make the distinction between:

- What pertains to antagonism (the Piagetian disequilibrium) in mathematical problem solving activities: uncertainty, the masking of objects of knowledge, the need for verbal exchanges and the rupture of a didactical contract.
- What pertains to compensation or adaptation: for example by basing ourselves on the functions of scaffolding (Bruner, 1983).

Our hypothesis is that the search for balance (or unbalance) by means of control or regulation of didactical situations is mainly possible by resorting to the scaffolding functions defined by Bruner (1983). The latter describes scaffolding as the resources employed by an adult or a specialist to help someone less adult or less specialist. (Bruner, 1983, p. 10). After observing pupils and tutors in a problem solving activity, Bruner (1983) identified six categories of scaffolding functions:

1. Recruiting interest in the task

2. Simplifying the task
3. Maintaining the pursuit of the goal
4. Pointing out critical features
5. Controlling frustration
6. Demonstration or presentation of an ideal version of the act to be performed

During learning situation in mathematics these scaffolding functions may be correlated to linguistic processes. In our research project the following research questions are investigated:

1) Do special education teachers resort to all the six scaffolding functions during mathematical problem solving activities? Do they use it consciously and explicitly? Do they give priority to some scaffolding functions and why?
2) Can a linguistic analysis of discourse provide a better awareness of the progressive dimension of the didactical situations analysed through a semiotic process?
3) How can in-service training raise teachers' awareness that the six scaffolding functions are important for promoting adaptation?

During this communication, preliminary results related to research question 1 and 2 will be presented and their implications discussed.

THE SPECIFICITY OF THE DIDACTICAL ENVIRONMENT IN SPECIAL EDUCATION

The concept of the didactical environment stems from the theory of didactical situations (Brousseau, 1998). According to this theory, the use of antagonist situations (didactical situations creating a disequilibrium) are crucial for learning. The pupil learns thanks to a process of adaptation to an environment characterised by contradictions, difficulties and unbalance (Brousseau, 1988, p. 325). In these situations, learning is made possible thanks to successive adaptations of the didactical environment. In this model regulations and retroactions provided by teachers are at the heart of didactical concern. Teachers have to anticipate the instructional components that will allow their students to be self-regulated and autonomous. One of the specificities that we observed in the context of special needs education is that if the didactical environment contains elements producing a cognitive destabilisation, the teacher must compensate it by providing resources and educative alliances. It is necessary for the teachers to anticipate the students' diverse reactions. Indeed, some of the students with special educational needs can ignore the retroactions of the didactical milieu and never take actively part in the learning process. The goal of the adaptive learning model is in such cases unachieved, unless complementary or compensatory resources scaffolding the adaptive learning process are provided. The challenge in teaching pupils with special educational needs is to control the progression of the didactical time, and at the same time the maintenance of a pedagogical and relational balance, crucial in the context of special education.

LINGUISTIC ANALYSIS

To date, the study of the didactical environments (Bloch, 2002; Brousseau, 1990; Margolinas, 1995) does not seem neither completed, nor complete. We wish to explore another approach of the distinctive elements of learning situations in the context of special needs education. Based on the observations and analysis of classroom interactions during mathematic instruction conducted in our previous studies (Dias, 2007), a language analysis based on speech act theory (Austin, 1970), (Kerbrat-Orecchioni, 2001) is proposed in order to enhance our comprehension of the didactical environment. Three distinctive dimensions of discourse will be analysed: syntactic, semantic and pragmatic. As defined by Morris (Morris, 1938) in his classic presentation of semiotics, syntax is described as the study of the formal relations and combinations of signs. Semantics refers to the relations existing between signs and objects to which the signs are applicable (their "designata"). Pragmatics describes the study of "the relations between signs and interpreters" (1938, p. 6). These dimensions were used by many scientists interested in language (linguistic, semiotic and communication). The theoretical framework for the linguistic analysis of didactical situations in our study refers essentially to Morris's work (Morris, 1974).

Morris' model assimilates semiosis to a dynamic process, similar to the pragmatic approach developed by Peirce. It seems therefore particularly appropriate for gaining a better understanding of the various mechanisms involved in the interactions emerging during mathematical problem solving activities. In Morris's model the "interpretant" refers to the behaviour of the interpreter. Since the interpreter is the agent of the process, he must not be confounded with the "interpretant". This reference to behaviour suggests that the pragmatic dimension of discourse is essential in understanding the classroom's dynamic. The syntactic dimension is a „hidden dimension" for the students. Indeed, only the rules structuring discourse are explicit. In Morris' model all the signs do not necessarily refer to a real, tangible and perceptible thing. These « vehicles of signs » are mediators of knowledge in didactical situations. The pupils' possible actions in this syntactic dimension can be assimilated to motions on "idealitys", as described in the "*espace opératoire"* from Cavaillès (Cassou-Noguès, 2001).

The semantic dimension refers to the assignment of meaning(s) to the expressions of a discourse. In other words, this is the dimension where interpretation of discourse takes place. Because of the complexity of the relations existing between mathematical objects and their perception and comprehension, this is the main difficulty in mathematics instruction. It is in this dimension of discourse that the stakes of constructing meaning are the highest. Indeed, during mathematics instruction several actors interact with similar objects, which are not always interpreted in the same way (Dias, 2009). The verbal exchanges between the actors can lead to a consensus on the meaning of these objects, or not. This depends on the teachers' skills in regulating the didactical environments' dynamics (retroactions and antagonisms). If the teacher wants his pupils to interpret correctly his instructions, he must ensure that they are conveyed in the pupils' comprehension zone. The objects present in the didactical environment, which are conveyed as signs to be interpreted, are essential elements of this comprehension zone. The main issue at stake in this semantic dimension is the construction of a shared understanding of reality (Lelong, 2004).

THE RELEVANCE OF A LINGUISTIC ANALYSIS

During communicative situations in the classroom, teachers often discuss with their pupils but also sometimes struggle with meaning in a « language game» (Tisseron, Durand-Guerrier, & Héraud, 2006). The pragmatic dimension of discourse described in Morris' model, is based on the notion of « language in action ». It defines the relation between language and its functional use by the speaker in communicative situations. The pragmatic dimension is essentially contextual, as it refers to the interactions between participants in communicative situations. It can therefore be described as having a psychosocial nature. This dimension is highly relevant in didactical situations in the context of special needs education. Indeed, if a teacher wants to change the behaviour or enhance the knowledge of his pupils, he must necessarily build a social cooperation with his pupils.

On our opinion, interactions are neither dependent, nor independent of their context of production. They are as well constructions of the context itself, as manifestations of it. It seems to us that studying this pragmatic dimension of discourse is important to gain a more comprehensive understanding of didactical situations. In our linguistic analysis of discourse during interactions in pedagogical environments, the following references are used:

- The pragmatic register (Morris, 1938): analysis of the effects of the different utterances on the actors in the communicative situation
- The speech act theory (Austin, 1970). Austin and Searle distanced themselves from the syntactic and the semantic studies conducted by structuralists, which assume that every utterance implies an effect of this utterance, voluntary or not.
- The interactionist pragmatics (Kerbrat-Orecchioni, 2001), which studies the effects of the language acts during conversations and shows that the effects of some utterances are not consistent with their form. The interactionist analysis of language acts can highlight misunderstandings between teachers and pupils that can reinforce the disequilibrium present in didactical environments. This type of analysis seems particularly promising and could serve to identify several essential factors impacting on student-teacher interactions and their didactical relationship.

AN EXAMPLE OF CONTENT ANALYSIS

An example of content analysis presented in this section is based on an audio-recorded lesson, which took place in a self-contained classroom for pupils with special educational needs in spring of 2011. The teacher had presented her students a mathematical open-ended problem that they had to solve (Arsac & Mante, 2007). In order to solve this type of complex problems, pupils have to conduct an arithmetical research and use their knowledge of several mathematic facts.

Characterisation of scaffolding with Bruner's model

A content analysis in two steps is used in order to distinguish the exhaustive analysis of teachers' verbal scaffolding and their linguistic interpretation.

Step 1: analysis of teacher's interventions

Teachers' verbal interventions are systematically identified. Each language act is associated to a scaffolding function, based on Bruner's (1983) model. They are coded with the same numerals used by Bruner for each scaffolding function in his study (Bruner, 1983).

When necessary, the audio-recorded conversations were re-heard to enrich the reading of their transcription. The non-verbal explicit acts (gestures and looks) could not be taken into account in the analysis, because the lessons were not videotaped.

Step 2: Sequencing scaffolding interventions

The transcription of the lesson is then divided in short episodes corresponding to communication sequences. This allows the identification of chains of scaffolding interventions that are used preferentially or at least recurrently by teachers. The goal is to establish a profile of teacher's monitoring of the progression of didactical time.

Episodes	lines	Scaffolding functions
1.	line 1 to 9	2-3-3-4-2
2.	line 9 to 19	1-3-3-4-2-2-(4)
3.	line 20 to 37	1-3-3-5-3-3-5-2-2
4.	line 38 to 47	1-3-3-2-(4)
5.	line 47 to 52	1-3-4-2
6.	line 55 to 63	1-4-(2)-6-5
7.	line 63 to 76	1-5-4-4-2-4-3-(4)-2

Table 1. Example of an analysis of content from a corpus

Our analysis shows a frequent use of function 3 « sustaining the pursuit of the goal» during the first episodes of the activity. The teacher seems to compensate the antagonism of the milieu created by the complexity of the mathematical problem that the pupils were asked to solve. Indeed, because there is no obvious solution in open-ended problems, pupils are confronted to mathematical retroactions synonymous with temporary failures. Therefore, it seems normal that the teacher tries to sustain her pupils' orientation on the task, in order to avoid that they abandon their search for a solution out of discouragement. Through this scaffolding technique she also aims at exerting a didactical control on the problem solving process.

An analysis of these episodes also highlights that the function 2 « simplifying the task » has a conclusive impact on communication. This may be a phenomenon very specific to mathematics teaching in the context of problem solving activities. Indeed, the use of this type of scaffolding is not anticipated in a learning situation which promotes pupils' search of a solution and the production of statements, whose validity is postponed. During the phase of *formulation* (Brousseau, 1990), only the retroactions of the didactical environment can foster the verbalization of knowledge. The teacher's simplification of the task does not play this role and stops the verbal exchanges between pupils.

In this extract, an evolution of the types of scaffolding functions used by the teacher can be observed in accordance with the progression of the problem solving procedure and the progression of the didactical time. Function 4 « Pointing out critical features » appears progressively, as a manifestation of the teacher's will to stabilize pupils' hypothesis and findings. In our opinion, this could be a phenomenon specific to problem solving situations in the context of special needs education. Special education teachers often observe that their pupils have difficulties in identifying the important elements in terms of knowledge after spending a time trying to solve a problem. The profusion of information and the absence of identification of their domain of validity is a source of difficulties for pupils.

Scaffolding function 5 « Controlling frustration » appears belatedly in the succession of episodes. This confirms the teachers' willingness to loose progressively her control of the progress of problem solving. This could be described as a professional skill. It could be interesting to highlight it in a context of pre-service or in-service training for teachers.

The implicit character of language acts and disequilibrium in the didactical environment

This second type of analysis is related to our hypothesis that some of the teachers' interventions during mathematical problem solving activities are intended to scaffold pupils' learning, but are not perceived as such by the pupils themselves. Because of these miscomprehensions, elements creating disequilibrium and antagonism, which are not always consciously wished by the teachers, are introduced in the didactical environment. The following extract is an example of this type of perturbation.

20	teacher	this is not… Someone else? Quentin ?
21	student	I calculated that for a banana the camel had to walk one kilometre, so I calculated 1000 x 1, which makes 1000
22	teacher	yeah
23	student	then I divided 3000 by 1000, which makes 3 camels.
24	teacher	yeah

25	student	then, as we know that one camel eats 1000 bananas, I calculated 1000 bananas for one camel, and then subtracted 1000 to 3000, which makes 2000
26	teacher	yeah
27	student	then as 2000 bananas were left, I sent another camel with 1000 bananas.
28	teacher	how much?
29	student	1000 bananas
30	teacher	ah yeah, 1000 bananas
31	student	then I did 2000 minus 1000 makes 1000 bananas
32	teacher	but your 1000 bananas stayed at the entrance of the desert?

An analysis of the language acts identified in the above mentioned extract as creating imbalance yields the following findings.

line 22: interpretation of the answer « Yeah »

This first « yeah » is an assertion (statement presented as true). The illocutionary value is an affirmation, but the perlocutionary effect is to point out to the pupil that the teacher heard him and at the same time that he agrees with the content of his statement and enjoins him to continue his reasoning.

line 24: interpretation of the answer « Yeah »

With this second « Yeah », the teacher agrees with the operation performed by the pupil, but creates confusion because her illocutionary act validates the entire proposition. She intended to validate only the result of the division but not the pupil's proposal to use 3 camels. The assertion of this pupil's answer creates confusion because it does not respect the constraints given in the instructions of the problem (only one camel can be used). Because of the teacher's assertion of this answer with a « yeah », the entire proposition of this pupil will be followed by his classmates in their reasoning during several rows of conversation. This will last some time, before the teacher realizes this confusion and reminds her pupils that they have the right to use only one camel (line 59 of the corpus).

line 30:

The teacher uses the word « Yeah » for the third time. It has the value of an assertion: the locutor commits himself in recognising the truth of the proposal expressed by the pupil. However, this answer creates/sustains the disequilibrium because it was already used previously on two occasions with another linguistic value. Therefore, it is unlikely that the pupils will be able to interpret this intervention correctly on a semantic level.

line 32:

This intervention suggests that the teacher misunderstood the pupils' reasoning. A true disequilibrium is created in the didactical environment and is followed by a time of latency showing the ambiguity of the communicative situation.

CONCLUSION

The preliminary analysis of this corpus highlights the impact of the verbal interactions on the didactical environment, and particularly on its antagonist characteristics. The interplay of interactions related to scaffolding functions contributes to the modification, enrichment, or complication of the didactical environment. It renders it either more accessible, or more opaque for the pupils. The teacher's use, or non-use, of the six scaffolding functions seems to depend from the specificities of the didactical environment, as well as from the didactical time.

The different scaffolding functions identified by Bruner seem to be located in the chronology of interactions and form sequences comprising a succession of scaffolding interventions. These sequences can be clearly identified and seem to be provided in a relatively stable way. Some functions are used more scarcely; probably by fear of a modification of the characteristics of the didactical environment, in particular the fear to make it an ally.

In our corpus, scaffolding seems to be related to the progress of the didactical time. The real function of scaffolding interventions depends on the perlocutionary effect of the language act. Thus, the pragmatic analysis of discourse that we adopted seems to contribute to a relevant identification of the real effects of verbal scaffoldings.

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ANNEXE

The problem:

In a desert of 1000 km, you have to carry 3000 bananas with a camel. This camel can carry 1000 bananas on his back.

We know that it consumes 1 banana per kilometer.

What is the largest number of bananas that you can get at the end of the desert?