Gap in Mathematical Achievements of Migrant Students: Is It "Just" a Question of Language?

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Abstract: Between 2015 and 2016 we conducted computer based tests with 177 French migrant students enrolled in primary, middle and high schools, to evaluate their mathematical abilities and their levels of literacy. With 26 of this group, we supplemented data from their results with interviews and exercises on paper. By comparing their scores to those of native speakers, we sought to establish the reasons for the gap in mathematical achievement that exists between these groups of learners. We have observed that academic language plays an essential role in this phenomenon but we have proved that this factor is not necessary linked to their proficiency in French. In addition, we have found other obstacles which hinder mathematical achievement of some migrant students. Consequently, considering the range of these factors, we have concluded that an evaluation of the specific needs of each migrant student has to been made so that each of them can receive the help that they require.

Introduction

In numerous countries, the number of immigrant and refugee students has recently increased. In the United States, the percentage of children with low levels of English literacy has nearly doubled between 1975 and 2005 (Federal Interagency Forum on Child and Family Statistics, 2005. America's Children: Key National Indicators of Well-Being. Washington, D.C.). They now represent one of the fastest growing components of the school-aged population (Fry, 2007) and the number of children with an immigrant background are expected to increase from 12 million in 2005 to 18 million in 2025 (Passel, 2007). In France, around 60 000 multilingual children are enrolled in French schools during the academic year 2016-2017 (Robin, 2018).

These students usually begin with specific classes providing them with an intensive language programme before being integrated full-time in mainstream classrooms. In spite of these measures, immigrant children fail in catching up in academic assessments, even after several years of schooling in their host country (Andon, Thomson & Becker, 2014; Ercikan, Roth, Sandilands & Lyons-Thomas, 2014). In the United States, for example, more than half of 8th grade English Language learners obtain poorer results in national standardised tests and 71% score below basic level in mathematics (Fry, 2007).

This paper investigates the factors which can explain the performance gap between native speakers and second language learners. Previous studies pointed out the impact of limited language skills in academic achievements. Miller (2009) stressed the challenge immigrant children in Australia have to face when they arrive in mainstream classrooms, especially in science lessons. She observed that in spite of the intensive English language courses they received, they do not possess the lexicon necessary to understand the lessons. Abedi and Leon (1999) observed a smaller performance gap between native speakers and second language learners in text-free exercises than in traditional text-based exercises. In 2008, Abedi, Leon, Wolf and Farnsworth complemented this study by proving the relationship between item text length and specific difficulties encountered by second language learners during math assessments (Abedi, Leon, Wolf & Farnsworth, 2008).

However other factors can also have effects on immigrant children's performance. Numerous previous studies highlighted the impact of the families' socio-economic status on second language learners' mathematical achievement (e.g., Chiu & Xihua, 2008; Roberts & Bryant, 2011). Taggart (2018) analysed many studies concerning Latino students and she identified several groups of factors which can undermine their academic achievement: demographic variables, sociocultural variables, prior academic experience, psychological variables, and school/institutional variables. Consequently we would like to give further consideration to this matter: are these factors really significant compared to the role of linguistic challenge? Or is it "just" a question of language?

To frame our discussion, we examined several previous studies concerning the difficulties encountered by second language learners during maths assessments. Then we analysed a range of data gathered from a French multidisciplinary investigation (EVASCOL (2015-2017) which is a research carried out by INSHEA and funded by the 'Défenseur Des Droits'. Available on: https://evascol.hypotheses.org/) conducted during the school year 2015-16. All these considerations lead us to question the actual practises in reception classes and to develop new strategies likely to improve mathematic teaching for multilingual students.

Theoretical Framework

In this article, we are interested in the performance gap in mathematics between native French speakers and those for whom French is a ‘second’ language (in some cases French is their third language). In order to better understand this situation, we would like to analyse the effects of several “bias factors” which may contribute to this performance gap. We call ‘bias factors’, factors which can prevent some students from succeeding in a test even though they possess the mathematical ability to perform at that level. An obvious example would be language itself - when the language of home and the community most familiar to a student is not the language of learning. We will explore the impact of other bias factors in this paper.

The Impact of Language Skills

By examining results of 1,174 eighth graders, Abedi and Lord (2001) demonstrated the impact of the language factor in mathematics tests. After having been given exercises which had been modified to reduce their linguistic complexity, they observed a significant improvement in students’ results, especially concerning ‘English Language Learners’ (ELL). Wolf and Leon (2009) examined the impact of language complexity on English language learners’ performances in various national assessments of mathematical ability. They succeeded in separating language difficulty from mathematical content to prove that misunderstanding of instructions hinders the mathematical capability of students with low English language proficiency. This is particularly evident with tasks that should otherwise be ‘relatively easy’. According to Pennock-Roman and Rivera (2011), simplifying the text of instructions is really useful for ELLs with intermediate language proficiency: results of students with limited language proficiency are not really improved. Consequently, Brown (2005) raised the issue of the literacy-based performance assessment that requires high levels of literacy in English. By comparing their results to fully English proficient students, she questioned whether it is an appropriate method to evaluate the mathematical achievement of English language learners.

It seems to be difficult to determine the relative contribution of specific features of linguistic complexity on the gap between second language learners and their monolingual peers during mathematic tests. Martiniello (2008) highlighted the implications of non-mathematical language complexity on English language learners’ performance. She observed that the gap between ELLs and fully English proficient students increases as language complexity increases. However this phenomenon decreases when non-linguistic schematic representations are included in the instructions. Haag, Heppt, Stanat, Kuhl and Pant (2013) put emphasis on the importance of the ‘everyday academic language’ (Ehlich, 1999) which refers to vocabulary used both in everyday conversation and in school-related contexts but with a slightly different meaning. Teachers may believe it is not necessary to ‘explain’ these terms as the words are not specific to their tasks; native speakers succeed in understanding them thanks to knowledge of their meaning in everyday language. Students who barely understand these terms cannot interpret them in a lesson context, so they represent greater challenges for second language learners. Actually, during the analysis of 21,618 assessments, Haag et al. (2013) concluded that everyday academic language constitutes one of the main difficulties when second language learners try to understand the instructions that accompany mathematical exercises.

However, many researchers (e.g. Gibbs & Orton, 1994; Pimm, 1987; Schleppegrell, 2007; Setati, 2005) identify a 'language' of mathematics (it's special vocabulary and phrases, grammatical patterns, methods of presentation, …) compared to the natural language and these specificities may prevent the second-language learners from understanding mathematics test items (Campbell, Davis & Adams, 2007; Shaftel, Belton-Kocher, Glasnapp & Poggio, 2006) : "Difficult mathematics vocabulary had a consistent effect on performance for all students at all grades" (Shaftel et al., 2006: p.105).

In 1979, Cummins recommended the need to distinguish between basic interpersonal communicative skills (BICS) and cognitive academic language proficiency (CALP). He showed that both kinds of language skills were not always developed at the same time: if two or three years could be sufficient to lead a daily conversation, five to seven years would be necessary to fully understand the language used in classrooms. Endorsing these conclusions, Spolsky and Shohamy (1999) studied second language learners in Israel and found that these students succeeded in speaking fluently in only two to three years whereas they needed seven to nine years to acquire the language skills expected at school. Specific to Mathematics, Millon-Fauré (2011) showed that acquiring the linguistic skills necessary for this discipline does not always require mastering the BICS: she observed that some second-language learners succeed in understanding and producing mathematical statements before being able to lead a daily conversation. As Ni Riordain, Coben and Miller-Reilly (2015) explain: " Mathematics learners are required to possess competency both in everyday language and mathematic-specific language, but competency in the natural language does not necessarily contribute to competency in the mathematic-specific language (Lemke, 1989)" (Ni Riordain et al., 2015, p. 19)

This phenomenon is magnified because the role of language is not limited to communication (understanding mathematics instructions and answering questions). It also affects the elaboration and organisation of thoughts (Ni Riordain and Mccluskey, 2015; Ni Riordain et al., 2015). It raises the question, 'In which language do you *think* when the knowledge you need has been taught in a different language than your first language?' Planas and Setati (2009) noticed that the bilingual students they observed tended to shift from one language to another during mathematical lessons, depending on the context. For example, when they spoke about new knowledge, they tended to use their second language which is the language in which the concept was taught. But when they were deeply engrossed in solving a problem, perhaps in a small group, they used to go back to their first language. We can only imagine the difficulties and the tiredness this practise may add to the mathematical task. Obviously low linguistic skills hinder academic achievement of second-language learners but this phenomenon might also have other explanations.

Factors Independent of Linguistic Skills

Lots of researchers underline the trauma refugee-background young people have faced because of their forced displacement and the repercussions on their schooling: that is the reason why according to Block, Cross, Riggs and Gibbs (2014), schools have to develop an approach focused on learning, social and emotional needs to provide an inclusive education. In the same way, Miller, Ziaian and Esterman (2018) promote several approaches developed by Australian school in order to take into account these students' refugee background. Furthermore refugee students' trauma is not always caused by their forced displacement: some can appear in the host country when they have to cope with an unfamiliar cultural frame. Consequently Due, Riggs and Augoustinos (2016) support pedagogical practices which rely on migrant children's linguistic and cultural background to facilitate their inclusion and their learnings.

In addition to these factors, Woods (2009) remarks that many refugee-background young people have had an interrupted schooling or sometimes have never attended school. Therefore they may be trying to learn English without having basic foundations in print-based literacy in their first language. Mendonça-Dias (2013) also points to the specific difficulties encountered by immigrant students with interrupted schooling.

Even if they had received complete schooling in their country of origin, the mathematics knowledge taught could be different from one country to another: for example, there exits many ways to execute operations (Girodet, 1996). Besides, pedagogical approaches are not the same. When she tried to determine bias factors in mathematics achievement tests among Israeli students from the Former Soviet Union, Levi-Keren (2016) noticed that these students used to refer to 'formal' mathematical discourse used in textbook and had difficulties to solve exercises which were a bit different from the ones they had studied before. Levi-Keren assumes that this phenomenon is due to the pedagogical approach prevalent in their country of origin which is mainly based on reinforcing technical competences as learners. Lastly some mathematical instructions require some cultural references to be understood, which can be problematic for migrant students (Lamprianou & Boyle, 2004). For example, Campbell et al. (2007) describe a migrant student who has failed in solving a mathematical problem just because he did not know the baseball rules. Taggart (2018) analyses the repercussions of cultural discontinuity concerning school based learning and finds that it has negative effects on academic outcome of Latina/o high school students. All these reasons can explain why Millon-Fauré (2010) has proven that migrant children encounter difficulties to reuse in their host country knowledge previously learnt. Furthermore as migrant students are encouraged not to use their first language, they tend to forget their cultural references and their previous knowledge in the same way (Civil, 2008).

All these reflections show that bias factors in mathematics achievement tests are numerous. However it is difficult to compare their impacts on performance gaps between students with migrant or refugee backgrounds and their counterparts. Are factors independent of linguistic skills really significant?

Method

The Different Tests

In this article, we will use data from a national multi-disciplinary investigation called EVASCOL which aims at evaluating the circumstances of newly arrived children in France (Armagnague, Cossée, Mendonça Dias, Rigoni & Tersigni, 2018). Between 2015 and 2017, students who took part in this research were evaluated in Mathematics and French using several tests (Mendonça Dias, 2017):

- Shortly after their arrival in a French school, 353 students were given multiple-choice exercises in order to determine their language skills in French and their mathematical skills. The exercises taken depend on students' age. In order to prevent their difficulties in French limiting their performance in the exercises, mathematical instructions have been written in their first language thanks to the translations of the CASNAV in Aix-Marseille (Available on: http://galileo.crdp-aix-marseille.fr/mathsenaf/) as you can see in figure 1. These exercises had previously been tested on native students so that we can compare results obtained by migrant students against the mean score reached by a given native student.

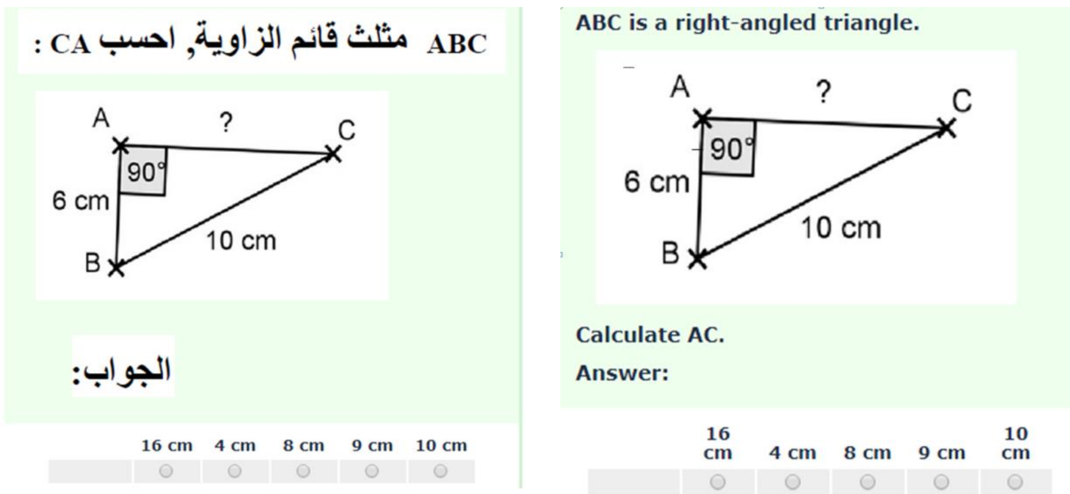

Figure 1. Examples of Exercises in Different Languages

- At the end of their first year of schooling in France, they were given the same test again but all the instructions were in French. For each student we compared the results obtained in both tests in order to measure acquisition or loss during this first year. 177 students passed tests in French and in Mathematics.

- In addition, we made a more detailed study of 26 pupils chosen randomly from the 177 previously identified, to refine our perceptions of their knowledge in French and in Mathematics. We interviewed them and conducted exercises that had to be solved on paper without a computer or calculator. During these tests a researcher observed each student, asking questions to help determine reasons for difficulties with specific exercises. This kind of test allowed us to devise tasks that would otherwise be difficult to assess with computer-based exercises, like drawing geometrical shapes.

We also collected numerous other forms of data on each student including: country of origin, language(s) used at home (prior to departure), and language(s) used since arrival in France. We finally chose four pupils who appeared to be representative of the different types of students we have encountered and we tried to cross-reference all the information concerning them. This study is detailed in Mendonça Dias and Millon-Fauré's article (2018).

Sample

The 177 students who have passed the computer-based tests, were enrolled in mainstream classrooms but they also followed – for several hours a week - an intensive language programme to learn French (the UPE2A, which means 'Unité pédagogique pour élèves allophones arrivants'. This programme provides specific lessons for multicultural students recently arrived in France). They were between 5 and 18 years old. A quarter was enrolled in one of four 'primary schools' (schools for pupils who are between 6 and 10 years old) and three-quarters attended one of fifteen secondary schools: 69% of the students we interviewed were in 'middle schools' (schools for pupils who are between 10 and 14 years old) and 6% in 'high school' (schools for pupils who are between 14 and 18 years old). Our sample was composed of almost equal numbers of girls and boys (82 girls and 95 boys).

Our 177 students came from 46 different countries, with the majority originating in Spain, Bulgaria and Italy and around 75% had arrived in France only a few months before the beginning of our investigation. They often had a low level of literacy in French: at the beginning of our study 73% were competent at level A1, 23% at level A2 and 4% had achieved level B1 according to the six levels of the Common European Framework of Reference for Languages (from the breakthrough A1 to the mastery C2). Ten months later, 55% were still at level A1, 27% had progressed to A2 and 18% had achieved level B1. Of the 26 pupils interviewed during the follow-up study, 6 were in primary schools and the others in middle schools. They were 14 girls and 12 boys.

Results

Analysis of the First Test

In this test, each student could select the language of the instructions so that difficulties in French did not impact on their mathematical activity. By comparing their results to the scores of their French peers in the same school level, we discovered that 56% of migrant students did not possess the mathematical knowledge required to succeed in the class where they had been placed. This situation can have several causes. For example, these students might have had an interrupted schooling before arriving in France, or the school curriculum could have been different in their country of origin and they may have acquired knowledge which was not relevant in this test. In conclusion, we found that more than half of the migrant students we interviewed had not mastered the mathematical concepts required in a French school and this will almost certainly be a barrier to their school achievement.

By contrast, more than 10% of the students we interviewed had such an advanced level of mathematical comprehension that they could have attended lessons in a higher class than the one in which they had been placed. This helps to illustrate the diversity of the migrant students who arrive in France.

We have also compared the gap between migrant and native students in the different mathematical domains (numbers and calculations; geometry; measurements) to determine whether one of them was particularly difficult for migrant students. There were not real differences except for measurement where the gap was slightly bigger: the exercises of conversion especially were the less performed. The explanation can be that some countries use different units of measurement than ours, which prove that cultural particularities can also have impacts on mathematical achievement of migrant students.

Analysis of the Second Test

The test was identical to the first, except that instructions were in French instead of their first language. When we compared results obtained in this test to those of the first one, we observed a significant regression for 29% of the students we interviewed. As the exercises were exactly the same, we believe this phenomenon is due to the difficulties of understanding the instructions in French. We found one third of the migrant students observed did not succeed in solving some exercises despite possessing the mathematical knowledge required to do so because of their low level of French literacy, even after one year of schooling in France. It is particularly alarming because after one year in the intensive French language programme, migrant students are expected to be able to keep up in mainstream classrooms exactly like native speakers.

In some ways this results surprised us: the figure of 29% was higher than we expected. By contrast, 23% of the study group obtained almost exactly the same results when the instructions were in French compared with when the instructions were in their native language, whilst 48% (almost half of the study group) succeeded in improving their mark between tests. So in little time, they not only gained the language skills necessary to understand instructions and to solve exercises (as if they were in their first language) but they even acquired new mathematical knowledge.

We have tried to determine which factors can be linked to the variations between both tests. First, using an ANOVA with an alpha-risk of 0.05, we have observed that these variations and their mastery of French when they arrived are related (the p-value was equal to 0.016). However there is no correlation between their progress in mathematical and everyday language (either in oral form or in written form), which seems to agree with previous studies (Millon-Fauré, 2011; Ni Riordain et al. (2015b.)). Similarly, there is no correlation between their progress in mathematical tests and the fact they have spoken French (in some cases exclusively French) at home since their arrival.

On the contrary, an ANOVA with an alpha-risk of 0.05 shows that their progress *is* related to their level in mathematics on arrival in France (the p-value was equal to 0,007): students who had high levels of achievement in Maths in their country of origin found it easier to understand the French instructions and to use their previous knowledge. For this sub-group it seemed easy to recognise a mathematical word in French when the accompanying mathematical concept was already understood, whereas students who had a weak foundation in the subject had difficulties to learn the French terms.

Finally, we found no correlation between the results obtained from the first test and the gender of the student, but it appears there may be a weak correlation between progress made in the tests and gender of the students: irrespective of their initial level in mathematics, the girls we observed appeared to succeed slightly better in the test with French instructions than their male peers.

Secondary Study

We conducted one-to-one interviews with 26 students chosen randomly from the 177 in the study group, in order to identify problems they may have experienced whilst completing the tests. Firstly, we observed misunderstandings of basic terms of geometry. For instance, the diagrams below (figure 2) show answers to the instruction "*Construct a circle with centre A and passing through B"*. These drawings reveal confusions between the concept of 'circle' and, respectively, the notions of segment, square and triangle:

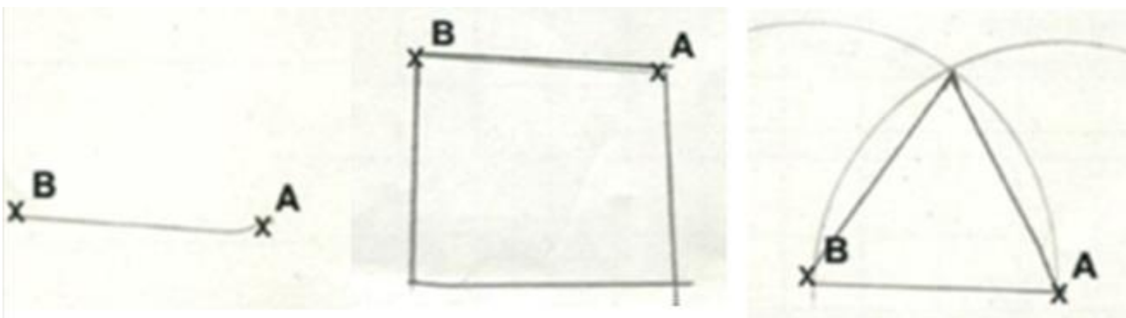

Figure 2. Figures drawn in response to the question "Construct a circle with centre A and passing through B."

Even though in the third diagram it appears that the pupil has used a pair of compasses, which may show that they associate this instrument with the term 'circle', they appear to have not understood the task.

We also observed errors in diagrams produced by non-migrant students, but errors were more pronounced in the work of migrant students. For example, 21 migrant students out of 26 appeared to misunderstand the word 'perpendicular'. In figure 3, we can see some of the answers that were given:

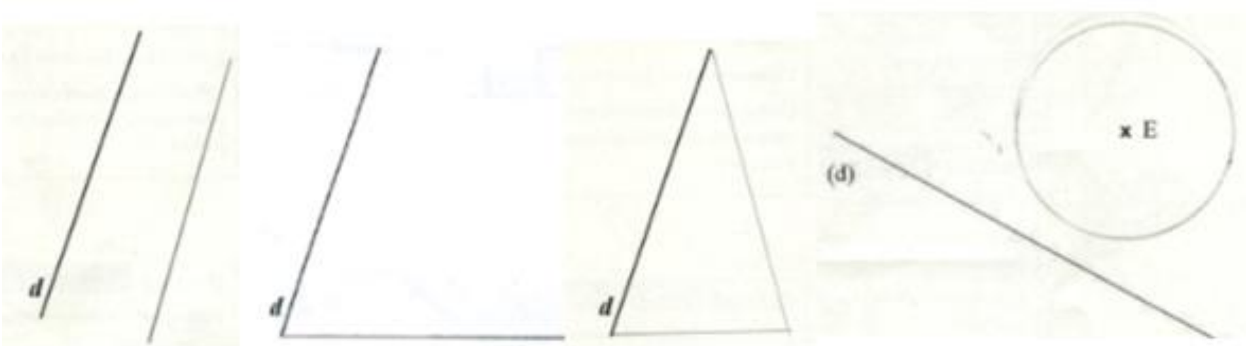

Figure 3. Figures Drawn in Response to the Question "Construct a Line Perpendicular to D"

In the first example, the student appears to have confused 'perpendicular' with 'parallel': we observed this mistake seven times even amongst migrant students who were enrolled in middle school. Three pupils drew a 'horizontal line' (like in the second diagram) instead of 'perpendicular line' (one of these students was in last year of middle school). The third and the fourth diagrams appear to show that some students did not understand the concept of the word 'line': four students have drawn a triangle like in the third diagram and one has drawn a circle. In addition, six students did not answer this question, and two of them have spontaneously said they did not understand the term 'perpendicular'. We may be able to conclude that it was difficult for a number of participating students to understand the instructions to these geometrical exercises.

We also observed another problem: the use of geometrical instruments. For instance, a student in the last year of middle school told us that she did not know how to use a pair of compasses and she preferred to complete the exercise (shown in figure 4) by hand. Another pupil explained that he had never used a pair of compasses before arriving in France.

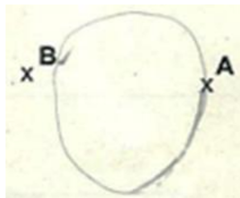

Figure 4. Figure Drawn in Response to the Question "Construct a Circle with Centre A and Passing Through B."

In addition, the measurement of the length of a segment seemed to create some difficulties. Only 13 students out of 26 (just over half) succeeded in completing this task. Three of them misunderstood the question (for example, one pupil calculated the perimeter of the triangle instead of measuring the length of one of its sides) and one of them did not answer the question at all. For 9 of the 26 students, the error was due to misuse of the ruler. We can see some examples of these mistakes in figure 5:

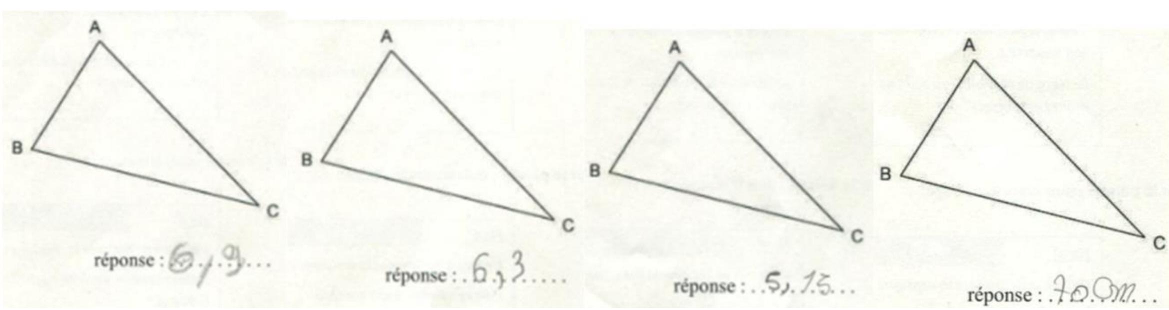

Figure 5. Answers in Response to the Question "Measure the length of the Side [BC]" (which in fact measures 5,7cm)

Three students gave an answer similar to the first one. They did not position the ruler correctly (they have put the graduation '1' in front of the point 'B' instead of the graduation '0') and one pupil was unable to answer the question until the research observer positioned the ruler correctly for them. One student wrote '6,5' instead of '5,6' which could reveal a problem with the writing of decimal numbers (they might have written the number for millimetre before the comma and the number for centimetre after the comma). Two students answered '6,3 cm' like the response in the second diagram. They have correctly positioned the ruler but they appeared to read the length from the graduation '6' by counting the number of smaller graduations to the left (instead of starting at '5' and counting the number of smaller graduations to the right). In the third diagram, the student has correctly positioned their ruler but they did not achieve the correct reading of the length. They might have noticed that there was a larger 'mark' halfway along (that is to say at '5mm') and one extra smaller measurement beyond that (that is to say '1mm') but they did not succeed in expressing fully the fractional part of the number. Finally the last diagram shows an answer that is difficult to interpret: it might have been due to a misplacement of the ruler (as in the first diagram) and a mistake with understanding the unit of measurement (confusion between centimetre and millimetre).

Finally, we need to comment on the range of responses we observed: some migrant students have succeeded in obtaining really good results to this test. The precision of their constructions and the presence of symbols (to indicate the right angles for example) in their geometrical diagrams seem to prove that they have perfectly understood the expectations of their mathematics teacher.

Conclusion

From an analysis of these tests, we gained a better understanding of the reasons for achievement gaps between migrant and non-migrant students. Our evidence indicated that language difficulties represented one of the key factors. In our opinion, it was the biggest bias factor that inhibited learning. Even after one year following an intensive French language programme, almost one third of the migrant students we questioned did not succeed in solving some exercises when instructions were in French whereas they found solutions when instructions were provided in their native language. It seems that the key factor is essentially the mastery of the academic language: in this investigation, we have shown that many migrant students cannot understand even basic geometry vocabulary.

However there are other factors which can explain difficulties migrant students encounter in mathematics. In other words, it is not 'just' a question of language. We observed that more than half the students we questioned did not possess the mathematical knowledge required to 'keep up' in the class in which they were placed. Whatever the reasons (interrupted schooling, differences between French school curriculum and school curriculum of their native country…), they do not have the mathematical knowledge necessary to understand the new material they have to learn. Furthermore we observed a correlation between their level in mathematics on arrival and their progress after one year in France: the migrant students who possess the mathematical knowledge required in their new context have fewer difficulties to acquire French terms and even to progress quickly in mathematics. In addition we observed that some migrant students encounter real difficulties in the use of geometrical instruments: more than one third of the students we interviewed do not know how to measure with a ruler… Lastly we observed that migrant students have specific difficulties with 'conversions' (litres to decilitres, for example), which shows us that some cultural knowledge is required to solve mathematical problems.

This investigation illustrated the variety of obstacles migrant students encounter during their mathematical learning. Consequently, we believe teachers need to understand really precisely the needs of the migrant students enrolled in their class and to provide individual assistance. In so far as the mastery in academic language is not necessarily linked to proficiency in casual, everyday language, teachers cannot just rely on their students' fluency in conversation to determine whether they will understand mathematical instructions: in these cases, we believe additional diagnostic tests need to be conducted. In addition, we have shown that programmes in intensive language are not sufficient to acquire mathematical language. It is for this reason that we have devised a specific programme for migrant students to help them learn the necessary mathematical language (Millon-Fauré, 2013, 2017). Finally, we believe that another form of evaluation needs to be scheduled on arrival in order to determine whether there is mastery of the mathematical knowledge necessary to keep up in class. If adopted, this evaluation needs to have instructions written in a student's first language, (so that language difficulty does not hinder understanding), and should also test basic mathematical knowledge, (such as the use of geometrical instruments). Realistically, this requires us to devise individualised programmes that recognise knowledge deficiencies before they become obstacles to success.

Clearly, the difficulties encountered by migrant students are more challenging than the difficulties encountered by native students: addressing the specific needs of each student is the only solution to close the gap in mathematical achievement of migrant children.

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