BROCCOLI AND MATHEMATICS: STUDENTS' SOCIAL REPRESENTATIONS ABOUT MATHEMATICS

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Social representations play an essential role in students' performances and school achievement. Collaborative work can act as a mediating tool in order to change them. Assuming an interpretative/qualitative approach, inspired in ethnographic methods, an action-research project was developed in an 8th grade class. Its main goals were to understand how collaborative work contributes to change students' social representations about mathematics, and to illuminate the impact of this process in students' performances and school achievement. The analysis of two cases illuminate the potentialities of collaborative work to promote more positive social representations about mathematics and students' competencies.

INTRODUCTION

In a multicultural society, like the Portuguese one, classrooms are getting more multicultural too. Portugal changed from being an emigration country, until the mid-seventies, into an immigration country (César & Oliveira, 2005). Thus, the education became less focused in a mainstream social class with its own ways of acting and values. It had to adapt itself to cultural diversity and to the challenges, but also to the richness, it brought into schools (César, 2007). Therefore, education, in general, and mathematics education, in particular, need to investigate and spread practices that are well adapted to all and every student's characteristics and needs (César, 2007; César & Oliveira, 2005), allowing them to construct their life projects. But this also means changing teachers' practices, and the evaluation system, assuming that the formal educational scenarios must be spaces and times that facilitate the emergence of social interactions, namely peer interactions, promoting students' academic self-esteem (César, 2007; César & Oliveira, 2005; Perret-Clermont, Pontecorvo, Resnik, Zittoun, & Burge, 2004; Renshaw, 2004).

The social representations that students develop about mathematics are constructed since when they were born, when they start to establish their first social contacts with the others, and they go on being developed under the influence of school, family, friends, and *media* (Abreu & Gorgorió, 2007; Piscarreta, 2002; Piscarreta & César, 2004). When they start school many students are already convinced that mathematics is only understandable for very bright people and that they will never be able to learn it and to succeed. Thus, changing students' social representations about mathematics is a first and essential step in order to promote their mathematical performances.

The problem is addressed in this study is the negative social representations about mathematics developed by many students. The research question addressed in this

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paper is: How do students' social representations change from the beginning of the school year until its end when they experience collaborative work practices?

In order to address this problem and questions we developed a study in Portugal, during the school year 2006/2007, that allow us to understand how mathematics is seen by 8th grade students (n = 21) and how changing teachers' practices, namely implementing collaborative work in the class, contributes to change these students' social representation about mathematics and their mathematical performances.

THEORETICAL BACKGROUND

The theoretical framework is based on a historical-cultural approach (Vygotsky, 1932/1978) and it is focused in collaborative work (Perret-Clermont et al., 2004), namely peer interactions, and in dialogism (Renshaw, 2004), conceived as tools that mediate students' mathematical achievement and the development of students' (mathematical) competencies (César, 2007). It is also based on social representations (Abreu & Gorgorió, 2007; Moscovici, 2000) and on the role they play in the learning process, namely in mathematics, learnt in formal educational scenarios (César, 1998, 2007; César & Oliveira, 2005).

The social representation construct was coined in the sociological theory of Durkheim. This author claims for the distinction between the individual social representation and the collective social representation (Piscarreta, 2002; Piscarreta & César, 2004; Ramos, 2003). But Moscovici (2000) was an essential author in order to stress the dynamic and multi-faced character of social representations that he defines as

> "systems of values, ideas and practices with a two-fold function; first, to establish an order which will enable individuals to orientate themselves in their material and social world and to master it; secondly, to enable communication to take place amongst members of a community by providing them with a code for social exchange and a code for naming and classifying unambiguously the various aspects of their world and their individual and group history". (p. 12)

He claims that social representations are the result of the interaction and communication between the individuals. The social representations are not constructed in an empty social context, but since the first social contacts that we establish with the others, and the society.

According to Moscovici (2000), social representations are a dynamic construct. As stated by Abreu and Gorgorió (2007), "social representation theorists agree that there can exist more than one social representation to interpret the same phenomenon. Social representations are not only plural but dynamically created and transformed" (p. 3). Thus, the role of social representations is to "organise and interpret the reality, giving a meaning to the information and trying to explain the surrounding situations, mediating behaviours and social relations which allow us to differentiate the diverse social groups." (Piscarreta, 2002, p. 26).

Studying and understanding students' social representations about mathematics allows to realise them but also to change them through practices, namely implementing collaborative work, tasks that are elaborated in order to allow for establishing connections between students knowledge and mathematics knowledge, and a differentiated process of evaluation (César, 1998, 2007). Abreu and Gorgorió (2007) claim that "the notion of social representation can offer useful insights into understanding practices of teaching and learning" (p. 1).

Working collaboratively, namely in peers, there is a change in teacher's and students' role, since the learning process is focused in the students (César, 2007; César & Oliveira, 2005; Perret-Clermont et al., 2004; Renshaw, 2004). The students assume a dynamic role in the classroom once they become more autonomous and responsible for their learning process. They negotiate meanings, roles, arguments, constructing what Perret-Clermont (2004) calls thinking spaces. Thus, they reconstructed their knowledge and their identity (César, 2007), namely by being part of a community of learning (Lave & Wenger, 1991), and becoming legitimate participants instead of peripheral ones (César, 2007).

METHOD

This work is based on the *Interaction and Knowledge* project which studies and promotes collaborative work in formal educational scenarios (5^{th} to 12^{th} grade). This project was implemented during 12 years and had three levels: (1) micro-analysis; (2) action-research; (3) case studies (for more details see César, 2007; Hamido & César, in press). This research is part of the action-research level of this project. Due to the collaborative work that was implemented during the whole school year, this class became a learning community (Lave & Wenger, 1991).

This research was developed in an 8^{th} grade class, in a school in the surroundings of Lisbon. At the beginning of the school year there were 28 students in this class. During the school year some students changed to another class and others drop out school. Thus, by the end of the school year there were 21 students which are the ones we consider as participants in the study. We also consider as participants the co-teacher-researcher and two observers (one supervisor and a colleague that also acted as trainee teacher). We analyse the productions of two students, a male and a female, whose names were changed in order to cover their identification data. These two students are paradigmatic cases as similar changes in their social representations about mathematics were also observed in many other students from this study.

Data were collected through a task inspired by projective techniques, questionnaires (at the beginning of the school year and in the last week of the school year), participant observation (registered in a researcher's diary, and including his own reflections about his practices) and students' protocols.

According to Carvalho and César (1996) and Piscarreta (2002), tasks inspired by projective techniques (TIPT) are an effective way to study social representations

about mathematics since they allow understanding the socio-cognitive and socio-affective dimensions. The task inspired by projective techniques was presented at the beginning of each school period as we aimed at illuminating the evolution/changing process that could emerge. Thus, we could illuminate this process for each one of the students and confront it with his/her mathematical performances. In tasks inspired by projective techniques instructions play a main role. In this case, each student received a white A4 sheet and they had to draw or write what was mathematics for him/her. But in order to better understand the importance of the instructions and how they shape students' answers, these instructions were slightly change: (1) in the first term (TIPT 1), it was said and was written in the blackboard "Write or draw what is mathematics for you."; (2) in the second (TIPT 2) and third (TIPT 3) tasks it was said and was written in the blackboard "Draw and write what mathematics for you".

RESULTS

This research aims at understanding the contributes of collaborative work to change students' social representation about mathematics. Thus, we decided to analyse students' social representations at the beginning and at the end of the school year, after working collaboratively during the school year. In the first task inspired by projective techniques all the students wrote what mathematics represented for them. But in the second and third tasks, in which we changed the instructions, students not only drew but also wrote what represented mathematics for them. This illuminates the essential role played by instructions and how students' performances change according to them. Thus, when analysing the results it is not only the nature of the tasks that must be made explicit and discussed but also the working instructions that were given. And when we aim at changing teachers' practices we must reflect upon the nature of the tasks and about the working instructions. Inaccurate instructions can change the results.

We are going to analyse Anna's and Peter's social representations about mathematics and the changing process that emerged from collaborative practices. Anna is a girl with presented a fair performance in mathematics (Level 3, in a scale from 1 to 5, being Level 5 the top mark) and she called herself as a fair student because " I'm distracted (…) and [teacher] thinks that I'm talker". In her first task inspired by projective techniques, she wrote:

> " For me, mathematics is an area in which we should develop the logic. All schools have mathematics as a subject, in any part of the world. Because there is mathematics everywhere and without it may not be able to enter at the studies or a job that we aim. And even if we don't like it, we have to learn it…" (Anna, TIPT 1, September 2006).

As we can see, Anna recognised the importance of mathematics in students' future and its role in the world. These are both social representations that are spread through the *media*, teachers' discourses, families and friends, as pointed out in other studies (Piscarreta, 2002). Nevertheless, this student expressed the idea that we must learn it

whenever we like it or not, which stresses its compulsory character. It also has the implicit assumption that there are many students that do not like mathematics, but they still have to learn it. Moreover, she recognises that most of students' future is connected to mathematics success – or failure – and this illuminates a point that was also claimed by many authors: mathematics shows high percentages of underachievement but is also one of the most selective subjects (César, 2007).

For Anna, doing and liking mathematics are two separated issues. In the first questionnaire (Q1, September 2006) when we asked her if she liked mathematics, she wrote that she liked it "More or less, I know I must learn it". Once again, whenever liking it or not, learning it is unavoidable. Thus, the question, for her, is not about feelings – liking it, or not – but about the huge need to learn it if one aims at succeeding in his/her studies and, moreover, in his/her professional life.

In the third task inspired by projective techniques (TIPT 3), this student used a metaphor - the broccoli and the mathematics - establishing the connection between her home culture and the academic culture. This unusual metaphor illuminates her creativity and sense of humour, revealing the ability to connect her daily life and mathematics.

Making explicit some of the graphic features of her drawing, we can add that she draw the broccoli on the top of the sheet. According to Bédard (2005), drawing in that part of the sheet means the head, the intellect and

Figure 1 – Anna's drawing in TIPT 3 (June 2007)

the imagination. It is characteristic of a person who is curious and who enjoys discovering. According to the students' questionnaire, we see that she would like to be a photographer, because she likes "to observe the beautiful landscape that the world has". She sees mathematics as being part of the world, but not as a beautiful landscape, at least for most of the students. After drawing the broccoli she wrote a short sentence clarifying the meaning of her drawing:

> For me, mathematics is like broccoli, many people don't like it, some of them only [eat them] when it is really needed, and some others really like it.

The analysis of the three TIPT illuminate that there was a change in her social representation about mathematics. The didactic contract, including the implementation of collaborative work, was an essential mediating tool for this change, as claimed by César (2007) and by César and Oliveira (2005). As Anna accounted in the final questionnaire (Q2, June 2007), working in peers should be continued in the next school year since "it was by working like this [in peers] that I was able to learn mathematics, and thus I started to like it". She also adds that "Now it is a good thing!".

Anna's case illuminates a positive change in her social representations about mathematics. At the beginning of the school year she felt she should learn mathematics but she did not like it. She only knew it was needed for her future. But at the end of the school year, after working collaboratively, she was able to give a meaning to her mathematics knowledge. She called it "really learning it" (Q2, June 2007), and that was what made possible for her to be able to like mathematics. As Moscovici (2000) claimed, the social representations are dynamic and they are influenced not only by the social context but also by the interactions with others. Thus, collaborative work can play a mediating role changing negative social representations about mathematics into more positive ones.

Peter is a boy with a higher performance in mathematics (level 4). He described himself as a good student in mathematics because he did not have "high grades nor negative grades" (Q1, September 2006). He considered mathematics as a subject which he liked less than others because he liked "much more the others subjects".

In the first task inspired by projective techniques he wrote:

> " For me mathematics is a very important subject for our future and it is needed for our good development". (Peter, TIPT 1, September 2006)

Once again this student focuses himself in the importance of mathematics for students' future and on its contributions to students' "good development", rephrasing many of the teachers' and *media* discourses. Each time there are international studies ranking students' mathematical performances (and the Portuguese ones were quite low in TIMMS and in PISA), or national exams with high percentages of failures in mathematics, these kinds of discourse appear again and are repeated over and over. Thus, they are also appropriated by students who use them to convince themselves that even hating mathematics they still need to make an effort and learn it.

In the third task inspired by projective techniques, Peter chooses to express his opinion by drawing. He filled all the sheet with materials and designations connected to the mathematics, many of them learnt at school and clearly connected to some mathematical contents.

Figure 2 – Peter's drawing in TIPT 3 (June 2007)

The student drew several triangles, connected to Pythagoras' theorem. According to Bédard (2005) "this symbol represents the knowledge" (p. 20). Peter also used many geometrical symbols, namely square forms. Other interesting aspect in his drawing is that he drew stars in two specific places: next to the Pythagoras' theorem and to "Matemática" [It means mathematics, in Portuguese]. As stressed by Bédard (2005), drawing stars means that we can not live only in the present, but we aim at "being a star", in the future, which means succeeding. Thus, this drawing also illuminates that this student aimed at showing higher performances in mathematics and at succeeding in his future studies and career.

At the end of the school year, he wrote:

> "Mathematics is a challenging subject and no matter how much we want it, or not, it appears in our day life, even when we do not realise it. It is something that may bother us for being difficult but it is something that hides interesting facts and many mysteries, that makes our head turn over and over to find out the solution". (Peter, TIPT 3, June 2007)

Comparing both tasks inspired by projective techniques we can see that the importance of mathematics is present in both of them. But in the end of the school year mathematics is seen as a challenge, but also as something he will be able to solve, even if this means a lot of effort. He is able to see himself as being successful in mathematics, and he is also able to point out some of its beauty.

We must add that at the beginning of the school year Peter was not convinced that working in peers was such a good idea. But as time went by and he realised that the practices were so much focused in students' contributions he got more engaged in the activities. He started to like the challenges that were presented by the teacher and by his colleagues. Thus, when we asked him, in the questionnaire (Q2, June 2007), if he

liked working collaboratively, he answered positively accounting that "I think that we learned more quickly".

In short, if both students claimed that mathematics is an essential subject for their future life as students and workers, they also state that recognising its need does not mean liking it. Working collaboratively, namely in peers, allowed them to learn mathematics and to become more confident about their mathematical competencies. This was an essential step in order to allow them liking mathematics and also to become more confident about their success b their mathematical performances.

FINAL REMARKS

The knowledge appropriation, and the mobilisation and the development of (mathematical) competencies are complex processes shaped by many elements, namely the nature of the tasks, the working instructions, the type of interactions established in the classroom and the didactic contract negotiated between the teacher and the students.

We illuminated that knowing and studying students' social representation about mathematics is an essential step if we aim at promoting students' mathematical performances. As Abreu and Gorgorió (2007) claim, "social representations are not just something one uses to inform one's practices, but something that becomes part of one's reality (p. 2). Thus, understanding why mathematics is so much rejected and feared by many students allows us to use forms of mediation during practices like the nature of the mathematical tasks and/or collaborative work, facilitating students' promotion of more positive social representations about mathematics, and their achievement in this subject.

Implementing collaboratively work in the classroom allowed students to change their social representations about mathematics and to develop more plastic and dynamic social representations. This contributed to the development of students' mathematical competencies, and also to promote their positive academic self-esteem. Moreover, knowing students' social representations about mathematics allowed us to deal with cognitive, social and emotional features of the learning process, adopting an ecological and systemic approach to learning that favours students' development and helps them to engage in life projects connected to mathematics.

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