BATIKS:
ANOTHER WAY OF LEARNING MATHEMATICS

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This paper examines a micro-project that was developed in an 8th grade class. Students elaborated batiks and then they discussed mathematical tasks based in their batiks' elaboration process. This research is based in two research projects: Interaction and Knowledge (IK) and IDMAMIM. We assume an interpretative approach and a case study design. Results illuminate the potentialities of these classroom practices, illustrated through the analysis of some video taped peer interactions. The focus of analysis is in the didactic contract, based in collaborative work, and in the nature of the tasks that were part of this micro-project.

THEORETICAL BACKGROUND

Portuguese schools are multicultural settings (César, 2007; César & Oliveira, 2005). Considering Nieto's definition (2002), culture is "(…) the ever-changing values, traditions, social and political relationships, and worldview created and shared by a group of people bound together by a combination of factors (…), and how these are transformed by those who share them" (p. 53). According to this definition, in school we find a great diversity of cultures. Not only origin cultures but also many others, including the school's culture, or some teenagers' group culture.

Sometimes the school culture is so far away from students' cultures that they focus their energies on other directions (Säljö, 2004). School needs to facilitate the emergence of "thinking spaces", a construct coined by Perret-Clermont (2004) that stresses the role played by securing spaces in which students may discuss doubts, conjectures, solving strategies, learning difficulties, developing their critical sense, learning autonomy, but also their "sense of identity" (Zittoun, 2004), of belonging to that particular learning community. As César (2007) claimed, becoming a legitimate participant in a learning community, namely in formal educational settings, facilitates students' engagement in academic tasks but also their construction of identities and the management of the dialogical I-positioning (Hermans, 2001) that are often conflictive when the student's culture is much different from the school's culture.

Schools also need to be more inclusive (Ainscow, 1999; César, 2003, 2007, 2009; César & Santos, 2006) and to promote interactions among community members and cultures. Intercultural (mathematics) education facilitates the emergence of dialogical interactions, namely among students from different cultures (D'Ambrósio, 2002;

Favilli, César, & Oliveras, 2004; Peres, 2000; Powell & Frankenstein, 1997; Teles & César, 2007). Ouellet (1991) has already stressed that this education is for everyone, based on the comprehension, communication, and promotion of interactions. Collaborative work among students (and with the teachers) was studied by many authors. It acts as a facilitator and mediator for student's knowledge appropriation when it is part of a negotiated and coherent didactic contract (César, 2007; César & Santos, 2006; Schubauer-Leoni & Perret-Clermont, 1997; Teles & César, 2005), and it also facilitates transitions (Abreu, Bishop, & Presmeg, 2002; César, 2007, 2009).

The development of intercultural (and interdisciplinary) microprojects related to handicraft activities promotes students' performances and academic achievement (Favilli et al., 2004). They underline the cultural dimension these activities give to the learning processes, also contributing to the mobilisation/development of competencies. Their social marking of the tasks, i.e., the possibility of connecting them to students' daily experiences and social life, plays an important role on students' engagement and mathematical performances (Doise & Mugny, 1981; Teles, 2005). It also plays an important role when teachers aim at changing students' social representations about mathematics. Social representations are often stated as being an important contribution for students' performances and school achievement (Abreu & Gorgorió, 2007; César, 2009).

METHOD

We assume an interpretative approach, inspired in ethnographic methods. This study is based in two research projects: *Interaction and Knowledge* (*IK*) and *IDMAMIM*. The first one was developed during 12 years (1994/95-2005/06) and its main goal was to study and implement social interactions in formal educational scenarios (for more details see César, 2007, 2009). The didactic contract that was negotiated in this class was clearly shaped by this project's features. Teachers' practices, based in collaborative work, were also shaped by this project's pedagogical ideals. *IDMAMIM* project was developed in some towns of Spain (Granada), Italy (Pisa) and Portugal (Lisbon). Its two main goals were: (1) to identify didactic needs in order to develop an intercultural mathematics education; and (2) to elaborate intercultural didactic materials, like the ones based in the batiks elaboration, and its later exploration in mathematics classes (Favilli et al., 2004). The mathematical tasks used in this class were part of this project.

This case is part of a broader study including 4 case studies. In all these case studies students developed an intercultural microproject, based on the elaboration of batiks. Batiks are a handicraft from Java, that was then developed in other parts of the world, namely in Cape Verde, where we collected information about how to elaborate them. Batiks assume different ways of being produced in different parts of the world, according to the native cultures of each country, and also to their economic conditions. In Cape Verde, as it is a very poor country, they use flour, water and lime, instead of wax in order to make the production process cheaper. Thus, even discussing the different ways of production of batiks, that students discover in the internet before elaborating them, it is a way to explore a critical mathematics approach. This is complemented by the discussion of the video we made in Cape Verde in which batiks are being produced. This way of approaching the microprojects also allows them to be explored in a multidisciplinary way, as teachers from different subjects may participate and, for instance, explore the texts from the internet in English language subject, the production process in Chemistry, the evolution of batiks around the world in History, the elaboration of the templates in Arts. In this paper we focus in the one of the mathematical tasks that was solved after elaborating the batiks. Thus, the research question that we analyse in this paper is: What are the contributions of intercultural and collaborative microprojects to students' mathematical knowledge appropriation?

The participants were the students from a 8th grade class (13/14 years old), their mathematics teacher, external observers and evaluators. This class had 21 students, one of them categorized as presenting special educational needs (SEN). There were 12 girls and 9 boys. These students were from different cultures and some of them were born, or had families that were born, in other countries. But even Portuguese students belonged to different cultures and socio-economical backgrounds. The mathematics teacher described this class as "(…) a working, engaged, interested and challenging class" (Teacher's final report, p. 7), as some of these students experienced underachievement in previous school grades in mathematics. Thus, many of them presented a negative social representation about mathematics in the beginning of the school year (September), according to the data of the *IK* project (students' protocols – for more details about the first week procedure, see César, 2009 or Teles, 2005). Some of these students usually did not participate in mathematics activities during classes, in previous school grades. They did not disturb the class work. They simply did not do anything and just waited for the end of the class to go to the break. Thus, many of these students never went to the blackboard after solving mathematical tasks, or participated in the general discussion. For these reasons, one of the main teacher's practices aims during the first month of classes was to promote students' participation in mathematical activities, and to avoid having only three or four of them – always the same ones – participating. The dyad whose peer interaction we chose to discuss is a paradigmatic one: J. was one of the students who experienced underachievement in mathematics in previous school grades while her peer loved participating in mathematics classes. Thus, the teacher tried to promote J.'s participation and, in this episode, we can see that she is no longer silent, or just trying to be unnoticed. She is already able to go to the blackboard, during the general discussion, after dyad work, and to explain to the whole class her dyad's solving strategy. Thus, this dyad illuminates some of the processes that could be observed in many other excerpts from the videos, and that were shaped by the collaborative work these students developed during the whole school year in mathematics classes.

Data was collected through observations, questionnaires (*IDMAMIM*), interviews (*IDMAMIM*), the teacher's and external evaluators' reports and students' protocols. In this paper we focus in the analysis of some video excerpts, the teacher's report and in students' protocols.

In this episode, students were solving a mathematical task in dyads, after elaborating their batiks. A batik is a pure cotton wrap tainted with colours where a drawing is contrasted. This elaboration process uses mathematical knowledge that can be explored further in later mathematics classes (for more details, see Favilli et al., 2004; Teles, 2005). They were discussing about the following situation:

Ms. Bela made a batik. It was in a square piece of cotton whose side measured 60 cm. Mr. Evaristo is interested in buying a batik. But he wants one with the double of the size.

- Ms. Bela, how much is a batik like that with the double of this size? – asked Mr. Evaristo.

- Look, Mr. Evaristo, this batik costs 18€. And I can sell you the other batik at the same price each m^2.

- Then, I offer you 36€! Do you accept my offer?

1.1. What do you think: Should Ms. Bela accept Mr. Evaristo's offer? Explain your reasons.

1.2. Complete the table below, considering the correspondence ***f*** that associates a square batiks' side (*x*) to its area (*y*).

Length of the side of the batik,		20		6
Area of batik, cm^2 (*y*)	0		1600	

Figure 1: Batik

RESULTS

This episode is an excerpt of an interaction between two students: J (a girl – 13 years old) and N (a boy – 12 years old). They are both Portuguese, but their family cultures are differentiated: N. comes from a highly literate family, whose parents have an university graduation; J. comes from a family whose parents have jobs related to commerce and services. From the economical point of view their families are from a class that is not very high or very low. They could be characterised as paradigmatic teenagers, with the hobbies, dressing code, language, and friendships of most of the teenagers in Portugal. J and N are on 8^{th} grade for the first time but they have different previous experiences with mathematics. J does not like mathematics. In the first term she still experienced some underachievement (she got Level 2, a mark that is negative, in the Portuguese educational system, in which students' marks vary from Level 1 – the lowest - up to Level 5 – the highest). But during the next two terms she was engaged in mathematics classes and she was able to achieve. N is a student with a calm and pleasant relationship with mathematics. He always succeeded in this subject. He shows a high self-esteem, namely an academic one, while J was less confident about her abilities and competencies, in particular in mathematics and during the first months of the school year. It was precisely their differentiated characteristics as mathematics students, and when they addressed the mathematics tasks – in the beginning of the school year J tended to give up very easily or even not try at all to solve them – that were the criteria for choosing them to be discussed and analysed in this paper, as they both represent many other similar students we had in this class, and even in the other three cases from the *IDMAMIM* project.

In this episode, they are solving the question 1.2. It is N who starts the interaction writing on his notebook his reasoning in order to explain it to J.

b) Preencham a tabela:

Comprimento do lado do batique, em cm (x)	0	20	40	60
Área do batique, em cm^2 (y)	0	400	1600	3600

Figure 2: J and N resolution (Question 1.2.b))

1 N: It is: 20, 40, 60. It is half of 1600 [He understood that 20 is half of 40; then the table should be completed with half of 1600, i.e., 800]. It is 800. It is the double of this [He points]. Then, here it is 40 is 1600; then 20 is 800.

2 J: A little confusing!

3 N: What is the part you don't understand?

4 J: This part [she points to the sum]. Why is this plus this?

5 N: Because… This plus this equals 1600. Teacher!?

[The teacher approaches them]

6 N: Could you see if my reasoning is correct?…

7 J: So, what do you [turning to J] think about his reasoning?

This piece illuminates the role of the didactic contract of this class (César, 2003; César & Santos, 2006; Schubauer-Leoni & Perret-Clermont, 1997; Teles & César, 2005): students can start their resolution of the task by individual work but they need to explain their reasoning to his/her colleague from the same dyad. They need to discuss the solving strategies they used in order to find a consensus. But they also need to understand each other's solving strategy because one of them may be asked to represent their dyad in the general discussion and to explain to their colleagues their solving strategies. As they are both engaged in this type of didactic contract, they know that just having an answer produced by one of them is not enough. Thus, J is trying hard to understand her peer's solving strategy and this is exactly what her teacher aimed: to improve her participation in the mathematical activities, during mathematics classes. Their teacher was trying to create what Perret-Clermont (2004) designates as thinking spaces, facilitating students' reflection upon their solving strategies and some mathematical concepts.

They also know that discussing their solving strategies is a way of learning for both of them. For the one who used this solving strategy as s/he has to clarify its steps in order to explain them and to answer to his/her peer's doubts and questions; and to the one who is, at that moment, acting as the less competent peer (Vygotsky, 1932/1978), as it helps him/her progressing in his/her mathematical performances and in knowledge appropriation. These features of collaborative work, that we can also see in other parts of this episode presented below, also help students develop their positive self-esteem – particularly clear in the way of acting of J, in this episode, namely when she goes to the blackboard during the general discussion and is able to explain her dyad's solving strategy without taking any sheet with their resolution in her hands (according to the video record, she acted like this due to her teacher's suggestion). Thus, it helps them to begin acting as legitimate participants and not as peripheral ones (César, 2007). This changing form of participation is illustrated by the ways J acts, during the different parts of this episode, as well as by the external observers reports, during the school year, and by the analysis of other episodes that were also video recorded.

In Turns 5 and 6 N asks for their teacher's help and assumes this dyad's leadership. He is assuming the role of the more competent peer (Vygotsky, 1932/1978). This happened in this dyad during the first month they worked together, as J considered N "much better than me" (questionnaire, January) and it took some time before she was able to express her opinions, solving strategies and arguments before listening to N. It must be added that while analysing many other pieces of videotapes from this class it was clear the teacher's effort in order to promote the positive self-esteem of J and to make her feel more confident. Her aim, according to the features of collaborative work, inclusive education and this particular didactic contract, was to be able to have the role of more competent peer assumed by each one of them, in different mathematical tasks, or even in different moments/steps of their solving strategies. But when one of the students usually performed much better than the other in previous school years, achieving this point takes time and needs a lot of knowledge about how to act from the teacher's point of view.

J considers N's resolution "A little confusing!" (Turn 2). Thus, N tries to realise what J did not understand. Then, he tries to explain J what she did not understand (Turn 5). But he is not very clear in his explanation. He realises that J is still confused and thus he asks for their teacher's help, trying to legitimate his reasoning (Turn 6). According to the didactic contract, their teacher does not answer him. Instead, she asks J's opinion about N's reasoning (Turn 7) and tries to promote a dialogical interaction between these students. The teacher assumes the role of a mediator of learning (Vygotsky, 1932/1978). She is more concerned with students understanding and with the interaction between them than just with the validation of students' answers. Their teacher's reaction illuminates how the expert other can facilitate students – in this case, J's – change from a peripheral to a legitimate participation (César, 2007, 2009; Lave & Wenger, 1991). As we stressed in other cases we analysed in other papers, this is an essential move in order to promote more inclusive formal educational settings, and an intercultural education (for more details see César, 2007, 2009; César & Santos, 2006; Teles, 2005).

8 N: It is 20…

9 T: But, I don't want that answer! [Points to Question 1] Well… explain! I said that we'll correct Question 1. So, I want you to explain me why you wrote this and…

10 N: 36€. 36€ is the double of batik that cost 18€. Ms. Bela's batik cost 18€.

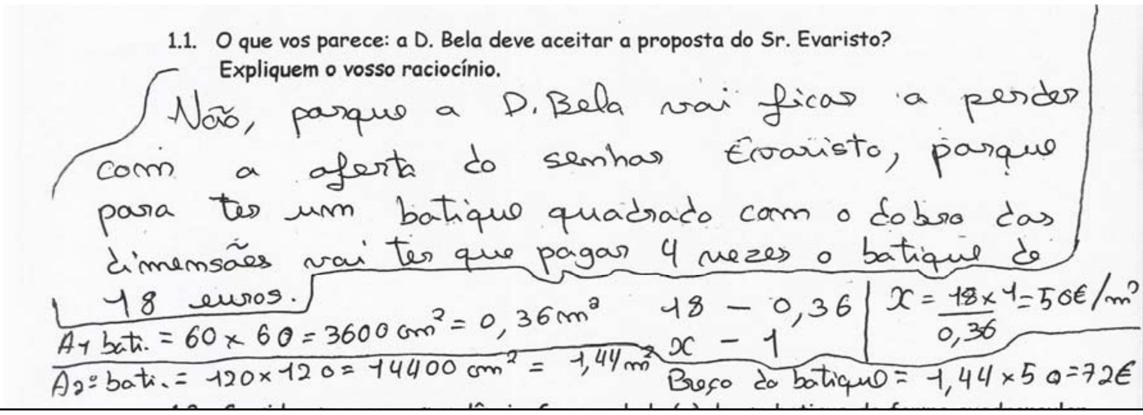
11 T: It measures 60cm in this side.

12 N: It is 60cm of side but we want the double of this batik…

13 T: You want a batik with the double of these dimensions [she points at each side of the batik].

14 N: Yes. Yes.

15 J: So, it is the double of this one.


1.1. O que vos parece: a D. Bela deve aceitar a proposta do Sr. Evaristo?
Expliquem o vosso raciocínio.

Não, porque a D. Bela vai ficar a perder com a oferta do senhor Evaristo, porque para ter um batique quadrado com o dobro das dimensões vai ter que pagar 4 vezes o batique de 18 euros.

A1 bati. = 60 x 60 = 3600 cm² = 0,36 m²   18 — 0,36   x = 18 x 1 / 0,36 = 50€/m²
x — 1
A2 bati. = 120 x 120 = 14400 cm² = 1,44 m²   Preço do batique = 1,44 x 50 = 72€

No, because Mrs. Bela would loose money with Mr. Evaristo's offer. Because in order to have a square batik with the double of the dimensions of the first one, he has to pay 4 times more, i.e., four times 18€.

Figure 3: J and N resolution (Question 1.1.) and students' answer translation

N starts the interaction with their teacher again (Turn 8), and explains the solving strategy they used to answer to Question 1. He answers the teacher's questions, but J also participates in this dialogue and concludes N's argumentation (Turn 15). But another interesting feature appears in Turn 9: these students, although engaged in solving the task, were not answering to the part their teacher had asked to be solved. This illuminates the importance of the teacher's role during classes, even when students are working in an autonomous way, it is only by observing closely what is going on that the teacher can help students to learn how to self-regulate their work in a more adequate way. In the excerpt, we understand that both students know the solving strategy they used and they can explain it because they co-constructed it together, according to the rules of the didactic contract (César, 2007, 2009; César & Santos, 2006; Teles, 2005). But in order to understand their different solving strategies students also need to establish an intersubjectivity that allows them to understand each other's arguments and solving strategies (Valsiner, 1997; Wertsch, 1991), as illuminated in the following piece:

16 T: Is it?

17 N: It is the same as we have another batik here, together.

18 T: Is it? I didn't think like this! Put two batiks together and confirm if it is a batik with 120cm of side.

19 J: We did 18x2.

20 T: I understood! But, I'm asking you if this is correct!?

21 N: Maybe!

22 T: Maybe? So, imagine that this is a batik. And you have another batik here …

23 J: It has 120cm of side.

24 T: Here [she points in their sheet of answers].

25 J: Yes.

26 T: And here? [she points again]

27 J: It doesn't. It is 60.

28 T: Ah… I want a square batik! 120 per 120. But, if you put two batiks together it has 120 per 60. Ah! Why? I said that I want the double of dimensions. The first one had 60 per 60 and this one has to have 120 per 120. Right?

An interesting point here is their teacher's care to avoid any evaluative comments on their work. She asks challenging questions as she seeks to encourage the students to realise their mistake (Turns 18, 20, 22, 24, 26, and 28). Their teacher wants these students to question themselves about what they did. Thus, she chooses to ask them questions and to pretend she does not understand what they did and why they did it this way (Turns 18 and 20). But her tone of voice is a kind one, she smiles from time to time, the interaction has an easy-going mood, and students, although paying attention, also have a smiling face.

As we can observe, J participates actively in this discussion, in spite of her usual introverted mood and her lack of confidence in her competencies (Turns 19, 23, 25 and 27). She believes on what she did with N.

> 29 J: Right! It is impossible!
>
> 30 T: Impossible!?
>
> 31 N: The teacher wants the double of this one. So, we have to add… we have to divide batik for all sides!?
>
> 32 J: What!?
>
> 33 T: To divide batik for all sides!? I don't understand.
>
> 34 J: I don't understand it either.
>
> 35 N: I don't understand it too.

J does not understand what their teacher told them, and thus she considers this problem impossible (Turn 29). Her attitude illuminates her lack of confidence and persistence in the activity, when she fails. This situation makes their teacher look for other alternative ways to promote students' interest and increase their positive academic self-esteem.

> 36 T: Let's think a little bit more. You are saying that … I think that you already understood that if you put another batik here… the other is the double, isn't it?...
>
> 37 J: If we put here (down side), it is not enough. It isn't 120.
>
> 38 T: [We can't understand]
>
> 39 J: But, here (down side) is not enough. It is 60.
>
> 40 T: And? You are about to have a square.
>
> 41 N: It is a square.
>
> 42 T: In the question they say that it is a square after we cut the batik. Think a little bit more.

Facing students' doubts and this impasse, their teacher decides to change the direction of the resolution because she wants them to go on trying to solve this problem. But, she starts from what she believes the students already understood (Turn 36). J's interest seems to increase during this interaction. She participates actively in the discussion. But, even more important, she goes on trying to solve this task when the teacher goes away again. Thus, although this episode ends without a resolution, students' discussion around that question continued. During the general discussion (whole group discussion) J went to the blackboard and was able to explain to their colleagues their solving strategy. She did it in a convincing way, explaining their solving strategy clearly and she was even able to answer to two colleagues doubts. Thus, J showed different I-positioning as mathematics student during this resolution. Basically, she passed from a non-confident I-positioning, typical of a low achieving student, to a confident I-positioning, that let her be considered a competent peer in the resolution of this task.

FINAL REMARKS

To get students' engagement a teacher needs some effort and creativity. Students' access to the rules of the didactic contract can help them understanding their role in that particular classroom and at school. It also facilitates facing the academic tasks in a confident and responsible way. As we could observe both N and J knew the rules of the didactic contract. They discussed their reasoning to find a consensus and they asked for their teacher's help only when they couldn't solve an impasse.

The teacher's role is another important feature. In this episode we could observe a teacher that assumes a mediating role. She did not tell students the right answer. She helped them to realise their mistake and she gave them assistance in order to facilitate their progress in their solving strategy. This teacher believed in the students' competencies and she aimed at facilitating the mobilisation and development of other students' competencies.

The nature of the task is another relevant feature to achieving students' engagement. In this episode the task was about batiks, which students elaborated in previous classes. The social marking of the task helped students' understanding of the task. As they elaborated batiks, they knew the process of elaboration and they were able to give a meaning to this mathematical task. Thus, the social marking of the task facilitated students' learning processes and also their knowledge transition from one situation (elaborating batiks) to another (mathematics class, solving problems).

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