BEHAVIOURAL DIFFICULTIES CAN ARISE FROM LEARNING DIFFICULTIES: WHY AND HOW TO INTERVENE IN MATH CLASSES. /LES DIFFICULTÉS DE COMPORTEMENTS POURRAIENT PRENDRE LEUR ORIGINE DAN....

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Behavioural difficulties can arise from learning difficulties: why and how to intervene in math classes.[1]

Les difficultés de comportements pourraient prendre leur origine dans les difficultés d'apprentissage: Pourquoi et comment intervenir en classe de mathématiques

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RÉSUMÉ

Notre but est d'étudier si les problèmes d'anxiété, d'agitation ou d'évitement des élèves peuvent être interprétés autrement que comme une réaction sociale ou un problème médical. En portant attention aux règles et aux habitudes développées par les élèves, par le concept de contrat didactique, il devient possible d'offrir une autre interprétation conduisant à des interventions différentes. C'est ainsi qu'il est possible de briser les silos dans lesquels nos champs de recherche nous enferment parfois. Nous avons étudié les difficultés des élèves en mathématiques lorsque ces derniers manifestent anxiété, agitation et évitement à l'égard des tâches. Le contrat didactique a été utilisé comme cadre théorique pour situer les activités cognitives des élèves en mathématiques. Nous avons vidéofilmé 46 médiations avec 27 élèves entre 6 et 12 ans dans deux classes régulières et une classe spécialisée. Notre analyse a permis d'observer que des difficultés d'apprentissage initient les difficultés de comportement chez les élèves que nous avons rencontrés et ce, à cause de phénomènes comme la rupture du contrat didactique, l'effet du contrat didactique et l'extension connaissances. En outre, nous avons observé les effets d'interventions utilisées par les trois expérimentateurs pendant ces médiations. Nous avons pu constater que chaque catégorie d'interventions semble avoir un rôle distinct. Nous concluons que des problèmes de comportement en classe sont mieux compris en examinant les attentes des élèves et en adaptant les interventions en conséquence.

MOTS-CLÉS : apprentissage mathématiques, difficultés comportementales, contrat didactique, abstraction, enseignement.

ABSTRACT

With this article, we illustrate how anxiety, agitation or avoidance behaviour can be interpreted as a conceptual rather than as a social or medical problem. Based on the notion of the didactical contract (inarticulated mutual expectations of teacher and pupil), we propose an interpretation that instead links these behaviours to students' inappropriate application of their private learning rules and habits. As a consequence, these behaviours require conceptual, rather than social or medical interventions. We studied the behavioural difficulties of pupils in mathematics by asking them questions when they exhibited anxiety, agitation or task avoidance. We used the didactical contract as a theoretical framework to study their expectations as part of their cognitive activities in solving problems with natural numbers or fractions and statistics. We filmed 46 mediations with 27 pupils between 6 and 12 years old in two regular classes and one specialized class. Using a second, related theoretical framework for analysis, we observed that behaviour difficulties originate in learning difficulties which, in turn are due to the breaking of the didactical contract (expectations), known effects of the didactical contract and the extension of a piece of knowledge fragments. Using a third theoretical framework, we also analyzed the types of interventions used by the three researchers during mediations and their effects. Our analysis showed that interventions acted at three distinct levels of interactional proximity with the pupils and demonstrated varying degrees of relevance. We conclude that behavioural problems in the classroom are best addressed by examining pupils' expectations and adapting interventions in consequence.

KEY WORDS: learning mathematics, behavioural difficulties, didactical contract, abstraction, teaching.

1- CONTEXT

Power & DeBlois (2011) have shown that variables related to the interactive dimension of social capital, as opposed to those relating to the normative and structural dimensions (Zang et al. 2008), have a great influence on success in school. The interactive dimension offers a different way of thinking about classroom interventions. Across society, there is growing concern about behavioural problems in regular classrooms. Interventions usually involve institutional, physical, social or emotional adjustements (DeBlois & Lamothe, 2005; Massé, Desbiens & Lanaris, 2006; Massé & Couture, 2012). For example, adjusting the physical environment may entail reducing the quantity of material made available to pupils. Adjusting the social environment could take the form of rewarding pupils for certain expected behaviours. Various proactive behavioural strategies such as reducing the duration of the task or segmenting the learning content have also been proposed. In this article we propose another kind of adjustements, namely conceptual adjustements.

Beaulac & DeBlois (2007) recognized that the notion of the didactical contract (Brousseau, 2002) contributes to understanding pupils' expectations and consequently their own private set of rules and habits that they consult when learning algebra. The didactical contract is the set of reciprocal obligations and rules which teacher and pupil impose or believe to have been imposed, often implicitly, with respect to the knowledge in question: their mutual expectations regarding the task at hand. We documented various expectations among pupils such as the usual support from teacher, the usual length of the equation, the usual type of number used to find a mathematic solution. For pupils, these expectations translate into private rules or habits that they consider to be knowledge. However, they are usually hidden from the teacher. We hypothesized that a pupils' behaviour manifests their expectations regarding the situation, i.e. their application of their private rules and habits to the task to be performed. To test our hypothesis, we interpreted agitation, anxiety and task avoidance as consequences of pupils' expectations, i.e. as an integral part of their cognitive activity.

2- THEORETICAL FRAMEWORK

With the goal of exploring pupils' cognitive activities, we used Piaget's (1977) theory of "reflecting abstraction" to study the process of learning numeration (DeBlois, 1996) and word problems involving an additive structure (DeBlois, 1997a, 1997b). Based on Piaget's theory, we created an interpretative model of pupils' cognitive activities (Fig. 1), which includes their initial representations, their procedures, their understanding (awareness) of the mathematical concept and their expectations (DeBlois, 2013, 2014, Bélanger, DeBlois et Freiman, 2014). According to this model, when pupils are asked to express their representations, they organize their thinking, which enriches their procedures (actions). Meanwhile, the teacher interprets their knowledge and procedures. We define "coordination" as the sequence of thought as they move back and forth between their representations and their procedures between pupils' representations and their procedures. The capacity for coordination can reveal creativity in the pupil (Bélanger, DeBlois & Freiman, 2014). The phenomenon of understanding (awareness) related to the expression of pupils aims to encourage the identification of the specific characteristics of a concept. For example, we have observed that an awareness of the relationship "if…then" in an algebraic word problem leads to a symbolization of the relation, then to an awareness of the data for which the quantifier is '1', and finally to work on an understanding the properties of operations (Beaulac et DeBlois, 2007; Lemoyne, Conne et Brun, 1993). We distinguish between understanding (awareness) and metacognition in pupils: awareness is their comprehension of a mathematical relation, while metacognition is their ability to explain their approach or compare it to others. Figure 1 shows the model we used to interpret students' cognitive activities faced with mathematical problems.

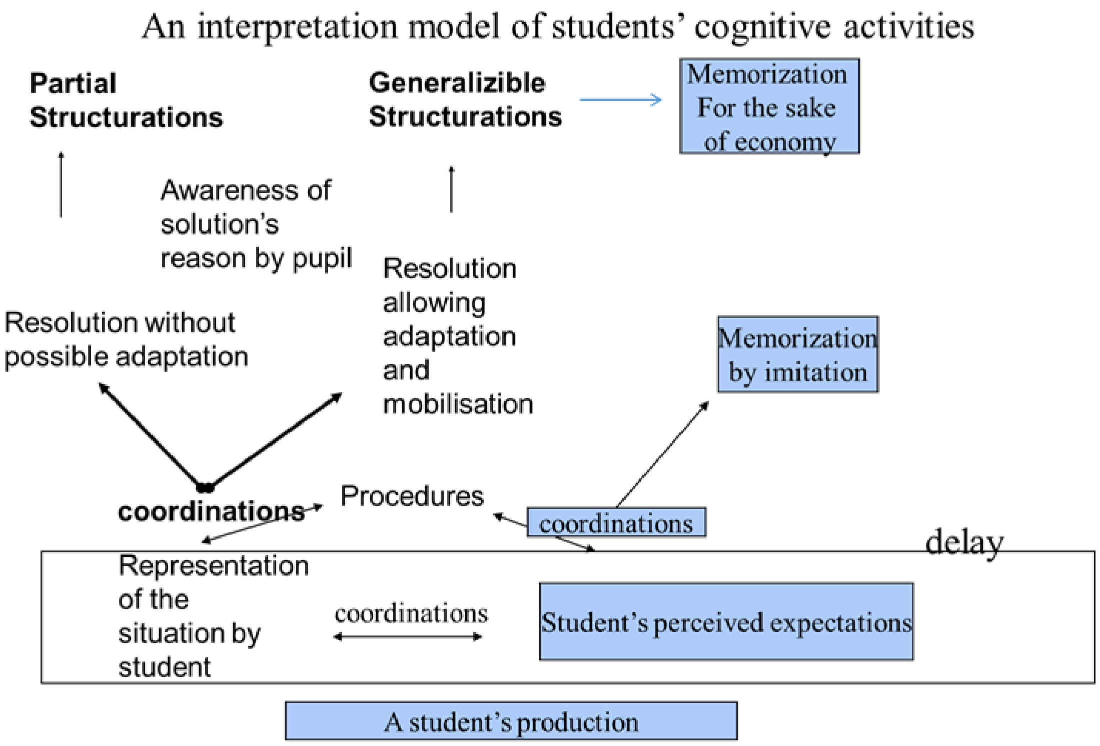


FIGURE 1. Interpretative model of students' cognitive activities (DeBlois, 2003; 2014)

The model (DeBlois, 2014) proceeds from the initial production of the pupils (at the bottom of the schema) to the structure (organization) of their understanding (at the top of the schema). We used this model to interpret errors in a pupil's production, or their agitation, anxiety or task avoidance, and formulated questions on the basis of various hypotheses about their initial representations or their expectations.

The notion of the didactical contract (Brousseau, 2002) proposes the presence of the private rules and habits that the pupil consults in constructing a distinct kind of knowledge (in French, connaissances). Their expectations, Connaissance, or C-knowledge, consists of private and discrete elements of knowledge, while savoir or S-knowledge is knowledge shared in an institutional form. C-knowledge and S-knowledge are both constituents of the didactical contract. A break in the didactical contract may not be explicit but may still generate a cognitive conflict. A break in the didactical contract occurs when the pupil's C-knowledge, including their private rules and habits, no longer suffices for solving the problem. This generates a cognitive conflict, which may manifest itself through some anxiety, agitation or task avoidance. However, when C-knowledge no longer works, an important learning opportunity arises because the pupil could feel about the necessity to learn. However, some anxiety, agitation or task avoidance could emerge.

Closely examining the learning content on which pupils were working when their behaviour became unacceptable provides a possible platform from which we can glimpse the "inner discourse" of pupils in relation to their expectations. Thus, our research questions are: What are the pupils' expectations when they manifest anxiety, agitation or avoidance in math? Can we formulate a hypothesis to explain the private rules and habits that develop during the learning of mathematic knowledge? Can we recognize different kinds of interactions and their consequences during mediation with pupils?

3- METHOD

Our research method was inspired by work on the clinical interview (Bang, Vinh, 1966; Liedtke, 1988, DeBlois, 1997a, 1997b; Beaulac & DeBlois, 2007). We called our meetings with pupils 'mediations' because we could not establish every question beforehand as a lot of mathematical content was being covered in the three classrooms. Pupils' errors were anticipated via a prior analysis of learning content in the curriculum. In addition, based on various kinds of open-ended questions were developed depending on the tasks proposed in the three classes. For example, questions such as 1) Tell me what you've tried, and then tell me what you thought; 2) What does this problem make you think about? 3) Explain to me/tell me the problem/the story; 4) Who's got the most? Who's got the least? 5) Could you give an example, what do you notice? 6) A friend told me that… What do you think about that?

In the first phase of the project (2011-2012), one researcher met with 10 pupils, aged 6-7 years old, in an ordinary classroom. In the second phase (2012-2013), another researcher met with 8 pupils, aged 8-9 years old in an ordinary classroom. They were not the same pupils. In the third phase (2013-2014), a third researcher met with 9 pupils, aged 10-11 years old in a specialized classroom. These three researchers were familiar with the interpretative model of students' cognitive activities (DeBlois, 2003, 2014). They developed their competencies in the formulation of questions during a masters' course.

Pupils were faced with a broad range of mathematical situations, such as word problems involving natural numbers or fractions, statistics, geometry and probability. Experimenters were in the classroom with the teacher who proceeded with their usual teaching. All three experimenters were known to the teacher because they had done their practicum with them the year before the research. Parents were informed about the research and mediations occurred only if they had consented to their child's participation. Each mediation was triggered by a pupil's behaviour in the classroom: i.e. they manifested anxiety, avoidance of the situation, or agitation during a mathematical situation.

Faced with these behaviours, experimenters asked a series of planned questions. The aim was to clarify the thinking of the pupil, to identify the private rules and habits he or she had developed, to find out their expectations and to study the didactical contract. As a mediation proceeded, the experimenter also developed tailored interventions to accompany the learning process of the pupil. We filmed mediations with a flip video camera. We transcribed the data verbatim for analysis. We analyzed the data using our theoretical framework: we coded the verbatim into the categories of representations, expectations (rules, habits), procedures, and understanding. We analyzed the verbatim of 46 mediations: 15 mediations with 6-7 years old pupils, 16 mediations with 8-9 years old pupils and 15 mediations with 10-11 years pupils.

Our interpretative and qualitative method used four criteria to validate data: credibility, transferability, reliability and internal consistency (Lincoln et Guba, 1985). Credibility was presented by the verbatim analysis crossed by 3 evaluations: each experimenter, the principal researcher and an evaluator.. Transferability was investigated by determining whether the results could be used in other mathematics classes because all data emerged from the real life of a classroom. Reliability was investigated by comparing the video, the pupil's productions and the verbatim during analysis. Finally, internal consistency was investigated by systematic use of the code based on our theoretical framework.

4- SOME RESULTS

4.1 Phenomena observed during mediations

To answer our first research question, what are pupils' expectations when they manifest anxiety, agitation, or avoidance, analysis showed that the didactical contract played a role in two-thirds of the 46 mediations. We observed two phenomena: breaks in the didactical contract and effects (consequences) of the didactical contract (DeBlois, 2014). Our analysis revealed another phenomenon: extension of a knowledge fragment (DeBlois and De Cotret, 2005). We explain these below.

First, while some pupils referred to their existing knowledge, they may not have adapted it as needed to the specific context. For example, Germain was agitated and anxious when he declared that his solution did not work. The verbatim showed that he was able to illustrate what ¾ of a sheet of paper looked like, but was not able to find ¾ of 12 (DeBlois, 2014). During the mediation, he explained: “They said to colour one in each [group of four]…”

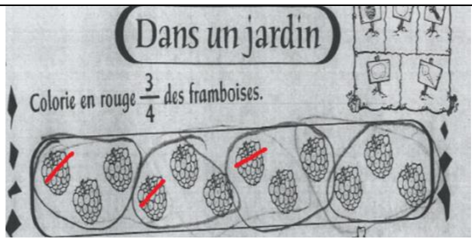
English version In a garden Place a red mark on ¾ of the raspberries.	

FIGURE 2. Germain’s production (DeBlois, 2014).

Figure 2 shows that he divided the 12 raspberries into four groups. It seems that the “part of a whole” sense of a fraction enabled him to identify the denominator. However, identification of the numerator presented a problem: he illustrated three objects instead of three groups of (three) objects. We call this kind of solution, i.e. application of a partial element of the concept of fraction, as “an extension of a knowledge fragment”. For Germain, this was a “solution that doesn’t work.” This extension of a knowledge fragment, i.e. in Germain’s expectations, which he expressed through agitation. We observed 16 cases of extensions of knowledge fragments in 46 mediations.

Second, Albert (DeBlois, 2014) showed an avoidance reaction from which anxiety was absent. In the task, the visible part of a iceberg is 587 m^3. This measure is represented as 10%. Analysis showed that the pupil was unable to interpret the percentage of the volume of the iceberg. For him, 10% of the volume of the iceberg was a small percentage and 587 was a large number. We interpreted his avoidance reaction as a break in the didactical contract because he compared 587 and 10 in an additive structure rather than a multiplicative structure as required by the task. When he used his private rules and habits, they informed him that addition was the required operation. The didactical contract his understanding that addition has worked before and therefore should work againWe observed 16 breaks of didactical contract in the 46 mediations.

Third, Alex presented anxiety. Our analysis showed that to solve a subtraction in a word problem[2] (8-2), Alex illustrated the two numbers (8 and 2) by drawing eight circles and then drew two more. He crossed out the last two circles to arrive at the number eight for his answer (Larivière & DeBlois, 2012). His explanation was based on the usual method of work proposed in book (i.e. drawing circles, crossing some out), but he ignored the relationship between the data. We interpreted this as an effect (consequence) of the didactical contract. Effects of the didactical contract appeared when a particular method of work was adopted to solve word problems, such as doing an illustration or highlighting important words. We observed 15 effects of the didactical contract in the 46 mediations.

We observed that all the pupils we met had tried something before manifesting

[2] You have 8 grapes. You eat 2 grapes. How many grapes do you have?

anxiety, agitation or task avoidance in the classroom. The didactical contract is usually hidden, but appeared particularly in the phase of implicit validation as we saw in the examples above. If a break in the didactical contract was sometimes expressed by agitation, at other times it was expressed by avoidance of the task. These differences between reactions could be explained by the "zone of proximal development" (Vygotsky, 1969). It seems that in this zone of proximal development, pupils are in the process of developing understanding about the concepts and the plausibility of their solutions, but still need further interaction with teachers and their peers to reach their full potential. Can we formulate a hypothesis to explain the private rules and habits that develop during the learning of mathematic knowledge? Can we recognize different kinds of interactions and their consequences during mediation with pupils

4.2 Expectations of pupils

When we studied the explanations of the pupils, we identified four types of expectations in the context of word problems: that solutions would be provided by benchmarks, by step-by-step procedures, by social interactions in the classroom, or by their day-to-day experiences (DeBlois & Bélanger, 2016). The search for benchmarks in word problems seemed to follow the organization of the presented data, such as the size of the first number being an indication of the operation required (Larivière & DeBlois, 2012; Giguère-Duchesnes, 2013). For example, subtraction was chosen because the first number in the word problem was eight and the second was two. Pupils also searched for benchmarks in words like "more" or "less". They interpreted the mathematical activity required as "doing something" in connection with these benchmarks.

The second type of expectation we observed in pupils' thinking was about step-by-step procedures. We observed difficulties in interpreting word problems when some data were absent, or in interpreting the solution found. For example, a pupil of 10 years old could build a statistical diagram to express data from a survey. However, he was unable to explain where the number 55 was situated on the axis because it showed the numbers 0, 10, 20, 30, 40, 50, 60, 70, but 55 itself was missing (Giguère-Duchesnes, 2013).

The third type of expectation was that the validation of a solution was the responsibility of the teacher through social interaction. The affirmation from the teacher that the answer was right was enough to halt any further reflection. The pupil would then move on to a new word problem without fully understanding the characteristics of the concept in the problem. In addition, if the teacher asked a question about the solution, the pupil would assume his answer was wrong and erase it.

Finally, some pupils mobilized their own day-to-day experiences related to the problem situation to give it meaning. For example, a word problem invited a 12 year old pupil to buy food for her pet. The pupil preferred to buy 4 bags of 2 kg each rather than 1 bag of 9 kg for a higher price because there would be only one bag to move rather than two. According to van der Veer (1998), the impact of these daily experiences and influences deserve to be further explored and questioned in education.

In addition, when we studied pupils engaging with natural numbers and their operations, we saw other kinds of expectations. We observed that our young pupils considered that a group of eight is a ten group (Larivière & DeBlois, 2012) because it is a group. Then, at the moment when a group exist the pupil call this «ten group» Also, we observed that all pupils we met considered the operation of multiplication as a repeated addition but without the characteristics of the equality of groups or the distributive property. The first characteristic has a consequence on the understanding that division can be seen as a share ("search the content of each subset"). This sense is used to introduce fractioned parts of a whole. This first characteristic has also a consequence to find the number of subsets used in division algorithms. The second characteristic has a consequence on multiplication algorithms such as 45 x 32 and on the learning of decimal numbers. This last characteristic allows a pupil to multiply two units on each digit of 45 and three tens (rather than three units) on each digit of 45. For example, we observed a 12 year old pupil who gave 300 as the solution for 24 x 100. He did 4 x 100 = 100 (rather than 400) and 2 x 100 = 200 and then added 100 + 200 = 300. It seems that this pupil tried to use the distributive property by successive distribution of each digit (2 seen as units rather than 2 tens).

A 9 year old pupil invited to divide the number 36 manifested some anxiety. He was urged to find the number of persons around a table; he drew 13 sticks around a table and wrote 13+13+13+13+13+13. He stopped his procedure and explained that the number 15, tried earlier, didn't work. He continued with numbers 11 and 6. These successive approximation procedures took a lot of time. Invited to try another procedure, he was confused and explained that it was impossible to mix tables and persons. However, he finished by using his times-table knowledge of 6 x 6, but before he wrote 36 x 6 = 36, he explained "I did my six-times table... 36" and gave no other explanation of the relationship between the numbers.

Expectations about rational numbers were interesting. We observed that some older pupils tried to create a relationship between the numerator and the denominator of a fraction. However, to develop this relationship, they expected to use counting rather than ratios. For example, one pupil used subtraction to calculate 1/10 of 100 and 1/5 of 10. His answers were respectively 90 and 5, rather than 10 and 2. He explained that the solution 10 and 2 were too small. Another pupil used a learned method to find the answer for 5/8 of 800. He illustrated 8 circles to represent 800, as the teacher had explained earlier, and chose 5 of them to arrive at 500 as the answer. But when asked to calculate 5/20, the same pupil drew 20 circles and stopped using his method before giving the answer. His expectations led him to use a method (which had worked before) but it seems that the meaning of this procedure was lost.

In conclusion, we could see that expectations create private habits and rules that pupils consider as knowledge even if the teacher has not institutionalized[i] them (i.e. recognized them as valid, useful, adaptable to other situations, and consistent with teaching objectives). In fact, pupils consider that repeating a task creates institutionalization. These C-knowledge are not based on logical-mathematical relationships but on rules or habits like an instrumentalization[3], i.e. on adapting their private rule or habit to the situation (Rabardel, 1995) to build their knowledge (DeBlois, 2014). They tried to find some regularity but only superficially. The anxiety, agitation or avoidance of tasks appeared after several tries. We continued our analyses to find out what kind of interventions were used and what kinds of knowledge they contributed to developing.

4.3 Kinds of interventions

We analyzed the nature of interactions between pupils and experimenters during the 46 mediations. We found 224 interventions and nine kinds of intervention (see Table 2). More than one kind of intervention occurred during each mediation, but if the same intervention occurred more than once in a mediation we only counted it once unless it was used for a different purpose. We didn't create a category named "pedagogical materials" because material was always on the table. It is important to note that insert some of the intervention categories in our method of research. For example, "Fictional pupil" and "Open questions," rather than closed questions.

To classify our interventions, we used a theoretical framework that describes three kinds of proximity during interactions in classroom: horizontal proximity, inductive proximity and deductive proximity (Robert & Chappet-Pariès, 2015).

TABLE 1. Kinds of interventions during mediation

Types of Proximity	Kinds of Intervention	Relevant	Somewhat relevant	Not relevant	Total
Horizontal proximity (81/224 36%)	Fictional pupil	(2) 2 [1]	(3)7[1]	(2) 4[1]	23
	Rephrase pupil's words	(3) 1 [1]	(1) 2 [2]	(11)9[-]	30
	Remind pupil of question	(2) 5 [2]	(-)-[8]	(1) 1 [-]	19
	Give explanation to the pupil or a way to approach the problem	(-) 1 [3]	(-)1[3]	(-) - [1]	9
	Total	**23/81**			
Deductive proximity (84/224 38%)	Open questions (rather than closed) including prepared questions	(4)12[3]	(-)23[15]	(3)14[2]	76
	Compare to another task	(2) - [1]	(1) - [1]	(-) - [3]	8
	Total	**22/84**			
Inductive proximity (59/224 26%)	Rephrase the problem	(-) - [5]	(-) - [2]	(-) - [1]	8
	Give counter-example	(2) - [1]	(1)2[-]	(-) - [-]	6
	Review students' procedure	(4)14 [7]	(1) 7 [6]	(3) 1 [2]	45
	Total	**33/59**			
		78	87	59	224

Key: (pupils 6-7 years old), pupils 8-9 years old, [pupils 10-11 years old]

[3] For Rabardel, instrumentalization leads to transforming knowledge in a tool in response to a person's need in a situation.

Horizontal proximity consists of interventions that attempt to stay on the same level of cognition as the pupil. This type of proximity is more social than cognitive because the aim is to maintain interaction with the pupils. For example, an 8 year old pupil gave the answer 40 to the problem 10 x 12[4]. The researcher said: "Ok, I met a friend of mine in another classroom. He had to do the same thing as you but he said that the answer was 120. What do you think about that number?" The pupil was confused and said that it was a big number. The researcher added: "How do you think he got to that number?" The pupil shook her head, looked at other pupils around her, and said: "I would do 12, plus 12, plus 12…" (Giguère-Duchesne 2013:86). This category also applies to the researcher's attempts to validate the pupil's understanding in an intervention called "Rephrase the pupil's words." For example, when the experimenter says, faced with a word problem[5]: "Ok, then… if you take jumps of two from 14 down to 0, do you know how many boxes of maple syrup you'll need? (Giguère-Duchesne, 2013:75). Another kind of horizontal proximity intervention appeared during mediation. Some were concentrating on the pupil's representations. For example, for a division problem (equal sharing)[6], the researcher said to a 7 year old pupil: "They have to give the same amount to each. You know, it must be *fair* for everyone". We called this kind of intervention "Give an explanation" (Larivière, 2012: 107). A fourth horizontal proximity intervention, called "Remind pupil of question," was when the researcher repeated the question read by the child or explained by the teacher.

Deductive proximity aims to help the pupil transfer knowledge from a definition (for example) to a particular context. These kinds of interventions were prefaced by open questions. For example, before a division problem [7]: "Ok then, what is the story in this problem?" (Giguère-Duchesne, 2013:66). We observed also another kind of deductive proximity: comparison. Different kind of comparison appears: comparisons between other pupils' explanations and the teacher's drawing; comparisons between the current task and a previous one.

In the category of inductive proximity, the cognitive activities of the pupil, but also of the teacher, create generalizations. The teacher must locate the pupil's reasoning in the learning process. In some of these interventions the researcher tried to review the pupil's procedures to situate their errors and help them understand where they went wrong, for example, by saying to the pupil: "Show me, explain how you did this." (Larivière, 2012: 147) or "Ok, and what did you do to find how much is in … all these

[4] Claude made 10 dozen fish to to stick on to his friends' backs [an April Fools' Day prank]. How many fish did he make?

[5] Madame Lise made maple taffy for everyone by pouring maple syrup on the snow. With one box of maple syrup, she could make taffy for 2 persons. How many boxes did she have to make taffy for everyone? [referring to 14 persons evoked in the previous word problem].

[6] Zoïk's team needs money to buy a book for $24. There are 6 children in the team. How much money must each child give, if they want to all give the same amount?

[7] To decorate a room, Juliette made garlands out of snowflakes. She had 48 snowflakes. With her 48 snowflakes, how many garlands could she make if she followed the A model (8 snowflakes illustrated) and the B model (6 snowflakes illustrated).

cents[8]? (Larivière, 2012: 85). Another example of inductive proximity was counter-examples. For example, looking at a statistical graph representing a number of visitors per day to Carnaval, with a scale of 25 per day on the vertical axis, the researcher asked an 8 year old pupil: "What if there were 55 visitors per day?" (Giguère-Duchesne, 2013:126). Other interventions invited the pupil to write down their solution or their procedure in another way. For example, an 11 year old pupil had to find 50% of the number 1180. First, he wrote 1180 ÷ 50. Then, the researcher asked: "You've written down the algorithm, could you write it in another way first, before getting to your algorithm? How did you know that you had to divide?" When the pupil hesitated, the experimenter added: "You see a circle that shows that 1180 fits with 50%. How can you write 50%?" The pupil wrote 1180/50, erased this fraction then wrote 50% of 1180. The researcher added: "Is it possible to change how you write this sentence before you solve it?" The pupil wrote 50/100 of 1180. The experimenter asked again: "Could you write in another way?" The pupil explained that he could reduce it, and wrote ½, then ½ of 1180. He drew 2 circles and wrote 1180 ÷ 2 to arrive at the right answer.

We observed that interventions were not all equally relevant to all pupils in all contexts and with all content. We qualified the intervention as relevant when the pupil manifested an explicit understanding by the exclamation (e.g. Oh, yeah!) or by continuing to work alone. In this case they explained what they didn't know before, what their confusion was, or how they found the right answer. We qualified interventions as "somewhat relevant" when the pupil found a solution without the pupil explaining or when the pupil began to work alone but didn't finish the problem. Finally, we qualified interventions as "not relevant" when pupils ignored the interventions or when they could not continue to work alone.

Horizontal proximity interventions were used in 36% (81/224) of mediations studied. However, only 28% (23/81) of them were relevant for developing an understanding (more than a success). The intervention we called "Give explanation to the pupil or a way to approach the problem" aimed to use the same level of vocabulary as the pupil used. However, "Rephrasing the pupil's words" is close to deductive proximity. In fact, when teachers rephrase the pupils' words they are inviting them to create a relationship between their new and old knowledge.

Deductive proximity interventions represented 38% of all studied. It seems that open questions were the most used. However, only 26% (22/84) of these interventions were relevant to develop understanding. These interventions permitted to surround expectations of pupils to lead their attention on their knowledge, consequently reducing anxiety.

Only 26% of the interventions were of the inductive proximity type (59/224) during mediations. However, close to 55% (33/59) of them were relevant. These interventions initiated a generalization when the researcher gave a hint. This type of proximity

[8] Pupils must count coins (1 cent, 5 cents, 10 cents) to find out if Laurent (a person in the word problem) will have enough money to buy something that costs 1 dollar.

requires locating pupils‘ thinking and procedure in a learning process.

We analyzed these types of proximity for their significance. We assumed criteria of independence between each intervention because one intervention did not necessary lead to another. In fact, it was the the pupil's procedures, representations or expectations that drove the interventions. The chi square test for the frequency of the type of proximity showed it was not significant (0.08) (Table 2).

TABLE 2. Comparison between frequencies of proximity types.

Types of_Proxymity	Frequency	Percent	Test Percent	Cumulative Frequency	Cumulative Percent
Deductive Proximity	84	37.50	33.33	84	37.50
Horizontal Proximity	81	36.16	33.33	165	73.66
Inductive Proximity	59	26.34	33.33	224	100.00

Chi-Square Test for Specified Proportions	
Chi-Square	4.9916
DF	2
Pr ChiSq	0.0824

However, the relevance of the type of proximity was significant (0.0003) (Table 3).

TABLE 3. Comparison between the relevance of proximity types.

Type of Proximity	Impact of interventions			
Frequency Row Pct	**Somewhat**	**Not Relevant**	**Relevant**	**Total**
Deductive Proximity	40 47.62	22 26.19	22 26.19	84
Horizontal Proximity	28 34.57	30 37.04	23 28.40	81
Inductive Proximity	19 32.20	7 11.86	33 55.93	59
Total	87	59	78	224

Statistic	DF	Value	Prob
Chi-Square	4	21.2388	0.0003
Likelihood Ratio Chi-Square	4	21.0571	0.0003

Type of Proximity	Impact of interventions			
Frequency Row Pct	Somewhat	Not Relevant	Relevant	Total
Mantel-Haenszel Chi-Square		1	9.2810	0.0023
Phi Coefficient			0.3079	
Contingency Coefficient			0.2943	
Cramer's V			0.2177	

Sample Size = 224

5- Discussion

Our analysis showed that it is possible to explain the anxiety, the agitation or avoidance of the mathematics’ task by reference to the didactical contract. It seems that the didactical contract played an important role in the cognitive activities of pupils, particularly concerning their hidden C-knowledge.Then, repetition of a task (exercise) conduct pupils to institutionalize their expectations (rules and habits) by instrumentalizing (Rabardel, 1995) their C-knowledge. A relevante intervention would help pupils to learn to negotiate the transition between C-knowledge and S-knowledge.

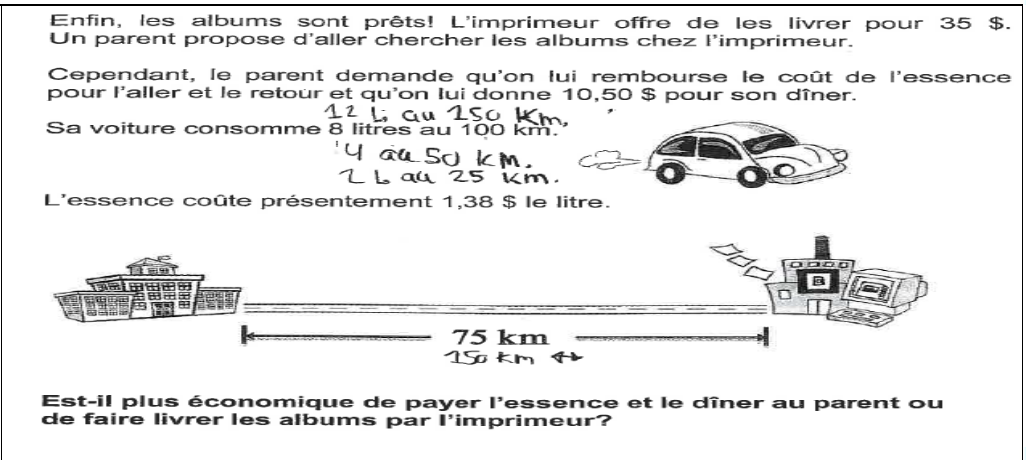
However, we saw that the creation of private rules or habits, consequences of the didactical contract, were different for each mathematical situation. Bélanger, DeBlois & Freiman (2014) recognized that the data and logical mathematical relationships that constitute a pupil’s personal knowledge system are organized in a variety of ways when applied to a word problem. In fact, it seems important to develop the sensitivity of pupils confronted with the implicit and explicit relations in a mathematical situation. This would discredit the superficial similarities between problems which lead pupils to attempt to apply their private rules and habits to every new situation, whether relevant or not.

Our results showed the importance, for the teachers, to recognize a variety of conceptual adjustements and their impacts. However, if we want to conserve the relationship between teachers and pupils, it seems that the most effective interventions are those that maintain a horizontal proximity. These kinds of interventions can take many forms. For example, describing the solution found by a fictional pupil in another class, rephrasing the pupil’s words, reminding them of the question, giving an explanation or suggesting an approach could come from our own experience of school. The aim at that moment is not to create understanding for the pupil, even if that were possible, but to reduce their anxiety or agitation faced with the task. This in itself opens up the potential for collaboration between teachers and parents in a school.

In addition, horizontal proximity interventions create among pupils more receptivity to inductive proximity. To intervene through inductive proximity, the teacher must situate the learner in a process. Once a horizontal proximity has been established, the pupil will be more receptive when the teacher, or the special education teacher, rephrases the problem, uses counter-examples or reviews pupils' procedures to analyze their C-knowledge and understand why it does not work. However, to enter into this inductive proximity, the pupil must accept risk-taking. This attitude appears when a pupil considers his role to be that of a learner rather than a pupil or a child (DeBlois, 2014a). This transition between positions can occur when they are faced with new challenge.

For example, during our mediations, we observed that a 12 year old pupil with a learning disability was able to solve a proportional reasoning problem involving content not yet taught. He created a new way of thinking and a procedure. Invited to choose the best price for having books delivered (Fig. 3), he calculated half of 8. After that, he added 8 and 4 to find that the parent would need 12 L of gas to drive 150 km. Then he calculated 12 x 1.38 = $16.56 and added $10.50 for lunch. He decided that the parent's offer, which would cost $27.06 (as opposed to $35), was the right answer.

Finally the books are ready. The printer will deliver them to the school for $35. However, a parent suggests he will fetch them but wants to be reimbursed for the gas (return trip of 150 km) plus $10.50 for lunch. His car consumes 8 litres per 100 km. Gas costs $1.38/litre. Which choice is more economical?



Mels (2011) l'Album

FIGURE 3. The creativity of a pupil with learning disabilities

CONCLUSION

This article illustrates how anxiety, agitation or avoidance behaviours can be interpreted in another way than as social or medical problems. Mediations with pupils with math problems showed they had always tried something first, before they exhibited these behaviours. Explaining behavioural problems seen in the classroom by examining pupils' expectations appears to be important for structuring conceptual adjustement. Varied interventions are needed to develop pupils' competencies not only in S-knowledge mathematics but in the pupils' learning processes during the class.

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