THEMATIC RESEARCH

FROM EXTRACURRICULAR KNOWLEDGE TO CURRICULAR KNOWLEDGE OF SCIENCE:

An Ethnographic Study in Elementary School Classrooms

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Abstract:
This article is an ethnographic study of discursive interaction among teachers and students in normal science classes in the classrooms of a public elementary school. The study focuses on analyzing the actors' use of classroom dynamics and the students' extracurricular knowledge, particularly knowledge related to their "empirical" experience. The assumption is made that "empirical evidence" is what the participants deal with as a result of their perception and not as objective data. By analyzing the sequence of interaction, it is found that everyday knowledge acquires new meaning in a discursive and negotiating process that constructs curricular knowledge of science, which is legitimated in the classroom as scientific facts. The importance of this type of studies lies in their using the best aspects of teaching traditions, and guiding proposals more in agreement with the school context.

Key words: ethnography, classroom, science teaching, extracurricular knowledge, curricular knowledge of science, Mexico.

Introduction

In this article, I propose to show the importance of the study of discursive interaction among teachers and students in school classrooms as an indispensable referent for improving the teaching of the natural sciences, maintaining a dialogue with Mexican and foreign research on the topic. I understand discursive interaction in the classroom to mean the verbal interaction among teachers and students. I attempt to contribute what Jerome Bruner suggests (1988:132) "What we still lack is a reasoned theory of how to interpret the social negotiation of meaning with regard to pedagogical axiom [...] in synthesis of the joint creation of culture as the object of teaching." In particular, in this article I analyze if teachers incorporate students' extracurricular knowledge into the dynamics of classroom interaction, and particularly knowledge related to "empirical" experience out of the classroom; I also study the way they do so.

The referent of research carried out in this field will be the state of knowledge of education in the natural sciences 1992-2002, coordinated by Ángel López y Mota and published by COMIE (2003). It is important to relate my research to the challenges and needs this type of research must address in our country. Although the compilation by López y Mota (2003) has an interesting review of international research related to the topic in question, the current article updates the review by taking some references from more recent publications (particularly from 2005), and in part from some of the most important journals in the field: *Science Education, International Journal of Science Education*, *Journal of Research in Science Teaching* and the Spanish publication entitled *Enseñanza de las Ciencias*. In spite of the need to situate the project relative to current research on science teaching, it must also be placed in the framework of the progress made by educational research in the classroom, and especially the sociocultural and qualitative focuses (Candela, Rockwell and Coll, 2004).

In order to work on this viewpoint with empirical data that provide evidence of theoretical positions, I shall analyze fragments of discursive interaction among teachers and students in public elementary schools. In particular, I shall analyze the way students' extracurricular experience, as part of daily knowledge, is referred to in the classroom, in order to study how this experience is established and negotiated for constructing the curricular knowledge of science.

Classroom Research in the Context of Research on Science Teaching

Research on teaching science has been dominated by the central proposition of improving practice in the school context. Studies were initially centered on isolated aspects of the process, such as research on children's learning. These studies were marked by the psychological theories of Piaget, the most widely known of the time. Such postures, the originators of constructivist focuses, oriented and continue to orient a large part of the research on science teaching by employing experimental studies about students' and teachers' conceptions of various topics in science—the basis for designing proposals that attempt to bring exchange daily closer to scientific conceptions. At present, these experimental studies have been expanded by studies that analyze diverse aspects of didactic interaction in the classroom while basically focusing on putting proposals into practice.

Of the 108 articles and seventeen book reviews published in *Enseñanza de las Ciencias*, *Science Education, International Journal of Science Education* and J*ournal of Research in Science Teaching* in 2005, only thirteen projects do not refer to proposals. Out of these, only four articles (Bronwen, 2005; Brown, Reveles and Kelly, 2005; Haigh, 2005; Morge, 2005) and one book (Mortimer and Scott, 2003) study natural interaction in the classroom without the intervention of proposals; one refers to a teacher's life story, and four editorials refer to the need to carry out case studies and ethnographies to bring research closer to classroom conditions and teachers, who have stopped reading the journals and taking proposals into account (Oliva, 2005).

A recent book by Fensham (2004) reviews the tendencies of science teaching based on articles published in two journals (*Science Education* and *Journal of Research in Science Teaching*) and on interviews with researchers in the area. The idea presented is that traditions in Europe are didactic and aim for a certain degree of personal development without concentrating as much on content, while in the Anglo-American tradition, the purpose is the curriculum; the conclusion is that most published Anglo-American research is centered more on the theory and method of research, than on the applications of learning and teaching. Texts previous to this time period—which I mention because they represent relatively new lines of study on the construction of scientific knowledge in the classroom context—are the article by Lemke (1990), who began studying the role of speech in science classes from a semiotic focus; in Mexico, the article by Candela (1999) on the discursive interaction in science classes from an ethno-methodological perspective; and the pioneer essays that open an unexplored but highly important line involving multi-modal studies on science in the classroom, with an analysis of different semiotic modes—images, gestures and body movement, in addition to language—in communicating curricular knowledge of science (Ogborn, *et al.* 1996; Kress *et al.* 2001).

In spite of these new lines of studies that analyze interactions in the scholastic context, we can state that research on science teaching is still marked by proposals designed with regard to psychological considerations external to the working conditions of the classroom, and then taken to the school context. One of the contributions of such research that has enjoyed most consensus is the model of "conceptual change" originally proposed by Posner, Strike, Hewson and Gertzog (1982), which indicates the conditions that permit replacing "erroneous" conceptions of natural phenomena (from a scientific viewpoint) with conceptions that are closer to science. After more than thirty years, it can be stated that these proposals have not had a great influence on daily teaching practices nor on the permanent change of students' conceptions. Some of the principal reasons these science teaching models have not had the expected effectiveness are the following:

- Some initial authors of the model of conceptual change (Strike and Posner, 1992, taken from López y Mota, 2003) expressed criticism more than ten years ago because the model's purely cognitive and rational considerations undervalue the motivational and contextual factors of learning.
- From my point of view, these models have not had the expected influence because they assume that we have unique conceptions of natural phenomena and that these conceptions change when we are shown that they do not explain a certain physical phenomenon. However, psychological and anthropological research has broadly proven since the 1970s (Cicourel, 1974; Bruner, 1984; Coll, 1984) that the conceptions of learning depend on the social and cultural context in which they are manifest (Forman, Minick and Stone, 1993). The consequence is that a person may have various representations of a certain natural phenomenon and that these representations are not eliminated because their effectiveness has been proven in a certain context, such as the school context; different representations have different locations and contexts of use and can have greater or lesser effectiveness according to the context of use (Hodson, 1999; Pozo y Gómez Crespo, 1998).

  Research has shown us that children and adults, regardless of whether or not they are educated, and even scientists themselves, continue using non-scientific, religious or magic conceptions instead of science in daily contexts in which they are pertinent (Hodson,1999). Pozo and Gómez Crespo (1998) state this as the relative independence of scientific, daily and even cultural conceptions. Alternative conceptions coexist in most cases (Hodson, 1999). Such evidence permits understanding the reason members of other ethnic groups, such as indigenous groups, do not replace their conceptions of a cultural cosmos with scientific conceptions; both conceptions can coexist and be utilized in different contexts because their pertinence has been proven through centuries of application in social practice (Semali and Kincheloe, 1999; Gasché, 1995; Godenzzi, 1996; Helbert, 2001; Hodson, 1999).
- Another problem of these proposals is that they do not take into account that science is a cultural construction that has taken humans centuries to structure coherently. It cannot be reconstructed by students based only on empirical evidence because the interpretation of science is not unique, and students cannot construct the same meaning that is constructed from theories and scientific conceptions. For science—like any other form of describing reality—to be intelligible by a community, a set of suppositions and knowledge for interpreting the natural world must be shared (Phillips, 1985; Gilbert and Mulkay, 1984). This is an idea that arises from the criticism of empiricism, and that leads to the need—if science is to be learned—to communicate verbally some of the basic assumptions used for constructing the interpretations that science attributes to "empirical evidence" (Lemke, 1990; Sutton, 1992).
- The Piagetian constructivist focuses that form part of the theoretical assumptions on which these proposals are based, are the individual aspect of the construction of knowledge, while educational work in a social context like school requires a social focus for the construction of knowledge, like that of Vygotsky (1984). This is the conception we allude to when we mention interest in studying socially constructed knowledge in the classroom. The socio-cultural perspective developed initially by Vygotsky (1987) suggests that people interpret reality based on conceptions that are interiorized in their social and historical/cultural context.
- From my point of view, another important reason these proposals are not easily adopted in educational practice in the classroom is that they are not based on nor do they take into account the institutional characteristics of school or the working conditions at school. Such factors include teacher training and teacher practices, which through tradition have proven their effectiveness in that particular context, with its norms, possibilities and conditioners.

Taking into account the above points of view, in this article I state the importance of carrying out studies on science teaching in the classroom, from an ethnographic perspective that permits knowing the Other's logic before attempting to change it (Rockwell, 1986). Most articles that analyze interaction in science classes (Tobin, 1998) tend to disqualify traditional practices without analyzing their pertinence in processes of constructing curricular knowledge with real people and conditions. Science would consider it inconceivable to present the solution for a problem without taking into account the initial conditions in its logic. The problems that can be seen while working with a group of real students, with school conditioners, are very different from those that can be assumed from a "should be" perspective of science. It is therefore necessary for the researcher to acquire the sufficient autonomy to disconnect himself temporarily from the purposes of change and understand the processes of constructing knowledge in its complexity and from the participants' perspective; i.e., from the logic of teachers and students at different educational levels.

With regard to the statements by Roth (1996, quoted in López y Mota, 2003), that sustain that human practices are indescribable and unrepeatable, and therefore irrelevant to describe, we can state that for theorists of qualitative and ethnographic research (Erickson, 1989), in-depth case studies do not permit description but are a way of accessing the essential mechanisms of studied processes in order to find their elements of generality. On the other hand, experience allows me to affirm that these studies are an ideal way for teachers to see themselves reflected and therefore determine the aspects of their practice that are most adequate for promoting a certain type of reflection and construction of student knowledge.

In this article, I propose to analyze—in natural working situations in groups at public elementary school, where no proposal other than the official curriculum has been implemented—if discursive interaction in science classes turns to students' physical experience outside of school, and how that daily knowledge is given new meaning to bring it closer to scientific knowledge at school. I assume that qualitative research on teaching does not attempt to discover which teacher behaviors make students learn most because such behaviors are not causal actions and cannot be controlled in interactions among individuals with a free will. My assumption is that qualitative research is focused on studying which conditions of meaning are created collectively to facilitate learning (Erickson, 1989).

"Empirical Evidence" as a Source of Scientific Knowledge

Growing interest in the social contexts of cognition makes language—the means of uniting cognitive and social factors (Cazden, 1990)—occupy an increasingly important place for cognitive psychology and the study of science teaching from sociocultural perspectives (Lemke, 1990 and 2001; Sutton, 1992).

From the focus of the sociology of scientific knowledge, science is a social construction that is subject to certain specific discursive processes, including versions on certain topics like the organization of discourse and the way of speaking, arguing, analyzing, observing, building the result of experience with words, validating knowledge and establishing truth. Therefore research studies are considered pieces of textual and argumentative discourse. Scientific knowledge assumes the descriptions of natural phenomena that the scientific community establishes with an impersonal character and operates as a reality. Thus it is supported by what it establishes as "empirical evidence", which is assumed to be objective. Especially in science, scientific knowledge is knowledge that is produced with a form of apparent neutrality, independent from individuals and the social conditions of production, and is therefore established as truth (Gilbert and Mulkay, 1984; Potter, 1996).

School is also an institutional place where, in principle, specific forms of communication exist, and where discourse also has a distinguishable structure (Mehan, 1979; Drew and Heritage, 1992). School has defined rules of social interaction, and a particular manner of describing the surrounding world is learned at school. In this study, curricular knowledge of science is understood to be knowledge about science topics that is constructed through interaction among teachers and students in the classroom, and is legitimated by its apparent objectivity, universality and independence from subjects and social conditions of production.

The trajectory from scientific knowledge to a curricular knowledge of science passes through a series of transformations. Chevallard (1980) has called such transformations a didactic transposition, which is related to the discursive participation of teachers and students in a specific context: school. From the ethnographic perspective, curricular knowledge of science cannot be judged from the scientific logic of whether or not it is correct; rather, it must be described from the logic of educational actors to comprehend it in its entire complexity. Daily knowledge, in contrast with scientific knowledge, is related to personal experiences and is conceived as beliefs, ideas or conceptions that depend on the context and therefore cannot be assumed as universal.

I assume that the privileged manner we have to access individuals' processes of constructing knowledge is through the discourse they use to interact socially; therefore, I center this study on the analysis of discursive interaction (Candela, 1999) among teachers and students, seen from the viewpoint of discursive psychology (Edwards and Potter, 1992). The social construction of knowledge in the classroom through discourse is a group task in which meanings are negotiated, and shared understanding constructed (Edwards and Mercer, 1987) in addition to the elaboration, argumentation and contrast of alternate meanings (Candela, 1996). The studies on the analysis of discourse on which this article is based (Edwards and Potter, 1992) consider speech to be a contextual construction of conceptions, which can produce multiple versions according to the daily situation in which speech is produced.

Within this line of research, this specific article attempts to contribute to the debate on science teaching, with the idea that children cannot learn science only from perceptive experience: they must also learn how this experience is described in scientific discourse and especially in scholastic scientific discourse. They have to discover the criteria for preferring certain explanations or descriptions at school (Candela 2003).

School attempts to teach how physical phenomena are explained from the viewpoint of science; i.e., what "really happens" or what the facts are for science. The proposal to present students with "evidence" through observation and experimental activities is and probably has been the most significant element of science teaching from diverse psycho-pedagogical perspectives (Candela, 1991).

Many follow-up studies on the proposals of experimental work find that activity in itself does not lead to a change of conceptions or favor the construction of knowledge if adequate work is not done to allow, in discursive interaction, a construction of the meaning of "the evidence"—which permits articulating the students' interpretations of curricular scientific conceptions based on their daily conceptions.

Both in science and science teaching, the discourse on "evidence" considers that hypotheses and theories can be verified "objectively", supported by the assumption that a direct relation exists between perception and reality. This relation between "perception" and "reality" is one of the points we are interested in analyzing from the perspective of discursive psychology (Edwards and Potter, 1992; Potter, 1996). We find that the topic of factuality and factual descriptions (Potter, 1996) is central for science teaching, since many of the discourses among teachers and students in science classes revolve around the legitimacy and "veracity" of a certain version as a criterion to distinguish it from other versions.

In the diverse sources of knowledge of science (Elkana, 1983), "the evidence" (or what participants describe as what "is seen" or "observed in reality") plays a predominant role. This is defined in the social process of discursive interaction as what is derived from the perception and physical experience of participants ("what is seen/perceived"); and within this process, "empirical experience or evidence" may become relevant for constructing the facts. Extracurricular "empirical" experiences are also reconstructed discursively in the classroom, and it is of interest to see how they are reconstructed and articulated with the knowledge that is legitimated in the classroom as impersonal, generalizable and in synthesis, scientific.

In attaining good articulation between the experimental "evidence" and an interpretation that is validated as scientific in the classroom, we find one of the fundamental nuclei of the orientations that attempt to the students' science learning in a constructive manner, and based on laboratory work. I assume that the students' extracurricular experience based on "empirical evidence" is one of the references of daily conceptions that must be mobilized to construct knowledge that is established in school as scientific. Thus I focus on the way the classroom takes into account students' extracurricular experience based on their relationship with natural phenomena.

I assume that "empirical evidence" is not objective since individuals interpret reality based on the conceptions they hold. In diverse studies on discursive interaction in the classroom (Candela, 1999), I find that "what is seen" by teachers is frequently not "seen" by students, since they interpret reality in a different way. I also find, however, that in science classes allusion to "empirical evidence" is permanent as a mechanism to legitimate the validity of a version.

In this article I analyze the characteristic of discourse in several extracts from fifth-grade science classes given around the middle of the school year. The teachers have approximately ten years of teaching experience and received initial training at Escuela Normal de México (Normal School of Mexico). They have received no additional training although they are aware of some ideas that are considered innovative, such as allowing students to participate in class and taking into account their ideas about the phenomena under study, in order to favor a constructive appropriation of knowledge.

The nonparticipative observation of these classes was carried out with the teachers' voluntary authorization since they knew the researcher, who has done ethnographic work in the school for extended periods since 1985. The study involved ethnographic logs and the videotaping of more than sixteen class hours as an empirical referent. The school is a public elementary school in a marginated area of Mexico City, and is attended by children from low socioeconomic levels. Their families, who migrated to the city from fifteen to twenty years ago, work in the informal sector of the economy.

The fragments of the log analyzed in this article are taken from transcriptions of these classes, after watching the videos repeatedly and selecting units of analysis according to general criteria that orient the work without having previous categories. Some of these criteria are locating moments when discursive interaction has greater wealth and therefore allows a better analysis of the diverse contributions to the construction of knowledge in the classroom. A comparison of theory and the empirical data from the transcriptions permits elaboration of the analytical categories (Rockwell, 1982). In this case, such categories allow us to analyze how teachers and students constitute extracurricular "empirical evidence" as a source of knowledge for establishing curricular knowledge of science in the classroom. This topic is also important because schoolwork is frequently disqualified with the argument that the curricular knowledge of science is out of context, and that bridges with knowledge for life are not established. It will be of interest to discover if this is so.

Extracurricular "Empirical" Experience in Classroom Discourse

Analyzed below is an example of how students' extracurricular "empirical" experience is mentioned and worked discursively in a science class. The sequence I analyze below is part of the first class on the topic of "Gravity" presented to a group of fifth-graders according to the textbook. Since the topic was studied in the middle of the school year, the relationship between the students and teacher is well-established. The students have appropriated the standards of social participation that the teacher establishes. In this case, such standards favor the students' contributing their points of view regarding the knowledge under discussion.

The article makes use of specialized annotation developed from the ethno-methodological focus of discourse analysis (Edwards and Potter, 1992) (see Appendix 1). After an exchange of information in class, with extensive student participation in the discursive interaction on some of the effects of gravitational attraction towards the center of the earth (known as weight), and an exchange of knowledge on planetary movement (discussed previously by the group), the teacher asks the students a questions that will orient the entire discursive interaction.

Extract 1: "Balloons"

1	Ma:	Well:: (.) ^You have told me that there is a
2		force:: (.) /of gravity (.2) We're going to see that
3		that force of gravity (.) eh:::: (.3) is based
4		::on various (.) >things< (.2) ^First of all,
5		(.5) we would have to see (.6) mmm:::: (.) /weight.
6		(.4) But let's not talk about weight, eh:::
7	As:	Ha::: Ha:::
8	Ma:	^WHAT: happens with:: (.)balloons sold on the
9		street (.) The ones that have helium(.) [when we let
10		them go?
11 **	Aa:	[They fly away.
12 **	Ao:	They fly away.
13 **	Ao:	They float.
14 **	As:	THEY FLOAT.
15	Ma:	They :: float (.) or:: or they rise, right? (.) ^And what
16		happens let's say (.2) with:: a:: balloon that doesn't have
17		helium? (.) I have two balloons (.) [I let them go (.)
18	Ao:	[It falls
19	Ma:	Let's see (.) I have two balloons (.) >One with helium and
20		another without /helium (.) ^I let one go and I let the other
21 **		one go at the same [time<
22 =>**	As:	[ONE [FALLS:: AND THE OTHER FLOATS
23 **	Ao:	[THEY FALL TOGETHER
25	Ma:	WHY::? Will one fall and the [other one °float?°
26 =>**	Ao:	[because the air
27 **	((many try to answer at the same time and shout, their comments	
28 **	cannot be distinguished))	
29	Ma:	LET'S SEE (.) >in ::order< (.2) Why?
30 =>	Ao:	Because: since it has air inside (.) the balloon
31		rises
32	Ma:	But the other one also has air, if not, what did I ::
33		inflate it with
34	As:	Ha:: Ha::
35	Ma:	no::? (.2) Why:::? Let's see, Iván=
36 =>	Aoi:	=Because one has helium and the other has air?
37	Ma:	And what:: happens if one has helium and the other has air
38 =>	Aoi:	One weighs and the other one doesn't
39	Ma:	>ONE will weigh more and the other will weigh
40		less (.) So the one that weighs more is attracted sooner
41		by this force (.) and the one that weighs less will be
42		attracted later (.) YES OR NO?
43	As:	°yes:::::°

The teacher begins the intervention by giving the students the role of knowledgeable people, of people who have knowledge, and not simply as receptors of knowledge (**You have told me that there is a force of gravity**). This discursive movement can also be seen as an example of teachers' concern for developing knowledge as if the students had produced it (Edwards and Mercer, 1987).

Then the teacher presents a hypothetical problem (**WHAT: happens with:: (.)balloons sold on the street (.) The ones that have helium (.) [when we let them go**) to see the correspondence between the force of gravity and relative weight in a concrete case related to students' extracurricular experience. On introducing this problem, which is not included in the textbook, the teacher displaces the textbook as the sole source of knowledge and gives the children authority for extracurricular daily knowledge.

The students' responses on lines 11 to 14, first suggesting that the balloons fly and then that they float (they change the term in light of the teacher's lack of acceptance), as well as the number of children who attempt to participate, even before the teacher has finished talking, show the students' confidence in dealing with the topic at hand. Also proven is that the example is close to their experience and that it motivates and stimulates their interest in participating. When the teacher asks what happens with a balloon that does not have helium, the situation repeats itself: many children attempt to answer at the same time and in a loud voice (**ONE [FALLS:: AND THE OTHER FLOATS; [THEY FALL TOGETHER**). The teacher's recognition of the students' knowledge may contribute to favoring their strong participation throughout the extract as they interact with the teacher as well as among each other, which is indicated in the transcription as incomprehensible background noise (**).

The teacher returns to the response that one falls and the other floats and asks, "**WHY::?**" to demand arguments that justify the affirmations. The request for arguments to justify affirmations is a common practice among elementary and secondary school teachers (Candela, 1996) to promote reflection on what is said. It also orients students towards the causes of phenomena as an important attitude in science teaching (Giordan, 1982).

Many students answer again, with overlapping responses. One boy produces a justification (**Because: since it has air inside (.) the balloon rises**). Instead of accepting the response, the teacher answers with another argument that interactively has the function of rejection (**But the other one also has air, if not, what did I:: in<u>flate it with</u>**). Thus the teacher demands greater precision in the observation and marks the weakness of the argument presented.

The teacher asks again, now directing the question to a specific boy (Iván), so that he can explain why one balloon falls and another floats. Iván answers immediately, marking the difference between the content of the two balloons (**=because one has helium and the other has air?**). Thus Iván makes progress in producing an explanation that shows the difference in the content of the two balloons. The teacher repeats the boy's response in acceptance, but requires an expression of the consequences; i.e., an argument supporting the relation between the difference of content and the phenomenon of a floating and falling balloon. In response, the same boy, Iván, links content to the cause of flotation by saying that "**one weighs and the other one doesn't**".

The teacher accepts Iván's response and makes a reformulation that (**ONE will weigh more and the other will weigh less**). The teacher replaces an absolute formulation (weighing or not weighing) with a comparison (weighing more or less). With this reconstructive formulation (Edwards and Mercer, 1987), she assumes a better position to relate the notion of relative weight to the notion of gravitational attraction, which is the central topic with which the children are working. This type of formulations or recapitulations can be seen as the teachers' oral mediation between the written text and the children's speech (Edwards and Mercer, 1987; Rockwell, 1991). The formulations change what the children say by bringing their speech closer to what the teacher/textbook/curriculum specifies discursively as curricular knowledge of science.

An aspect that also indicates the reconstruction of daily knowledge for establishing curricular knowledge of science is that at the beginning of the activity, the teacher intervenes by personalizing some actions: "**let's see**" and "**we would have to see**" refer to the group perception, which is personalized. However, in the rest of the sequence, the grammatical form the teacher uses is impersonal, centered on a description that attempts to answer the question, "**What happens...**". This impersonal form suggests that through interaction, knowledge is being constructed that discursively is not dependant on individual beliefs. What happens to the balloons is established as a fact, not as something that is believed or perceived individually.

This extract shows the teacher's guiding activity in orienting students toward a collective and reflective construction of knowledge, while also encouraging scientific attitudes like asking about the causes of phenomena and searching for explanation by comparing arguments. The teacher guides by asking the students questions that allow them to link a description of the facts (one balloon rises and another does not) with curricular scientific knowledge (**ONE will weigh more and the other will weigh less (.) So the one that weighs more is attracted sooner by this force (.) and the one that weighs less will be attracted later::**). Although this affirmation is incorrect from a scientific point of view because one of the balloons is attracted with more force (weighs more) than the other, it does not change over time as the teacher affirms. In the perspective sustained in this article, curricular scientific knowledge is knowledge that is built through interaction and that brings the students' descriptive formulations closer to science. In this case, the teacher ends by linking the example from the students' extracurricular experience with curricular scientific knowledge like the force of gravity and relative weight (weighs more or weighs less) in order to present an explanation of the phenomenon of the balloons' greater or lesser flotation in the air.

Extracurricular Physical Experience Mentioned by Students

In the classroom, the teachers are not the only ones who turn to students' extracurricular physical experience. Students also make use of this experience to support their points of view and present reinforcing arguments. The following extract is a fragment from another fifth-grade class that is analyzing the concept of density by comparing ten different materials that must be placed in order of decreasing density. The activity is carried out after the same volume of different materials is weighed on a scale to appropriate the concept of density. This topic is also approached in the middle of the school year in a dynamic activity in which the teacher permanently encourages the students' reflection, asks for their opinion on the content, and almost never imposes a version of knowledge or establishes affirmations as absolute truths. The teacher uses the book and resources like argumentation, majority opinions, and consensus. The limitations in understanding content involve the lack of equipment and specialized scientific knowledge (Candela, 2002).

These attitudes generate a context of arguments that encourage student participation in the discursive dynamics of the classroom. In this case, the teacher discusses with the students which of two materials—wood or iron—is more dense. The discussion advances from a reference to density to a reference to weight.

Extract 2: "Let's see. Carry a tree."

	(A boy raises his hand insistently for permission to speak)	
46	Mo:	YES, SON (.) TELL ME.
47	Ao:	that <sometimes > (0.2) wood is heavier than
48		:::: iron
49	Mo:	Are you sure?
50	As:	Yes:::
51 =>	Ao:	Yes because (.) Let's see, carry a tree to see if
52 **		it's heavy
53 **	((There are many comments among students. The	
54 **	teacher smiles))	
55 *	Mo:	Well (0.2) let's put iron (.) By a majority
56		opinion. Then we'll make a list =
57 =>	Ao:	=How are we going to know if it's:: right?
58	Mo:	Let's see (0.2) You, Rubén. You come forward (.) to put the
59		second one?
60	As:	Me, me, me, Teacher.

In this fragment, a student affirms that **<sometimes > (0.2) wood is heavier than:::: iron**. However, in a movement that frequently provokes change in children's responses because of the lack of explicit acceptance (Pomerantz, 1984), the teacher questions the boy's suggestion ("**Are you sure?**"). But instead of the boy's rectifying his position, the teacher obtains collective rejection of his own position and the other students support the boy's version (line 50). After this collective support, the boys speaks again and provides an argument that wood is heavier than iron (**Yes**

because (.) Let's see, carry a tree to see if it's heavy), although no one makes the direct request. The argument offered is based on an imaginary construction of the student's imagined extracurricular daily empirical experience . This case of "**let's see**" is mentioned two times as a kind of discursively constructed reference to what would be an empirical proof.

In the following turns, on lines 55 and 56, the teacher ignores the empirical argument and maintains iron as the first option for second place (**Well (.2) let's put iron (.) By a majority opinion. Then we'll make a list=**). By using the expression of "**Well**", the teacher seems to try to close the previous debate and thus almost order what must be done next, "**Let's put**". However, in spite of the imposing form, it is interesting to observe that to justify the option, the teacher supports the version of iron "**by a majority opinion**". Here it seems that the teacher is utilizing the resource of the majority to legitimate a version of the "empirical evidence" constructed by the student. But justifying his version with the argument of the majority opinion seems to meet with the opposition of the other students. The teacher's authority does not seem to develop discursively as a sufficient source of knowledge to legitimate, with a debate, a particular version as "true" scientific knowledge.

However, when the teacher finishes talking, another boy intervenes by asking directly about the credibility of the teacher's argument. By asking "**=How are we going to know if it is:: right?**", the boy questions both the criterion of a **"majority opinion"** and the teaching authority as resources to legitimate a version of scientific knowledge: the boy requests for an argument that is convincing that this version "is right". In this fragment, we find evidence that students do not always consider the teacher's word as a legitimate source of knowledge and that their extracurricular experience seems to maintain sufficient legitimacy in the classroom to oppose the teacher's version. Students' extracurricular experience competes against the version toward which the teacher tries to orient the group, or the opinion that the teacher handles as a majority opinion by using the criterion that the majority is a criterion of truth.

In this extract, we once again find the presence of students' extracurricular experience as knowledge that enters the social process of discursive interaction in the classroom, and which contributes to constructing arguments regarding the versions legitimated at school.

Conclusions

Although no physical experimental activity is carried out in the first case, that first sequence reflects a very common practice in our schools: improvising interactions by turning to student experience in an extracurricular context to provide an example of the contents of the official curriculum. With these actions, teachers establish a bridge between the content of the text and children's knowledge, and encourage a link between students' extracurricular experience in their natural surroundings and scientific conceptions, by bringing them closer to the language science uses to describe phenomena. We could state that it is a virtual laboratory in which physical evidence deferred through memory is used.

The analysis of the first fragment shows that "empirical evidence" can be interpreted in several ways (Candela, 2002) since the students' first expressions are limited to describing what happens to the balloons. Only through interaction with the teacher is an interpretation constructed to orient the group toward the causes of the phenomenon and a meaning closer to that of science. It is important to note that the teacher is not limited to communicating the interpretation of the physical phenomenon in the language of science. What this detailed analysis shows us is that the process that the teacher follows is based on a scientific theory (gravity), turns to the students' daily experience, and leads them through questions, which follow a reasoning, distinguish between the balloons' differences, argue the causes, and approach a curricular scientific explanation; i.e., that what happens to balloons is due to gravitational attraction and the difference of their relative weights.

The process also generates scientific attitudes among students that have to do with the procedures of constructing science, such as reasoning on the "evidence", searching for causes of phenomena, "empirically" testing opinions, and arguing viewpoints. The children put some of these attitudes into practice in the second example in an unaided manner. In this case, the students also utilize their extracurricular empirical knowledge discursively (what is felt as weight) as a legitimate resource to question the teacher's viewpoints, even when the teacher supports his views on consensus or the majority opinion.

Teachers we could call "traditional" construct their authority as a source of legitimate knowledge in the classroom by correcting the book, orienting student responses and being those who establish knowledge that is legitimated as scientific, in a mediating process between children's versions and the versions of the text. But students also turn to their own knowledge as a source of legitimate discernment, as seen in the action of trying to incorporate their extracurricular experiences and having all students express an opinion.

This practice contextualizes the abstract content of the text and seems to motivate children to legitimate their knowledge, which encourages their participation in the social construction of curricular knowledge. Such a practice also permits students, as seen in the second extract, to turn to their extracurricular knowledge as a source of meanings to interpret, accept or reject constructions made in the classroom. The analyses show that the information obtained from empirical experience does not lead to a change of conceptions or favor the construction of scientific knowledge if it is not handled adequately in discursive interaction; a meaning is constructed of "evidence" that permits articulating students' interpretations of their daily conceptions and scientific conceptions, in what Bruner would call establishing a scaffold to guide the construction of knowledge.

In science classes it is important to develop this careful process of association between daily knowledge, extracurricular in this case, and curricular scientific knowledge so that students participate in its construction. This form of intervention, which mediates between students' knowledge and the knowledge of science, permits suggesting the irreplaceable role teachers have in the construction of curricular scientific knowledge.

The detailed analysis of the way this is carried out in many classrooms in our public elementary schools contributes to questioning the versions that disqualify teaching work, and serves as an example for improving the work of other teachers.

Appendix 1

Specialized Annotation Used in Transcriptions (Edwards and Potter, 1992)

Ma:	Female teacher
Mo:	Male teacher
Aa:	Female student
Ao:	Male student
As:	Several students at once
^	Indicates elevation of intonation
/	Indicates drop in intonation
=>	Indicates significant phrase for analysis
° °	Indicates a passage of lower intensity than adjacent speech
CAPS	Indicates a speech passage of greater intensity than adjacent speech
*	Indicates undistinguished background noise of students talking to each other
**	Indicates background noise of greater intensity
> <	Indicates a speech passage of faster speech than surrounding speech
< >	Indicates a speech passage that is slower than surrounding speech
[	Indicates overlapping speech
::::	Indicates elongated emphasis on a letter
underline	Indicates special emphasis in a phrase
(( ))	Comments of transcriber, generally observations on the context of speech
(3)	Pause measured in seconds, three in this case
(.)	Perceptible but very short pause for measuring in tenths of a second
=	Speech linked to previous speech without the habitual time lapse in conversations

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