BEHAVIOURAL DIFFICULTIES COULD COME FROM LEARNING DIFFICULTIES: WHY AND HOW INTERVENE IN MATH CLASS.

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ICMI-Abstract

Research on the interpretation of students' cognitive activities in mathematics (DeBlois, 2014) and on teachers' sensitivity towards students' errors (DeBlois, 2006) provided evidence to analyse activities in the classroom. We studied behaviour difficulties of pupils in regard to when they exhibited anxiety, agitation and task avoidance as manifestations of learning difficulties. The didactical contract was used as theoretical framework to study students 'expectation as a part of students' cognitive activities in mathematics. We filmed 46 mediations with pupils between 6 and 12 years old in two regular classes and one specialized class. Our analysis recognized that learning difficulties initiate behaviour difficulties for pupils we met. We identified phenomena like break of didactical contract, effect of the didactical contract and extension of a piece of c-knowledge to explain anxiety, agitation or avoidance. In addition, we differentiated nine kinds of intervention used by researchers during these mediations to follow pupils.

1. CONTEXT

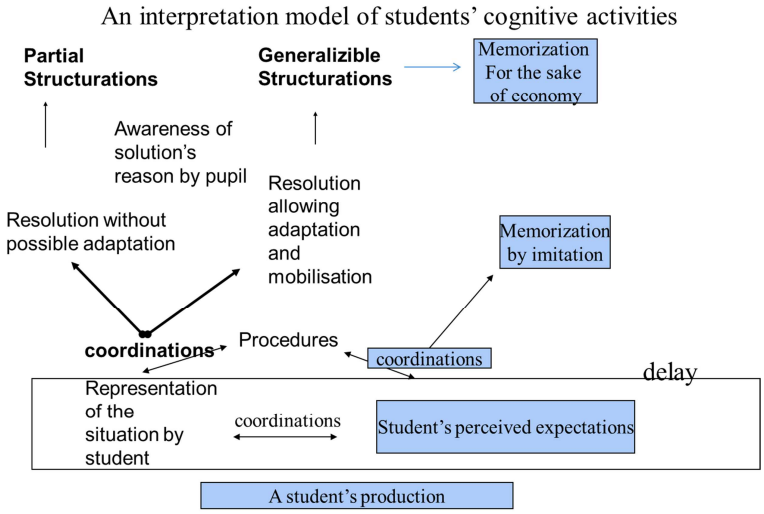
Across society, there is growing talk about behavioural problems in regular classes. We were interested to see if these problems could emerge from learning difficulties and which kind of interventions could help students. Power & DeBlois (2011) have shown that variables related to the interactive dimension, as opposed to the normative and structural dimensions (Zang et al. 2008), have a great influence on success. The interactive dimension offers a way to think about interventions in a class. On the other hand, interventions with students who manifest behavioural problems in ordinary classes could need more than institutional, physical, social or emotional adaptations (DeBlois & Lamothe, 2005; Massé & Couture, 2012). For example, adapting the physical environment may entail reducing the quantity of material made available to students. Adapting the social environment could take the form of rewarding students for certain expected behaviours. Various proactive behavioural strategies like reducing the duration of the task at hand or segmenting the learning contents are proposed. Is it possible to adopt a cognitive adaptation?

2. THEORETICAL FRAMEWORK

With the goal of discerning students' cognitive activities, we relied on Piaget's (1977) theory of "reflecting abstraction" (*abstraction réfléchissante*) to perform research on numeration and word problems involving an additive structure to recognize the place of students' initial representations of the situation, their procedures, their awareness of the mathematical concept and their expectations all connected by coordination the expression of their creativity (Belanger al., 2014). The model of students' cognitive activities leads our thinking (DeBlois, 2014) from the production of the students (at the bottom of the schema) to the understanding (at the top of the schema). Then, from an error in a student's production, in this case behavioural difficulties, we could see the pupils' production and

formulate questions from the basis of different hypothesis about their initial representations or their expectations.

Figure 1. Interpretative model of students' cognitive activities (DeBlois, 2014)



If students' behaviour manifests the students' expectations regarding the situation to be performed, we could hypothesize that such expectations, among some students, contribute to cognitive disorganization and therefore creates behavioural disorganization. Following testing of our hypothesis, we interpret agitation[1], anxiety[2] or task avoidance[3] as a consequence of students' expectations, a part of students' cognitive activities.

To identify the expectations of students regarding a situation, the notion of didactical contract[4] (Brousseau, 2002) contributes to identify the implicit rules created by the student about knowledge (*connaissances*)[5] in a situation. In this theory, the word "connaissances" refers to personally and discrete elements of knowledge and "savoirs" when knowledge is shared or institutional form. In this condition, c-knowledge and S-knowledge are constitutive of the didactical contract, a difference with a pedagogical contract, structuring the general life in class. Then, it is possible to discern the cognitive conflict stemming from a break in the didactical contract. Hence, when a c-knowledge no longer works, an opportunity for learning arises. This interpretation situates components in the process of learning (DeBlois, 2014) to monitor a possible mediation (Vygotski, 1933; 1985).

Closely examining the learning contents in which students were working when their behaviour became unacceptable provides a possible basis from which we direct one's attention to the "inner

[1]The student takes his pencil and attempts to draw the attention of his neighbour sitting opposite. He shoves a plastic basket separating them.
[2] The student talks to himself out loud, saying that he does not understand or does not know what to do.
[3] The student looks around him but does not start in on the task, lays his head down on the desk, or has his "head in the clouds."
4 The set of reciprocal obligations and "sanctions" which each partner in the didactical situation (Warfield, V. (2003). Glossary of terms used in didactique. Retrieved http://www.cmesg.org/wp-content/uploads/2015/05/CMESG2014.pdf, from http://faculty.washington.edu/warfield/guy-brousseau.com/biographie/glossaires/).
5 Warfield's enlightening, section 13 entitled "S-knowledge and c-knowledge" (pp. 109-111). Warfield, V. (2006). Introduction to Didactique. Seattle: University of Washington. Retreived October 11 2015, from http://www.math.washington.edu/~warfield/Inv%20to%20Did66%207-22-06.pdf.

discourse" of students, the content of their expectations. Then, we want to answer these research questions: Where do students' expectations come from when they manifest anxiety, agitation or avoidance in math? What kinds of intervention appear during mediation with these students?

3. METHOD

In the province of Quebec, pupils with learning difficulties and with behavioural problems are usually in an ordinary classroom. Then, to have a better understanding of the possible link between learning difficulties and behavioral problems, we analyzed didactical contract (Brousseau, 2002) in two ordinary classrooms and one specialized classroom where a researcher was in the class with the teacher. The researcher started mediation when a student manifested anxiety, avoidance of the situations or agitation during a mathematical situation in the ordinary class.

To prepare these mediations, open-ended questions were developed. For example, questions like «1) Tell me what you've tried, or 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 illustrate, what do you notice? 6) A friend told me that… What do you think about it? ». Students' errors were anticipated via a prior analysis of learning contents of the curriculum even if all mediations were carried in the classroom on the task given. Each researcher used the model of interpretation of cognitive activities of the students (DeBlois, 2014) during a master course before researching. These mediations allow insight into the student's expectations to study didactical contract. However, during these mediations we developed new interventions to accompany the learning process of pupils. In these conditions we could answer the two research questions.

We met pupils aged 6-7 years old (2011), 8-9 years old (2012), 10-11 years old (2013) when they manifested agitation, anxiety or avoidance during the task. One researcher for each group of pupils did and filmed the mediations *in* the classroom with a flip camera. We analyzed the verbatim of 46 mediations for a broad range of mathematical situations: word problems involving natural numbers, fractions, statistics, geometry and probability. Teachers continued their teaching in the classroom.

4. SOME RESULTS

4.1 Phenomena underlying the mediation

To answer to the first research question, we analyzed student's expectations and where they came from. Analysis shows that breaks in the didactical contract played a role in the reactions of avoidance, anxiety and agitation but only in one third of situations (DeBlois, 2014). Our analysis revealed two other phenomena in the same proportion: effects of the didactical contract and the extension of a piece of knowledge (DeBlois and De Cotret, 2005).

Then, some pupils referred to their knowledge. One of them was able to illustrate ¾ of 1 but was at a loss when confronted with ¾ of 12. He explained: "They said to colour 1 in each [group of 4]…". Then, the "part of a whole" fraction permits to identify 4 groups of 3 raspberries (denominator) by a familiar piece of knowledge, but block the identification of numerator, an expression of an extension of a piece of knowledge. The effects of didactical contract were more present with teachers using strategies that insisted on a particular method of work to solve word problems, like doing the illustration before solving. For example, to solve a subtraction in a word problem (8-2), a

pupil illustrated the number 8 by eight circles and the number 2 by two others but crossed out the last 2 circles to find again the number 8 for answer (Larivière et DeBlois, 2012). At the end, a break of didactical contract was observed, for example, when an 12 year old pupil could not interpret that $587m^3$ fit with the volume of 10% of an iceberg. For him, it was not possible that a little percentage (10%) could express a large number (587) (DeBlois, 2014).

4.2 Kinds of intervention

To answer to the second research question, we analyzed the nature of interactions during mediations. Nine kinds of intervention emerged from the analysis of 46 mediations. We found more than one kind of intervention during each mediation but we counted only one time a same kind of intervention during a same mediation except if relevance differed. In addition, the material was available on the table. Then, we didn't create a category named "manipulative".

We anticipated some interventions in the method like «Fictive student in class» and «Open questions rather than dichotomous questions where the pupil could answer by yes or no». In the first kind of intervention, a researcher presented the reasoning of another pupil. For example, a 8 year old pupil found 40 when she did 10x12[6]. The researcher said: "Ok, then euh, I met a friend of mine in another classroom. He must do the same thing as you but he said that the answer was 120. What do you think about this number? The pupil was confused and explained that it is a lot. The researcher added: "How could he arrive at that number?". The pupil shook her head, looked at other pupils speaking around her and said: "I will do 12, plus 12, plus 12…" (Giguère-Duchesne 2013:86). The second kind of intervention previewed (open question) allowed to ask a 8 year old pupil, for example facing of a word problem of division[7]: "Ok, then what is the story in this problem? (Giguère-Duchesne, 2013:66).

However, another kind of intervention appeared during mediation. Some were concentrating on pupil's representation. For example, during a problem of share[8], the researcher asked to a 7 year old pupil: "They must give the same amount, you know. It must be *fair* for all". We called this kind of intervention «Give some explanations» (Larivière, 2012: 107). In addition, when the researcher aimed at validating their understanding, the intervention was called: "Reformulation of the pupil's words". We identified this kind of intervention, for example, when in front of the word problem[9] a researcher said: "Ok, then… if you do some jumps of two from 14 to 0, could you know how many boxes of maple syrup you need? (Giguère-Duchesne, 2013:75).

It is also possible that the researcher repeated the question previously read before by the child or explained by the teacher. We called this intervention «Recall questions». At the end, some interventions invited the pupil to transform the writing. For example, an 11 year old pupil must do 50% of 1180. First, he wrote 1180÷ 50. Then, the researcher asked: "You wrote an algorithm, could you write this in another way before arriving to the algorithm? How did we know that we must

[6] Claude prepared 10 dozens of fish to put in the back of his friend [for the April 1]. How much fish did he prepared?
[7] To decorate a room, Juliette did tinsel of snowflakes. She did 48 snowflakes. With her 48 snowflakes, how much tinsel could she did if she follow the A model (8 snowflakes illustrated) and the B model (6 snowflakes illustrated).
[8] The team of Zoïk must have money to buy a book at 24$. There are 6 children in the team. How much money each child must have if they want to give the same amount?
[9] Madam [Lise] did tire on the snow for all people. With one box of maple syrup, she could give tire for 2 persons. How many box she must open to have tire of all persons [referring to 14 persons evoked in the word problem before].

divide?" Coping with the hesitation of the pupil, the researcher added: «You saw a circular diagram showing that 1180 fit with 50%. How could you write 50%?"The pupil wrote 1180/50, erased this fraction then wrote 50% of 1180. The researcher added: "Is it possible to modify the appearance of the writing of this sentence before to solve?" The pupil wrote 50/100 of 1180. The researcher asked again: "Could we write it in another way?" The pupil explained that he could reduce and wrote ½, then ½ of 1180. He drew 2 circles and wrote 1180÷2 to find the best answer.

Some interventions were concentrating on pupil's procedure. For example, «Comeback on students 'procedure» appeared when researchers said to the pupil: "Show me and explain how you did this!" (Larivière, 2012: 147) or "Ok and how do you do to find how much is it… all these cents[10]? (Larivière, 2012 :85). On the other hand, a counter example appeared. For example, invited to look at a statistic diagram representing the number of visitors in connection with days in a scale of 25 on the vertical side, the researcher asked an 8 year old pupil: "Then, if we had 60 visitors?" (Giguère-Duchesne, 2013:126). We observed also different kinds of comparison. We regrouped 3 kinds of comparison: a comparison between other students' explanations and the drawing of the teacher; a comparison between the task and another made before and a comparison between data of word problems and questions. What could we say about these kinds of interventions? What are their relevance in the cognitive process of pupils?

4.3 Types of proximity and relevance

We grouped the nine kinds of intervention with the frame of Robert & Chappet-Pariès (2015) who recognized three types of proximity during interactions in the classroom: horizontal proximity, inductive proximity and deductive proximity. The horizontal proximity consists in interventions that aim to conserve interactions between pupils and teacher. This type of proximity could be more social than cognitive because it stays on the same level of cognition. The inductive proximity aims to create some generalization. In these conditions, the cognitive activities of pupil but also of the teacher are fundamental. In fact, the teacher must locate the pupil's reasoning in a learning process. The last one, the deductive proximity aims to transfer knowledge from definition (for example) to a particular context. This framework conducted to build the table 1.

Table 1: Types of intervention emerge during mediation

Types of Proximity	Kinds of Intervention	relevant	In way	Non relevant	All
Horizontal proximity (81/224 36%)	Fictive student in a class	(2) 2 [1]	(3)7[1]	(2) 4[1]	23
	Reformulation of pupil's words	(3) 1 [1]	(1) 2 [2]	(11)9[-]	30
	Recall questions	(2) 5 [2]	(-)-[8]	(1) 1 [-]	19
	Give an explanation to the student or a way of doing	(-) 1 [3]	(-)1[3]	(-) - [1]	9
Deductive proximity (84/224	Open question (rather than dichotomies) including prepared questions	(4)12[3]	(-)23[15]	(3)14[2]	76

[10] Pupils must count pieces of money (1 cent, 5 cents, 10 cents) to find if Laurent (a person in the word problem) could have enough money to buy something cost 1 dollar.

38%)	Compare to another task	(2) - [1]	(1) - [1]	(-) - [3]	8
Inductive proximity (59/224 26%)	Writing transformation	(-) - [5]	(-) - [2]	(-) - [1]	8
	Counter-example	(2) - [1]	(1)2[-]	(-) - [-]	6
	Come back on students' procedure	(4)14 [7]	(1) 7 [6]	(3) 1 [2]	45
		78	87	59	224

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

We could observe 46 interventions with 6-7 years old pupils, 106 with pupils 8-9 years old and 72 with pupils 10-11 years old. We could interpret the differences because the tasks are shorter for the youngest pupils, then mediations were shorter. In addition, even if we expected 10 minutes for each mediation, researchers could not stop before pupils found a solution. Furthermore, we could see more horizontal proximity during mediations with youngest pupils (43% versus 22% of 24% for the two other groups) while mediations with 8-9 years old pupils present more deductive proximity (46% versus 31% and 23%). Mediations with oldest pupils present more balance between different proximities (31%, 35%, 33%). We must say that each group of pupils worked with a different researcher. Then, we could explain these differences by the experimenter.

We could see that interventions did not have the same relevance for all students in all contexts and contents. We qualified the interventions as "relevant" when pupils manifested an explicit understanding, by the exclamation of the pupil (Oh, yeah!) or by the fact that they kept on working independently. We qualified interventions as "in way of relevance" when pupils could find a solution without explanation or when pupils began to do something alone but didn't finish. We qualified interventions as "non relevant" when pupils ignored the interventions or when they could not continue to work alone.

Horizontal proximity was used in 36% (81/224) of discursive studied. However, only 28% (23/81) of them were relevant to develop an evident understanding (more than a success). These interventions did not have the same level of proximity. In this way, intervention called "Give some explanations to the student or a way of doing" aimed to use the same level of vocabulary without generalization when "Reformulation" was close to deductive proximity because it could invite pupil to create a relationship between new and old knowledge including definitions or s-knowledge. These interventions allowed to surround pupils' expectations to lead their attention on their knowledge, consequently reducing anxiety.

Deductive proximity interventions represented 38% of all studied. However, 26% (22/84) of these interventions were relevant. Only 26% of inductive proximity appeared (59/224) during mediations. Close to 55% (33/59) of them were relevant. These interventions started a generalization. At that moment, researchers gave a hint. This type of proximity needs to locate students' thinking and students' procedure in a learning process.

We tried to know if the frequency and the relevance of these types of proximity were significant. Then, we assumed criteria of independence between 224 interventions because interventions could not conduct to another. In fact, pupils' procedures or pupils' representations or expectations drove interventions. The chi square test about the frequency of the types of proximity is not significant as we could see in table 2. However, the relevance of the type of proximity is significant as we could

see in the table 3. We see that inductive proximity was relevant for the student's cognitive activities. Then, we have some data to understand the nature of interaction dimension (Power & DeBlois, 2011; Zang & al, 2008).

Table 2. Comparison between frequencies of types of proximity.

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

Table 3. Comparison on the influence of types of proximity.

type_proxymity	Impact of_intervention			
Frequency Row Pct	**In way**	**Non 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
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

CONCLUSION

Explaining behavioural difficulties in the classroom from an examination of students' expectations appeared to be important to structure a conceptual environment. Mediations showed that students had some learning difficulties before to react. In addition, didactical contract explained two third reactions. We must continue to investigate the tendency that showed by inductive proximity and its relevance. These results raise questions toward formation for preservice teacher. Varied interventions need to develop professional competencies not only in mathematic S-knowledge, but on the interpretation of the learning process during the class and on the nature of the interventions.

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