The Interpretation of Mathematical Difficulties in Primary School: Which Perspective to Choose?

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Research on learning difficulties in mathematics adopts one of two distinct perspectives. According to the first, learning difficulties are due to the intrinsic characteristics of the student. For supporters of the second perspective, those difficulties result from the interaction between the student and the school system. The objective of this study is to test the validity of these two perspectives in interpreting learning difficulties in mathematics among at-risk students. To this end, we collaborated with normally achieving (undiagnosed) and at-risk students. Results show that the second perspective is better suited to the interpretation of learning difficulties in mathematics students.

Keywords: mathematics, problem solving, learning difficulties, interpretation, intervention

Introduction¹

Since the reform of the (Quebec) education system in 2000, the proper integration and the success of students with learning difficulties have become major issues for the *ministère de l'Éducation, du Loisir et du Sport* (Squalli, Venet, & Lessard, 2006). These issues are the core orientation of the *Politique en adaptation scolaire* (Government of Quebec, 1999). With regards to the prevention of learning difficulties, mathematics is one of the disciplines that deserve closer scrutiny. In fact, Deblois (2011) argues that our mathematical knowledge is constantly solicited, in the daily tasks as well as in the professional duties we are called upon to perform.

The analysis of several research papers reveals two distinct positions on the issue of students with learning difficulties in mathematics. The first is mostly focused on the identification and the description of problems related to the student himself or herself, while the second is more interested in the education system and the specific phenomena that define the relationships between the performance of the student, the effective teaching situation, and the specificity of the knowledge being transmitted (Giroux, 2010; Roiné, 2009). Martin and Mary (2010) support this position, adding that these two perspectives are at odds when it comes to explaining the specifics of mathematics as taught to students with difficulties.

These two perspectives are based on specific theoretical and methodological rationales and are supported by various (mostly academic) research sources. Moreover, they impact the way mathematics are being taught to a specific group of students and, by extension, they also impact the way this discipline is being learned by this same group of students. (Martin & Mary, 2010, p. 230)

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¹ Another article about mathematical reasoning of ADHD students will be published in *International Journal of Technology and Inclusive Education*, vol 5(1).

To this end, scientific research that uses developmental psychology, neuropsychology, and cognitive sciences in its explanatory framework is associated with the first perspective (Giroux, 2010; Goupil, 2007; Martin & Mary, 2010). Supporters of this perspective argue that learning difficulties are directly related to the student. In fact, they appear to be intrinsically linked to the functional and structural characteristics of the learner (Lemoyne & Lessard, 2003). By adopting this point of view, the student is perceived as a subject whose personal attributes can be measured by standardized assessment tools. Also, still according to this perspective, the role of the teacher is to help the student make up for his/her difficulties via remedial interventions aimed at modifying his/her cognitive processes. In this context, the student is cast in the role of the person that requires help. Incidentally, some studies show that the assistance mechanisms put into place do not always stimulate the cognitive and mathematical engagement of the student (Martin & Mary, 2010). In that respect, Roiné (2009) mentions that difficulties in mathematics, as seen from this perspective, rest on the “specificity hypothesis”, which states that teachers’ interventions must be performed according to the classification of students into categories as performed in the school system.

Moreover, Lemoyne and Lessard (2003) point out that in the last decades, research on learning difficulties using cognitive sciences in its explanatory framework has yielded very little empirical results. According to these authors, this has led to a challenge of the immutable nature of the cognitive characteristics of learners and an investigation of the way school functions as an institution. Consequently, a second rationale has been developed for learning difficulties. It is essentially based on the didactics of mathematics. In this perspective, learning difficulties are seen as the result of the interaction between the student and the school system in which he/she participates. In this context, the learner is considered as a student (therefore a subject of the didactic system) whose difficulties are caused at least in part by the didactic contract² binding him or her to the didactic system (Perrin-Glorian, 1993). Therefore, according to Roiné (2009), learning difficulties are, in this perspective, viewed through the lens of a “contract hypothesis”.

This perspective considers teaching as the implementation of conditions that will encourage learning via didactic interventions that take into account the students’ mathematical knowledge as well as the specificity of the knowledge being transmitted (Martin & Mary, 2010). As for the students, they are modelled as active subjects who interact in a didactic environment developed by a teacher according to their cognitive dimensions and the characteristics of the knowledge to be learned (Mary, Squalli, & Schmidt, 2008).

In order to describe the perspective adopted by the various disciplines that study learning difficulties in mathematics, Giroux (2010) developed a diagram that classifies these disciplines by finality or epistemological stance. This diagram, shown in Figure 1, translates the finality of these disciplines on a lateral axis. A shift towards the left of this axis symbolizes a growing interest in the study of cognitive functions. This implies a focus on individual characteristics. Incidentally, Giroux (2010) mentions that a shift towards the right end of the axis is the sign of a growing interest for the study of the way knowledge works in learning or teaching situations. This move involves a focus on the interactive phenomena required in the transmission and the acquisition of knowledge.

² According to Brousseau (1998), the didactic contract allows the description of implicit or explicit rules governing the sharing of responsibilities in the transmission or the acquisition of knowledge between the teacher and the student. This contract is therefore a representation of the expectations of both parties.

Figure 1. Organization of the disciplines that study difficulties in mathematics, according to Giroux (2010).

Based on the findings of Giroux (2010), it is possible to assume that supporters of the first perspective, which specifically includes research stemming from developmental psychology, neuropsychology, and cognitive sciences, will be located on the left side of the diagram. This is justified by the explanatory framework for learning difficulties in mathematics, where the focus is on individual characteristics, which has been adopted by researchers from these disciplines. On the opposite, supporters of the second perspective would be more specifically positioned on the right side of the diagram, as they are more focused on student interactions in a given didactic system.

Departmental Position on Teaching Mathematics to Students With Difficulties

The evolution of special education legislation and policies tends to align the position of the *ministère de l'Éducation* with the first perspective on students with difficulties. This position is stated in the *Politique en adaptation scolaire* (Gouvernement du Québec, 1999), developed to refocus the high-level guidelines of the education reform on special needs and the specifics of students with disabilities or adjustment or learning difficulties. This policy includes a ministerial directive to teachers, asking them to adapt their teaching to the needs and characteristics of their students (Gouvernement du Québec, 1999; Gouvernement du Québec, 2006; Ministère de l'Éducation du Québec, 2000a; Ministère de l'Éducation du Québec, 2000b).

Incidentally, it is appropriate to review the basis for the ministerial directive on the adaptation of teaching to the individual characteristics and needs of the students. To this end, Giroux (2007) mentions that the position of the *ministère de l'Éducation* of Québec is not based on the consideration of the didactic dimension of teaching and learning. In fact, the ministerial guidelines tend to implement teaching practices that constantly seek new ways to “bridge the gap” that separates the student with difficulties from the other students at the expense of the consideration of the specificity of the teaching contents and the didactic conditions that facilitate his/her learning. Also, even though the use of explanatory frameworks related to the didactics of mathematics is on the rise since the eighties (Lemoyne & Lessard, 2003), these ministerial directives, because of their explanatory position on learning difficulties, neglect, in a way, the results achieved by the didactics of mathematics.

Research Objectives

All these considerations lead to a challenge of the interpretation conditions of learning difficulties in mathematics. In this research project, we will explore the validity of both perspectives on learning difficulties. To this end, we will assess whether the intrinsic characteristics of the students, as operationalized by the label “at-risk student”, are a valid explanatory framework for learning difficulties in mathematics. The goal of this approach is to test the “specificity hypothesis”. Moreover, to test the second interpretative perspective, we will explore the influence of the structure of statements of mathematical problems and the affiliation with a given school environment on the emergence of learning difficulties. This approach will be used specifically to test the “contract hypothesis”.

Methodology

Sample

The sample that we assembled allowed us to conduct our experiment on 522 sixth-grade elementary students. A total of 106 at-risk students, as well as 416 undiagnosed students, took part in the research project. The participants came from 28 schools of the Québec area.

Variables Studied

Several variables have been used in this research protocol. First, we considered the attribution of the “at-risk student” label to assess whether individual characteristics influenced the efficiency of problem-solving procedures used. The efficiency of the procedures used by at-risk students is compared with those of undiagnosed students.³ Then, to explore the influence of the adhesion to a specific learning community, we considered the class to which each student belonged.

Difficulties in Mathematics

In order to document the difficulties in mathematics encountered by at-risk students, we studied the relational calculus used to solve mathematical problems. More specifically, we analyzed the relational calculus developed in nine distinct problems on proportions. The problems varied according to the type of information presented: problems providing only the data essential to the resolution of the problem, problems providing situational elements of information, and statements providing superfluous elements of information. Also, our problem statements on proportions included three distinct types of numerical relationships: integer within relationship, integer between relationship as well as noninteger relationship. The characteristics of the nine problems that we used in our study are presented in Table 1.

Table 1

Presentation of the Structure of the Nine Problem Statements

	Essential data	Situational elements	Superfluous elements
Integer within relationship	Problem #5	Problem #2	Problem #6
Integer between relationship	Problem #4	Problem #1	Problem #7
Noninteger relationship	Problem #9	Problem #8	Problem #3

³ The concept of “at-risk student” refers to any student who cannot be classified as an at-risk student, a student with disabilities and/or a student with adjustment or learning difficulties.

Statistical Analysis

To meet our research objectives, we implemented three distinct statistical tests. First, to compare the efficiency of problem-solving procedures of at-risk and undiagnosed students, we performed chi-squared analyses for each of the nine problems. Then, to compare the level of difficulty implied by the structure of the problem statements, we performed paired t-tests for each problem pair. Finally, we performed an analysis of variance (ANOVA) and an analysis of covariance (ANCOVA) to explore the influence of the affiliation to a specific learning community. The goal of this analysis was to verify the existence of differences of performance in problem resolution between the various sixth grade classes with which we collaborated.

Results

Comparison of the Relational Calculus of At-Risk and Undiagnosed Students

To meet our first research objective, which is the comparison of the relational calculus of at-risk and undiagnosed students, we performed a chi-squared test for each of the problem statements. The results of the chi-squared tests are presented in Table 2. These analyses showed significant differences in the problem-solving procedures used in problems #2 (chi-squared = 20.998; $p < 0.001$) and #4 (chi-squared = 15.517; $p < 0.001$).

Table 2

Comparison of the Relational Calculus of At-Risk and Undiagnosed Students

Problem number		Relational calculus used			Chi-squared		
		Absence of a proportional reasoning	Presence of a proportionnal reasoning	Unclassified reasoning	Value	df	Sig.
<u>Problem 1</u>	At-risk students	25 (23,6%)	78 (73,6%)	3 (2,8%)	2,408	2	0,300
	Undiagnosed students	82 (19,7%)	329 (79,1%)	5 (1,2%)			
<u>Problem 2</u>	At-risk students	37 (34,9%)	48 (45,3%)	21 (19,8%)	20,998	2	0,000*
	Undiagnosed students	99 (27,2%)	282 (67,8%)	35 (8,4%)			
<u>Problem 3</u>	At-risk students	59 (55,7%)	33 (31,1%)	14 (13,2%)	4,556	2	0,102
	Undiagnosed students	189 (45,4%)	176 (42,3%)	51 (12,3%)			
<u>Problem 4</u>	At-risk students	22 (20,8%)	78 (73,6%)	6 (5,7%)	15,517	2	0,000*
	Undiagnosed students	44 (10,6%)	366 (88,0%)	6 (1,4%)			
<u>Problem 5</u>	At-risk students	56 (52,8%)	43 (40,6%)	7 (6,6%)	6,050	2	0,049
	Undiagnosed students	173 (41,6%)	224 (53,8%)	19 (4,6%)			
<u>Problem 6</u>	At-risk students	56 (52,8%)	43 (40,6%)	7 (6,6%)	6,050	2	0,049
	Undiagnosed students	173 (41,6%)	224 (53,8%)	19 (4,6%)			
<u>Problem 7</u>	At-risk students	38 (35,8%)	58 (54,7%)	10 (9,4%)	9,565	2	0,008
	Undiagnosed students	95 (22,8%)	293 (70,4%)	28 (6,7%)			
<u>Problem 8</u>	At-risk students	59 (55,7%)	38 (35,8%)	9 (8,5%)	5,096	2	0,078
	Undiagnosed students	188 (45,2%)	200 (48,1%)	28 (6,7%)			
<u>Problem 9</u>	At-risk students	53 (50,0%)	42 (39,6%)	11 (10,4%)	1,846	2	0,397
	Undiagnosed student	197 (47,4%)	189 (45,4%)	30 (7,2%)			

Comparison of the Level of Difficulty of the Problems

To meet our second research objective, we compared the levels of difficulty of each of the mathematical problems. To this end, we performed a paired t-test for the various possible combinations of problem pairs. We conducted a total of 36 distinct paired t-tests, since there were 36 possible combinations. To address the inflation of the alpha, we performed the Bonferroni correction by dividing our level of significance by 36 for each of these

tests. Consequently, our level of significance for each paired t-test was set to $p \leq 0.001$ (0.05/36). Conducting these tests allowed us to conclude that out of the 36 pairs of problems, 26 involved diverging levels of difficulty. The results of paired T-tests are present in Table 3. These results show that statistically significant differences exist in terms of the difficulty involved in the majority of the problems selected in our research protocol. The prioritization of the levels of difficulty based on the structure of the problems is depicted in Figure 2. Moreover, the ordering of didactical variables according to their level of complexity is shown in Table 4.

Table 3

Results of the Paired T-tests for the Various Possible Combinations of Problem Pairs

Paired T-tests								
	Paired differences					t	df	Sig (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence interval of the difference				
				Lower	Upper			
Pair 1 : Problems 1 and 2	0,66284	2,10048	0,09194	0,48223	0,84345	7,210	521	0,000*
Pair 2 : Problems 1 and 3	1,60920	2,11850	0,09272	1,42704	1,79135	17,355	521	0,000*
Pair 3 : Problems 1 and 4	-0,22605	1,93727	0,08479	-0,39263	-0,05948	-2,666	521	0,008
Pair 4 : Problems 1 and 5	1,12452	2,38715	0,10448	0,91926	1,32978	10,763	521	0,000*
Pair 5 : Problems 1 and 6	0,92529	2,26128	0,09897	0,73085	1,11972	9,349	521	0,000*
Pair 6 : Problems 1 and 7	0,65709	2,14163	0,09374	0,47294	0,84124	7,010	521	0,000*
Pair 7 : Problems 1 and 8	1,32759	2,01481	0,08819	1,15434	1,50083	15,054	521	0,000*
Pair 8 : Problems 1 and 9	1,36207	2,12587	0,09305	1,17928	1,54486	14,639	521	0,000*
Pair 9 : Problems 2 and 3	0,94636	2,23070	0,09763	0,75455	1,13817	9,693	521	0,000*
Pair 10 : Problems 2 and 4	-0,88889	1,97565	0,08647	-1,05876	-0,71901	-10,280	521	0,000*
Pair 11 : Problems 2 and 5	0,46169	2,30818	0,10103	0,26322	0,66015	4,570	521	0,000*
Pair 12 : Problems 2 and 6	0,26245	2,21626	0,09700	0,07189	0,45302	2,706	521	0,007
Pair 13 : Problems 2 and 7	-0,00575	2,28110	0,09984	-0,20189	0,19039	-0,058	521	0,954
Pair 14 : Problems 2 and 8	0,66475	2,01260	0,08809	0,49170	0,83780	7,546	521	0,000*
Pair 15 : Problems 2 and 9	0,69923	2,26455	0,09912	0,50452	0,89395	7,055	521	0,000*
Pair 16 : Problems 3 and 4	-1,83525	1,98354	0,08682	-2,00580	-1,66469	-21,139	521	0,000*
Pair 17 : Problems 3 and 5	-0,48467	2,33573	0,10223	-0,68551	-0,28384	-4,741	521	0,000*
Pair 18 : Problems 3 and 6	-0,68391	2,24200	0,09813	-0,87669	-0,49113	-6,969	521	0,000*
Pair 19 : Problems 3 and 7	-0,95211	2,33795	0,10233	-1,15314	-0,75108	-9,304	521	0,000*
Pair 20 : Problems 3 and 8	-0,28161	2,06497	0,09038	-0,45917	-0,10405	-3,116	521	0,002
Pair 21 : Problems 3 and 9	-0,24713	2,18840	0,09578	-0,43530	-0,05896	-2,580	521	0,010
Pair 22 : Problems 4 and 5	1,35057	2,08589	0,09130	1,17122	1,52993	14,793	521	0,000*
Pair 23 : Problems 4 and 6	1,15134	2,05913	0,09013	0,97429	1,32840	12,775	521	0,000*
Pair 24 : Problems 4 and 7	0,88314	1,95824	0,08571	0,71476	1,05152	10,304	521	0,000*
Pair 25 : Problems 4 and 8	1,55364	1,93215	0,08457	1,38750	1,71978	18,372	521	0,000*
Pair 26 : Problems 4 and 9	1,58812	2,14827	0,09403	1,40340	1,77284	16,890	521	0,000*
Pair 27 : Problems 5 and 6	-0,19923	2,17792	0,09533	-0,38650	-0,01197	-2,090	521	0,037
Pair 28 : Problems 5 and 7	-0,46743	2,38274	0,10429	-0,67231	-0,26255	-4,482	521	0,000*
Pair 29 : Problems 5 and 8	0,20307	2,26823	0,09928	0,00803	0,39810	2,045	521	0,041
Pair 30 : Problems 5 and 9	0,23755	2,34809	0,10277	0,03565	0,43945	2,311	521	0,021
Pair 31 : Problems 6 and 7	0,26820	2,26568	0,09917	0,07338	0,46301	2,705	521	0,007
Pair 32 : Problems 6 and 8	-0,40230	2,10178	0,09199	-0,58302	-0,22158	-4,373	521	0,000*
Pair 33 : Problems 6 and 9	-0,43678	2,30846	0,10104	-0,63528	-0,23829	-4,323	521	0,000*
Pair 34 : Problems 7 and 8	-0,67050	2,14240	0,09377	-0,85471	-0,48628	-7,150	521	0,000*
Pair 35 : Problems 7 and 9	-0,70498	2,44265	0,10691	-0,91501	-0,49495	-6,594	521	0,000*
Pair 36 : Problems 8 and 9	-0,03448	2,10446	0,09211	-0,21543	0,14647	-0,374	521	0,708

Figure 2. Prioritization of the level of difficulty of each problem statement.

Table 4

Ordering of Didactical Variables According to Their Level of Complexity

Level of difficulty	Types of numerical relationships and elements of information included in the statements
Classification of didactical variables in ascending order of difficulty involved More successful Less successful	Noninteger relationship
	Superfluous elements of information
	Essential data
	Integer within relationship
	Situationa; elements of information
	Integer between relationship

Exploration of the Impact of Belonging to a Class

Finally, we verified if belonging to a class supervised by a specific homeroom teacher had any impact on the resolution of problems on proportions. To this end, we performed an analysis of variance (ANOVA). Also, to meet the conditions of application of ANOVA, we assessed the homogeneity of the data by performing Levene's test. Results of those tests are shown in Tables 5 and 6.

Based on the data yielded by our ANOVA, we can conclude that the performance of the students in problem-solving was influenced by the sixth-grade class to which they belonged ($F = 3.999$; $p \leq 0.001$). Also, Cohen (1988) states that the portion of the variance in problem-solving explained by the school environment is quite significant ($\eta^2 = 0,168$). A subsequent analysis of covariance (ANCOVA) revealed that these class-based

differences in performance were partially caused by the students' socioeconomic environment ($F = 2.882$; $p \leq 0.001$; $\eta^2 = 0,118$). The results of the ANCOVA are presented in Table 7.

Table 5

Results of Levene's Test

Dependant variables	Levene's statistics	Df1	Df2	Sig.
Total Results	1,085	25	496	0,356

Table 6

Results of the ANOVA for the Success Rate in Resolution of Problems on Proportions as Obtained by Every Class

		Sum of squares	df	Mean square	F	Sig.	Effect size
Total Results	Between groups	8276	25	331,044	3,999	0,000	0,168
	Within groups	41056	496	82,776			
	Total	49332	521				

Table 7

Results of the ANCOVA for the Success Rate in Resolution of Problems on Proportions as Obtained by Every Class

		Sum of squares	df	Mean square	F	Sig.	Effect size
Total results	Between groups	5487	23		2,882	0,00	0,118
	Within groups	41056	496	238,589			
	Total	497957	522	82,776			
	Corrected total	49332	521				

Data Interpretation

We think that the results of this research project tend to confirm that the “contract hypothesis” is the most appropriate interpretative perspective to explain the learning difficulties in mathematics experienced by students with difficulties. This conclusion is reached because the characteristics of the students, operationalized by the use of the “at-risk student” label, have little influence over the efficiency of the relational calculus used to solve the problems on proportions. In only two problems out of nine did the undiagnosed students use more efficient procedures than at-risk students. This conclusion challenges the validity of the “specificity hypothesis”, because demonstrating that the nature of the procedures used by the various categories of students did not differ implies that teachers do not need to adapt their interventions to the characteristics of their students.

We have demonstrated that the structure of the problems and the student's sense of belonging to a school environment have significant impact on his/her performance. These results support the “contract hypothesis” by arguing that various didactic considerations influence the relational calculus of sixth-grade students. Consequently, we suggest that the difficulties in solving problems on proportions experienced by students be interpreted based on their interactions with the school system in which they operate and the specificity of the knowledge involved. Our results challenge the very basis of the ministerial directives that recommend educators take action according to the psychological characteristics of the students.

Further research in didactics of mathematics is required to better understand the teaching of proportional reasoning to at-risk students. Thus, we suggest the exploration of the various didactic phenomena likely to happen in a class where inclusive education is encouraged.

Conclusion

In conclusion, the research results show that the mathematical learning difficulties of at-risk students should be interpreted by considering the role of school system in the emergence of those difficulties. To this end, we should give formation to primary school teachers in order to help them to analyse their own practices and think about the impact of their pedagogy. Moreover, our results show that the learning difficulties in mathematics should not be interpreted through a psychological perspective. In fact, our research demonstrates that at-risk students adopt the same mathematical reasoning and the same mistakes of the normal achieving students. The only thing that differs between those two types of children is the number of mistakes. Consequently, we suggest that teachers do not have to adapt their interventions in class to the characteristics of the at-risk students.

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