UAB
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LiEC

Perspectives sobre el context en educació científica: Aproximacions teòriques i implicacions per a la pràctica educativa

SEMINARI DE DOCTORAT

Facultat de Ciències de l'Educació

13-14 desembre 2013

Organitzat pel Grup LIEC i el Departament de Didàctica de la Matemàtica i de les Ciències Experimentals de la UAB amb la col laboració de:

COL·LEGI OFICIAL DE DOCTORS I LLICENCIATS EN FILOSOFIA I LLETRES I EN CIÈNCIES DE CATALUNYA

PERSPECTIVES SOBRE EL CONTEXT EN EDUCACIÓ CIENTÍFICA: APROXIMACIONS TEÒRIQUES I IMPLICACIONS PER A LA PRÀCTICA EDUCATIVA

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Editora: Mariona Espinet
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Maquetació: Laura Valdés-Sánchez

Índex

Presentació

El grup de recerca LIEC (Llenguatge i Ensenyament de les Ciències) durant el curs 2012-13 ha focalitzat part del seu treball en aprofundir tan a nivell teòric com pràctic sobre el paper que el context té en l'ensenyament de les ciències i en la transferència dels coneixements apresos. Aquest treball s'ha difós en diferents àmbits com la presentació d' un simposi al congrés 2013 ESERA celebrat a Xipre que ha recollit les aportacions de diferents especialistes en didàctica de les ciències ibero-americans sobre la diversitat de perspectives en la conceptualització i aplicació pràctica del context en l'educació científica. També en el marc del IX Congreso de Investigación en Didáctica de las Ciencias celebrat a Girona s'ha presentat un simposi sobre la promoció i el desenvolupament de competències científiques a partir d'activitats en context. Aquest seminari pretén continuar la reflexió tot generant un espai més ampli per a aprofundir de manera crítica sobre les aportacions teòriques i pràctiques de diferents perspectives que s'utilitzen actualment per comprendre el context en la didàctica de les ciències. La metodologia de treball s'estructurarà al voltant de set contribucions temàtiques amb la finalitat d'animar una discussió per part de tots els participants que faci emergir els reptes que planteja la contextualització en l'educació científica. Les aportacions d'aquest seminari i d'altres autors externs es recolliran en un llibre sobre el context en l'educació científica.

A qui va dirigit

El seminari està dirigit a estudiants de màster i de doctorat, investigador@s, i professorat interessat en la recerca en didàctica de les ciències, didàctica de la matemàtica, educació ambiental, i altres especialitats.

Ponents

Isabel Martins (NUTES/UFRJ, Brasil), Agustín Adúriz-Bravo (Argentina), Christina Siry (Universitat de Luxembourg, Luxembourg), Conxita Màrquez (UAB), Merce Izquierdo (UAB), Neus Sanmartí (UAB), Mariona Espinet (UAB), Mercè Garcia-Milà (UB); ***Comentadors i moderadors:*** Rufina Gutiérrez (Instituto de Estudios Pedagógicos Somosaguas- IEPS), Joan Aliberas (UAB), Antoni Santisteban (UAB), Nuria Planas (UAB), Maria José Gil (Universidad de Zaragoza), Marilar Jiménez Aleixandre (Universidade de Santiago de Compostela), Mercè Junyent (UAB), Nuria Solsona (UAB), Marina Castells (UB), Conxita Màrquez (UAB), Isabel Martins (UFRJ)

Dinàmica

Les sessions s'organitzaran en base a tres aportacions per a cada un dels set àmbits temàtics: (a) La presentació d'un ponent durant 30 minuts on exposarà el seu punt de vista sobre el context des d'una perspectiva teòrica, pràctica o de recerca en particular; (b) La reflexió d'un comentador/a que durant 15 minuts exposarà la seva reacció a la presentació i identificarà preguntes rellevants per a promoure la reflexió; (c) La discussió coordinada per un moderador i amb tots els participants durant 30-45 minuts per enriquir el debat, connectar-lo amb la pràctica i identificar noves qüestions de recerca. Els ponents aportaran un text previ a la realització del seminari que podrà ser llegit amb antelació pels participants inscrits.

Llengua

Les llengües acceptades al seminari són el català, el castellà i l'anglès. Les ponències seran en castellà o català excepte les dues contribucions de dissabte (contribucions 6 i 7) que s'impartiran en anglès. La taula rodona final podrà tenir contribucions en les tres llengües. Les transparències de totes les contribucions seran en anglès, amb independència de l'idioma amb que es presentin, per facilitar la comunicació amb els parlants d'aquesta llengua. Per a les discussions col·lectives es podran fer aportacions en qualsevol de les tres llengües del seminari.

Organitzadors

Grup de recerca LIEC (Llenguatge i Ensenyament de les ciències) i Departament de didàctica de la matemàtica i de les ciències experimentals de la Universitat Autònoma de Barcelona. Amb la col·laboració del Col·legi oficial de Doctors i Llicenciats en Filosofia i Lletres i en Ciències de Catalunya.

Coordinadora

Mariona Espinet, Universitat Autònoma de Barcelona

Espais

El seminari es celebrarà a la Facultat de Ciències de l'Educació de la Universitat autònoma de Barcelona (Campus de Bellaterra) el divendres 13 de desembre, i al Col·legi Oficial de Doctors i Llicenciats en Filosofia i Lletres i en Ciències de Catalunya (Barcelona) el dissabte. Les ponències es realitzaran als següents espais:

Divendres 13 de desembre	Aula 41 Mòdul III	Facultat de Ciències de l'Educació **Universitat Autònoma de Barcelona** Campus de Bellaterra, 08193 Cerdanyola del Vallès (Barcelona) Tel (34) 93581 2646
Dissabte 14 de desembre	Sala Ramon Fuster	**Col·legi Oficial de Doctors i Llicenciats en Filosofia i Lletres i en Ciències de Catalunya.** Rambla Catalunya, 8. pral. 08007 Barcelona Tel. (34) 93 317 04 28

Com arribar-hi

Divendres

Al campus de Bellaterra de la UAB s'hi pot arribar amb Ferrocarrils de la Generalitat de Catalunya (estació Universitat Autònoma), RENFE (estació Cerdanyola Universitat), autobús (SARBUS) o amb cotxe per la AP-7 o la C-58.

La Facultat de Ciències de l'Educació es troba a la part nord del Campus, propera a la estació de FGC. En el següent mapa podeu trobar l'Aula 41.

Dissabte

El Col·legi Oficial de Doctors i Llicenciats en Filosofia i Lletres i en Ciències de Catalunya es troba molt a prop de la Plaça Catalunya de Barcelona, a Rambla Catalunya, 8. pral.

Programa

Divendres 13 de desembre

Lloc: Facultat d'Educació, UAB, Cerdanyola del Vallès

9 - 9.15	**Obertura del seminari**	Mariona Espinet, UAB	Aula 41
	CONTRIBUCIÓ 1		
9.15 - 9.45	**Contribució 1:** *La noció de context epistemològic com una eina teòrica per a l'educació científica,*	**Presentador:** Agustín Adúriz-Bravo, Argentina	Aula 41
9.45 - 10	**Reflexió de la contribució 1**	**Comentadora:** Digna Couso, UAB	
10 - 10.45	**Discussió col·lectiva de la contribució 1**	**Moderadora:** Marina Castells, UB	
10.45 - 11.15	**DESCANS**		
	CONTRIBUCIÓ 2		
11.15 - 11.45	**Contribució 2:** *Consideracions sobre la diferència entre "context de l'alumne" i "context de modelització científica escolar" i de les dificultats que se'n deriven.*	**Presentadora:** Mercè Izquierdo, UAB	Aula 41
11.45 - 12	**Reflexió de la contribució 2**	**Comentador:** Joan Aliberas, UAB	
12 - 12.30	**Discussió col·lectiva de la contribució 2**	**Moderadora:** Digna Couso,UAB	
	CONTRIBUCIÓ 3		
12.30 - 13	**Contribució 3:** *La vessant psicològica de Context i les seves implicacions en l'Ensenyament i Aprenentatge de les ciències*.	**Presentadora:** Mercè Garcia-Milà, UB	Aula 41
13 - 13.15	**Reflexió de la contribució 3**	**Comentador:** Antoni Santiesteban, UAB	
13.15 - 14	**Discussió col·lectiva de la contribució 3**	**Moderadora:** Maria Pilar Jiménez Aleixandre, UAB	
14 - 16	**DINAR**		
	CONTRIBUCIÓ 4		
16 - 16.30	**Contribució 4:** *Text i context des d'una perspectiva discursiva: lectures, apropiacions i Implicacions per a la recerca i la pràctica en educació científica*	**Presentadora:** Isabel Martins, UFRJ	Aula 41

16.30 - 16.45	**Reflexió de la contribució 4**	**Comentadora:** Marilar Jiménez Aleixandre, Universidade de Santiago de Compostela	Aula 41
16.45 - 17.30	**Discussió col·lectiva de la contribució 4**	**Moderadora:** Núria Solsona, UAB	
17.30 - 18	**DESCANS**		
	CONTRIBUCIÓ 5		
18 - 18.30	**Contribució 5:** *Evolució de la noció de context en la didàctica de les ciències*	**Presentadora:** Neus Sanmartí, Conxita Màrquez, Ivan Marchán, UAB	Aula 41
18.30 - 18.45	**Reflexió de la contribució 5**	**Comentadora:** Maria José Gil , Universidad de Zaragoza	
18.45 - 19.30	**Discussió col·lectiva de la contribució 5**	**Moderador:** Antoni Santiesteban, UAB	

Dissabte 14 de desembre

Lloc: Col.legi Oficial de Doctors i Llicenciats, Barcelona

	CONTRIBUCIÓ 6		
10 - 10.30	**Contribució 6:** *Contextos i entorns d'aprenentatge en educació científica i ambiental*	**Presentadora:** Mariona Espinet, UAB	Sala Ramon Fuster
10.30 - 10.45	**Reflexió de la contribució 6**	**Comentadora:** Mercè Junyent, UAB	
10.45 - 11.30	**Discussió col·lectiva de la contribució 6**	**Moderadora:** Maria José Gil, Universidad de Zaragoza	
11.30 - 12	**DESCANS**		
	CONTRIBUCIÓ 7		
12 - 12.30	**Contribució 7:** *Sociocultural perspectives of context in science education research and practice*	**Presentadora:** Christina Siry, University of Luxembourg	Sala Ramon Fuster
12.30 - 12.45	**Reflexió de la contribució 7**	**Comentadora:** Núria Planas, UAB	
12.45 - 13.30	**Discussió col·lectiva de la contribució 7**	**Moderadora:** Isabel Martins, Brasil	
	TAULA RODONA I CLOENDA		
13.30 - 14	**Presentadors:** Agustín Adúriz-Bravo, Mercè Izquierdo, Mercè Garcia-Milà, Christina Siry, Neus Sanmartí, Conxita Màrquez, Isabel Martins i Mariona Espinet	**Moderadora:** Marina Castells, UB	Sala Ramon Fuster

Textos

Recull de textos de diversos autors que reflexionen sobre el context en l'educació científica des d'una perspectiva teòrica i prenent en consideració les seves implicacions en la pràctica educativa. Alguns dels textos són escrits pels presentadors de les contribucions i poden servir com a lectura prèvia a les seves ponències. Es presenten en algun dels idiomes en que s'impartirà el seminari (català, castellà i anglès), i en alguns casos en més d'un d'ells. Es recomana la lectura d'aquests materials abans del seminari.

Els textos es presenten per ordre alfabètic dels cognoms dels autors. Índex dels textos:

Text 1

The notion of “epistemological context” as a theoretical tool for science education

Agustín Adúriz-Bravo

CeFIEC-Instituto de Investigaciones Centro de Formación e Investigación en Enseñanza de las Ciencias, Facultad de Ciencias Exactas y Naturales
Universidad de Buenos Aires

Resumen

En esta presentación reviso tres significados históricos que se han dado a la idea de “contexto” desde la epistemología (o filosofía de la ciencia), bajo la hipótesis de que esos significados pueden ser valiosos, desde el punto de vista teórico, para la educación científica como práctica y para la didáctica de las ciencias como disciplina. El primer significado, de carácter neopositivista, equipara el contexto con el “encuadre epistemológico” dentro del cual se desarrolla la actividad científica; es desde ese encuadre que la actividad como un todo cobra sentido. En el segundo significado, fuertemente racionalista, el contexto pasa a incluir todas las relaciones epistémicas que ubican a los sujetos científicos es su lugar y su tiempo. Desde el tercer significado, asociado a la llamada “nueva filosofía de la ciencia” de los años 50s y 60s, el contexto está constituido por el conjunto de factores externos al propio conocimiento científico “clausurado” –por ejemplo, factores sociales, económicos, políticos, ideológicos, religiosos, educativos– que constriñen su naturaleza y su dinámica. En la presentación exploro algunas posibles implicaciones de estos tres diferentes significados del contexto en nuestra comprensión teórica y nuestra conducción práctica de la enseñanza de las ciencias.

Synopsis

The aim of this presentation is to review three historical meanings with which the idea of “context” has been used in the philosophy of science during the 20th century. This review cannot purport to be exhaustive, since the concept of ‘context’ has proved to be rich and fruitful in the philosophical reflection about the nature of science.

It can be argued that the three meanings of ‘context’ that I retrieve here are of theoretical value for didactics of science (i.e., science education as an academic discipline), as it will be discussed in the presentation.

I identify the three meanings through an examination of some mainstream schools of recent, professional philosophy of science: logical positivism, critical rationalism, new philosophy of science, and post-Kuhnian philosophy of science (figure 1).

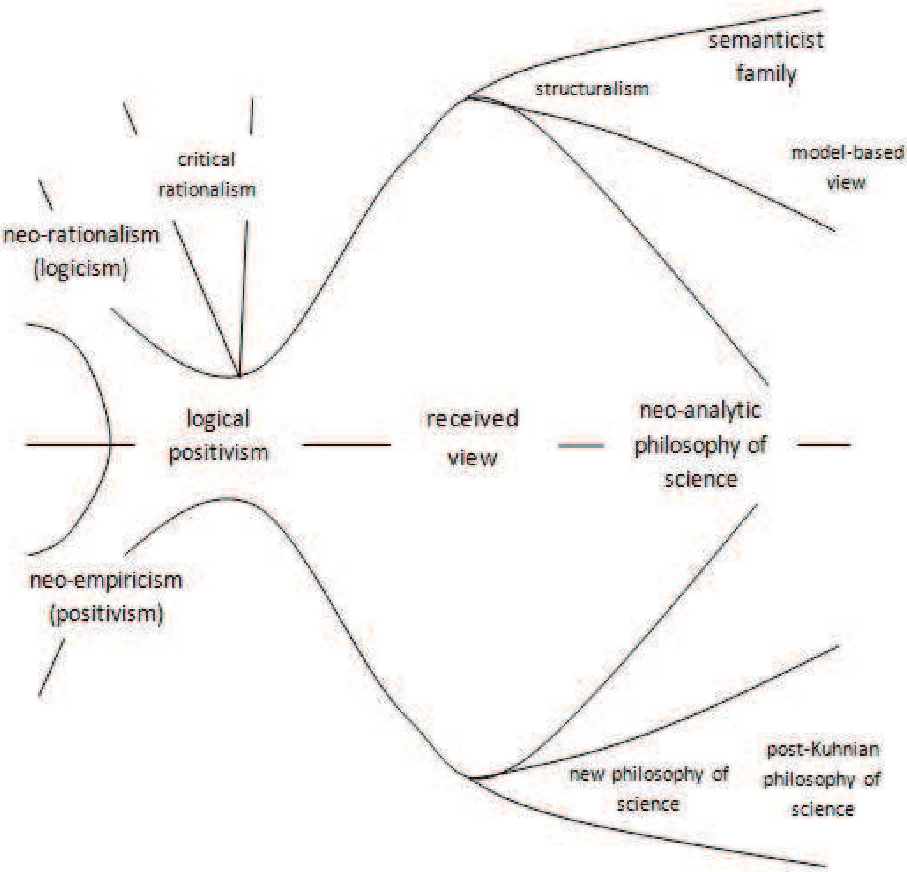

Figure 1. A map of the main schools of the philosophy of science in the 20th century. I have examined some of these schools to retrieve their use of the idea of 'context0.

As I have advanced, the aim and perspective of the examination presented here is provided by the discipline of didactics of science: I examine philosophical ideas through the lens of their eventual fruitfulness to characterise the nature of school science.

Context as the scenario for a specific kind of scientific activity

In the first sense, ' context' is understood as a scenario or framing that gives *epistemic* –i.e., intra-theoretical– meaning to some specific aspect of the scientific activity (cf., Martínez, 2003). That is to say, contexts can be equated to sets of elements that ' traverse' science and characterise it as an activity guided by a a diversity of aims and laden by a plurality of values. Such aims and values are internal and specific to the scientific endeavour; they are related to the cognitive will of giving meaning to the natural world.

In this first use of the idea of ' context' , the so-called contexts of discovery and justification were proposed by Hans Reichenbach (1938) during logical positivism, in the first half of the 20th century. This seminal proposal was extensively used in the philosophy of science, and then thoroughly criticised. The original, two-context proposal was enriched after World War II, in order to capture a wider variety of epistemic operations within science practice: discovering, inventing, creating, innovating, applying, transferring, justifying, assessing, evaluating, teaching, indoctrinating, popularising, etc. (cf., Echeverría, 1995; Carrier & Nordmann, 2011).

In science education, the idea of the existence of different epistemic contexts for the scientific practice can provide a meta-theoretical conceptualisation of science that better identifies and separates its various aims, giving a personality of its own to what can be called ‘school scientific activity’ (Izquierdo-Aymerich & Adúriz-Bravo, 2003). Incorporating a genuine context of scientific education can lead to recognising, in a more refined way, the continuities and discontinuities between scientists’ science and school science.

Context as the a backdrop or breeding ground for scientific subjects

In the second sense, shifting back to rationalism, the idea of ‘context’ has to do with opening up the theoretical perspective from an epistemic subject that, in order to be studied, was abstracted and separated from the background –an approach that was favoured by the positivistic view– towards a real, cognitive subject, creative and inventive, inserted into a community, and constrained and conditioned by different influencing factors. This new, contextualised conception of the scientific subject is timidly initiated in the writings of Karl Popper (1962), and then deepened in the so-called new philosophy of science of the 1950s and 1960s.

This second sense of ‘context’ is definitely relevant for constructivist didactics of science, since it brings to the forefront of the discussion the *situated activity* of those who ‘do science’, for instance, in the science classrooms.

Context as the network of social relations that constrain science

In the third sense, ‘context’ directly points at the incorporation of a *historicist* and *externalist* perspective (accordingly called ‘contextualist’) in the philosophy of science. The analysis of the products of science –and mainly of the scientific theories– since the 1950s has consistently taken into account the influence that, on their own internal dynamics, has the context constituted by factors that are external to scientific knowledge. Among those factors, the historical, cultural, political, economic, ideological, religious, linguistic, and educational have classically been considered (cf., Kuhn, 1962).

The kuhnian idea of ‘disciplinary matrix’, a refinement of the construct of paradigm, is a good example of this third approach to contexts, examining them as holons that overdetermine normal science.

A contextualist theoretical perspective, combining internalism and externalism in order to understand science, would provide the variety of elements required for a ‘humanist’ science education. Such approach would in turn promote in the science classes an image of science as an integral part of culture, as it is currently demanded by science curricula.

References

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Text 2

Contextos i entorns d'aprenentatge en educació científica i ambiental

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Abstract

The presentation aims at in one hand reviewing different models of "Context" used in context-based science curricula and teaching, in the other hand identifying different views of the concept "Learning environments" as used within science education literature as well as education more generally, and finally establishing relationships between the views of Context and Learning Environments to show their complementarities as the basis for a unified view. Four models of context are reviewed: (a) Context as direct applications of concepts; (b) Context as reciprocity between concepts and applications; (c) Context as provided by personal mental activity; and (d) Context as social circumstances. In addition three views on learning environments are also reviewed: (a) Learning environment as a psychosocial entity; (b) Learning environment as a system; and (c) Learning environment as a community. The comparative analysis appears to indicate that both Context and Learning Environments experience a sociocultural turn which embraces complexity and diversity. A cartography of contexts for science education is presented based on a set of attributes taking into account the four worlds that are interconnected such as school science, everyday science, professional science and citizens' science. At the end a model of context as Complex Learning Environment is set so that it can be a tool to account for the increasing complexities that science education needs to face today such as interdisciplinariety, students and teachers' diversity, and diversity of settings. The characteristics of such model will be presented, examples from school agroecology provided, and research questions identified during the presentation.

Introduction

Science education has adopted a context-based approach to curriculum and teaching to address the challenges faced by the science education community worldwide. Despite the interest towards context-based approaches very little programs and curriculum developments have been explicit in relation to the framework adopted (Gilbert 2006; King and Richtie 2012). There is an urgent need to clarify the meanings of context used in many influential context-based science education experiences, so that theoretical as well as practical advances can be made.

In addition influential global organizations from economical and political strands like the OECD-CERI (Center for Educational Research and Innovation) are at present undertaking worldwide studies on Innovative Learning Environments (ILE). Although we might not share their ideological background the social and political impacts of this institution's studies and programs are important and need to be taken seriously. The results of the ILE case studies (Dumont, Istance & Benavides, 2010) point at interesting issues which although they are not framed within science education explicitly they might be relevant to initiate a reflection on science education learning environments. The ILE case studies state that there is a need to reconsider learning and learning environments within innovative education reforms since the educational school experiences selected are: (a) Not sufficiently learning focused since they are described in terms of institutions and very little in terms of learning, (b) not sufficiently innovative focused since the experiences assume existing institutions and discourage innovations, hybrid and non-formal or informal learning, and (c) not sufficiently holistic or environmental focused since the experiences encourage fragmented learning based on single schools, single classes, and single teachers.

Finally, our recent work on promoting school agroecology through community networking (Espinet and Llerena, 2011; Espinet 2012) has triggered the need to re-conceptualize both context and learning environment at the interface between science education and education for sustainability. The learning environments and contexts designed in school agroecology are more complex than those usually chosen in science education. How can we develop a model that takes into account the complexities of both contexts and learning environments designed to promote better science education towards sustainability?. How can this model be useful for science education research and practice so that the diversity of educational levels, situations, content, students and teachers are taken into account?

Aims

The presentation aims at in one hand reviewing different models, attributes and activities associated to "Context" used in context-based science curricula and teaching. On the other hand the presentation introduces the idea of context cartographies in science education as a way to map the diversity of contexts at hand in science education based on the authors work on school agroecology. Finally a model on how to think about the characteristics of science learning environments is presented. The ultimate goal of this discussion is to resituate the concept of learning environment for context-based science education and to set the key characteristics of a Complex Science Learning Environment model with examples taken from school agroecology.

Contexts and Learning environments heading towards a sociocultural turn

The concepts of Contexts and Learning environments are often used interchangeably within the science education literature. Several questions could be asked to identify the place of both concepts in science education research and practice: In what ways are these concepts understood within the science education literature? Is there a progression on their conceptualization so that the situation, the content, the learner, and the teacher are taken into account interdependently? And finally, how is the diversity of content, learners and teachers being considered?

Models of Context

Although very few context-based courses have historically been based on an explicit model of context, Gilbert (2006) identifies four models. Taking into consideration the attributes for defining a context, the author identifies four models which represent four inductive ways of understanding context in chemistry context-based curricula and teaching: (a) Context as direct applications of concepts; (b) Context as reciprocity between concepts and applications; (c) Context as provided by personal mental activity; and (d) Context as social circumstances. These four models are organized in a progressive manner on the line of a continuum from less to more complex. Whereas the first model focuses only on the conceptual aspects of context being the learner and the social totally absent, the fourth model takes into consideration the concepts, learners' engagement and the social in its framing through the concept of community of practice (Greeno 1998). In this latter model I would include the unified view of context developed by King and Richtie (2012) using the sociocultural concept of field and I would stress the important notion the authors develop on fluid transactions among fields as a way to understand context-based learning and transfer in science education.

Views on Learning Environments

In a recent study undertaken by OCDE-CERI on Innovative Learning Environments (ILE) (Dumont, Istance & Benavides, 2010), the authors indicate that innovative schools worldwide offer poor learning environments being them too institutionally centered on one teacher, one group of homogeneous students, and only one subject. Espinet (2012) has set an interpretation of views on learning environments used in the science education research literature from different perspectives: (a) Learning environment as a psychosocial construct resulting from the interaction between the environment and the learner personal characteristics exemplified by the work of Fraser (2012) ; (b) Learning environment as a system exemplified by the French work on "didactical situations" and "didactical systems" (Otero 2010); and (c) Learning environment as a community exemplified by the work on science teacher preparation inspired by Wenger (1998). These views are also organized in a progressive manner from less to more complex. In the first view only the nature of social climate for learning is taken into consideration, whereas in the second view the focus is on building systemic learning interactions in didactical situations. Finally the third view acknowledges the social nature of learning environments which is situated and activated through the use of resources.

The comparative analysis appears to indicate that both Context and Learning Environments experience a sociocultural turn which embraces complexity and diversity.

Exploration of context cartographies in science education

The identification of context complexity and diversity in science education involves the agreement of a set of attributes which help the characterization of such contexts. In doing so we are better equipped to map the important context types which can be used in science education. I use the concept of cartography as a metaphor to start thinking about context complexity and diversity. Gilbert (2006) and Gilbert et al. (2011) had already identified four context attributes: (a) a setting as the result of social, spatial, and temporal frameworks; (b) a behavioral environment of encounters related to the task; (c) the use of specific language; and (d) a relationship to extra-situational background knowledge. This formulation has one important problem which is to find the place of the subject in this context. From a sociocultural perspective these attributes could be reformulated: (a) a community of practice with a diversity of spatial and temporal arrangements; (b) participating in an activity; (c) using specific language within multilingual environments; and (d) crossing boundaries among different communities of practice.

The context cartography of science education is organized around four intersecting worlds: school, everyday, professional and social worlds. These four context types sustain four different communities of practice which hold different science education aims: school science, everyday science, experts' science, and citizens' science. Science education experiences an important tension related to the way students and teachers interact with these four contexts which I would call "in-out tension": should we take students and teachers out of school to be part of the professional, everyday, or citizens' authentic science contexts leaving school context with no relevance? Or else should we bring to school these different contexts and thus engaging students in a not so authentic activity of learning about these out of school contexts? The central challenge could be formulated as how can school science relate to the other science contexts so that it develops authentic practices for students, teachers and community members?

The cartography of agroecology as a STEM discipline could be mapped using the four intersecting fields just stated: (a) school world as school agroecology; (b) everyday world as community agroecology; (c) professional world as agronomy and ecology; and (d) social world as agroecological activism. The challenge for school agroecology would be how to create authentic contexts in school for students and teachers to develop authentic agroecological practices in relation to the school food system. This would imply to introduce the four components of the food system in the school open to students and teachers' participation: (a) food production by developing the food garden through gardening; (b) food transformation by participating in the school kitchen through cooking; (c) food consumption by participating in the dining hall through the menus; and (d) food distribution by participating in the exchange of food within and outside the school. These four school agroecological practices would act as authentic contexts for science learning and would also facilitate the connection with the out of school agroecological practices as well.

A model of context as Complex Science Learning Environment

The comparative analysis appears to indicate that both Context and Learning Environments experience a sociocultural turn which embraces complexity and diversity. A model of context as Complex Learning Environment that takes into consideration the increasing complexities and diversity in science education will be proposed. The characteristics are the following: (a) *Systemic Level:* The model could be general enough to include the systemic level where it is applied in science education: at the level of a specific activity, at the level of a teaching unit, at the level of an inquiry process, or at the level of a whole school.; (b) *Lifelong Learning:* The model could be applicable to all educational levels from infant to secondary science education so that a progressive view on lifelong science learning environments is reflected; (c) *Context:* The model understands context as a focal event embedded in its cultural setting; (d) *Time and space:* The model considers new spatial and temporal arrangements which depart from traditional classroom organizations; (d) *Learners and teachers' communities:* The model acknowledges larger and more diverse communities where to establish learning relationships between diverse learners and teachers; (e) *Learning as boundary crossing:* The model understands learning as a process of boundary crossing among a diversity of learners, teachers and content (Akkerman and Bakker 2011). The characteristics of such model will be presented, examples from school agroecology provided, and research questions identified during the presentation.

Implications

Recent reflections on the nature of learning point at the need to reconsider the traditional learning environments through which we develop science education in schools. The first implication deals with the idea that there are at present many different ways to participate in science depending on the worlds we take as referents. Better ways to connect in and out the different worlds of science should be taken into consideration when implementing school science curriculum. The second implication is related to the fact that school is one but not the only place where to learn science. The systematical planning and designing of learning paths melting formal, informal and non-formal science education learning environments appear as an urgent endeavour to avoid losing learning opportunities through the lifespan of our students. Finally it appears also imperative to rethink schooling so that science learning environments become more authentic, action oriented, equitable, and put at the service of a wider and more transformative general education.

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Text 3

Consideraciones acerca de la diferencia entre 'contexto del alumno' y 'contexto de modelización científica escolar' y de las dificultades que de ella se derivan.

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1. *Resumen, a modo de introducción*

La estrategia didáctica que llamamos 'modelización científica escolar' pretende conseguir que las teorías científicas y los **lenguajes** con los cuales éstas se expresan tengan significado para los alumnos y lleguen a ser el resultado de la **actividad científica** de la cual ellos sean protagonistas y de la cual surja la necesidad de comunicar, de compartir ideas, de generar lenguajes. Se supone que, con ello, el alumnado adquirirà competencias de pensamiento científico. Para ello se han de diseñar situaciones / fenómenos que el alumno reconozca y que permitan el tipo de trabajo y las preguntas que se consideran adecuadas para llegar a construir los conocimientos científicos y sus lenguajes, que se han de poder aplicar a la vida cotidiana.

¿Es esto posible? ¿Las situaciones que permiten modelizar son las mismas que facilitan la aplicación de los conocimientos en contextos cotidianos?

Estamos convencidos que la actividad científica 'modelizadora' supone un gran cambio. Rompe con la tradición con la que podíamos estar más compenetrados, según la cual eran las prácticas, la experimentación, el contexto en el cual tomaban sentido los conceptos y lenguajes científicos. Pero al no poder ser interpretada por falta de marco teórico apropiado , no cumplió estas expectativas y, de hecho, no funcionó como contexto. El problema es que el lenguaje científico tiene un significado previo, teórico, remite a un marco conceptual demasiado nuevo para los alumnos que puede ser un freno para que sus ideas genuinas, significativas para ellos, puedan desarrollarse y transformarse.

Ahora nos planteamos empezar por las situaciones y fenómenos que consideramos que los alumnos deberían poder interpretar, los contextos cotidianos que sí que plantean preguntas genuinas a los alumnos. Pero estos fenómenos remiten muy a menudo a creencias de sentido común y a ideas que no se pueden prever de antemano con detalle;

debido a esto, no se puede asegurar que las palabras de la ciencia con las que se habla finalmente de ellos significquen lo mismo para los profesores y para sus alumnos .

En nuestro grupo de investigación trabajamos con la hipótesis de que se ha de dedicar más tiempo a consensuar el significado de los lenguajes que emergen de la actividad científica en la escuela, a la vez que vamos ajustando nuestras ideas sobre cómo debe ser esta actividad: ¿puede ser a la vez cercana a la experimentación científica y cercana a la actividad cotidiana? Porque va quedando claro que no es lo mismo, como quizás esperábamos de manera implícita y quizás algo ingenua. Sin duda, es necesario dedicar mucho tiempo y atención al diálogo en clase, pero debemos estar preparados para aceptar que no podremos lograr del todo que los alumnos aprendan a ver su mundo cotidiano desde lo que hasta ahora hemos considerado que era 'la perspectiva científica'. Debemos prepararnos para ajustar la evaluación de los aprendizajes de ciencias según nuevos parámetros que correspondan a una nueva 'ciencia para todos' y que no tengan como única referencia la ciencia de las disciplinas científicas.

Si bien la propuesta didáctica ´modelizadora para adquirir competencias ' hace necesaria contextualización de los aprendizajes, al hacer énfasis en que la ciencia surge de la actividad humana e intentar planificarla según el 'mundo' de los alumnos (porque sólo de esta manera su actividad puede ser genuina) se enfrenta a problemas epistemológicos. Estos problemas son en realidad los propios de la ciencia moderna, que ya no puede ser considerada una búsqueda de conceptos universales por parte de observadores externos a la naturaleza sino que debe incluir las emergencias debidas a una actividad que, al ser humana, compromete y emociona.[1] Podemos imaginar que la ciencia comparte ahora el destino humano de habitar un planeta que cambia debido a la vida que se desarrolla en él y lo hace en un tiempo abierto a un futuro que no sólo es irreversible sino que también es impredecible.

Estos problemas son especialmente importantes en la escolarización obligatoria; la función educadora y, por ello, humanizadora de la enseñanza de las ciencias es insoslayable y su principal aportación es hacer accesible a los alumnos el pensamiento científico. Voy a referirme aquí a la secundaria obligatoria (ESO).

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[1] STENGERS i PRIGONINE, (1990) nos hablan d e una nueva alianza entre ciencias y humanidades, una vez finalizado el tiempo en el cual el método científico imponía orden en la naturaleza. Se oponen a esta naturaleza pasiva, que se comporta como un autómata. Estacan la paradoja entre los orígenes humanistas de las ciencias y su imagen actual, deshumanizadora y antinatural.

D*os preguntas para empezar*

La pregunta inicial muestra la sospecha de que va a tener una respuesta negativa: las situaciones (contextos) apropiados para la modelización teórica no son los mismos que permiten a los alumnos iniciar una actividad que los comprometa. Y, sin embargo, nuestro objetivo docente es que los alumnos se comprometan en el proceso de modelización teórica.

Este es el problema al que se refiere esta comunicación. Empezaré por formular dos preguntas para concretarlo mejor. La primera se refiere al tipo de actividad que se ha de desarrollar, la segunda se refiere al tipo de lenguaje con el que esta actividad se comunica.

a) *¿Cómo desencadenar una* ***actividad*** *que sea científica (experimental) y que mantenga y alimente la sorpresa, la reflexión, el esfuerzo…que es necesario para actuar?*

La ciencia que se aprende debe ir acompañada de experimentos, de actividad experimental. Esto lo sabemos desde Piaget, desde Decroly, desde Dewey, pero aún no se ha llevado a la práctica de manera generalizada. Se han hecho muchos esfuerzos para adaptar experimentos científicos a las aulas, con la confianza de que los alumnos verían en ellos lo mismo que sus profesores, de que la traducción de determinados fenómenos a ideas y a palabras iba a funcionar de manera automática; y de que se implicarían en la tarea con entusiasmo. Se esperaba que las palabras de la ciencia tomarían sentido en el **contexto de los experimentos**. La realidad ha mostrado que el entusiasmo y el aprendizaje esperados no se producían de manera generalizada. La mayoría de alumnos lo pasan bien haciendo experimentos, pero no todos aprenden más; por lo tanto, los profesores que defendían otro tipo de enseñanza 'de pizarra' tuvieron (y tienen aún) argumentos para continuar enseñando las ciencias sin experimentar.

Ahora, a la luz de nuevas teoría sobre la cognición, sobre el aprendizaje y sobre el lenguaje, nos parece que la actividad que promovían determinados experimentos era tan artificial para los alumnos como las fórmulas escritas en la pizarra. Para generar preguntas, interés, sorpresa…que impulse una actividad experimental que emocione y que deba ser comunicada y compartida es necesario un 'contexto' más próximo al alumnado . Porque se empieza a ver claro que la ciencia para todos debe emocionar, pues sólo así va a poder integrarse en los esquemas de conocimiento que los alumnos activen para resolver problemas que les presenten el mundo físico y biológico. Ahora bien, la emoción ha de ser debida a la maravillosa experiencia de 'comprender como funciona el mundo' ; y para ello es necesario que esta experiencia se haya producido.

b) *¿ Qué función tienen los términos científicos en el proceso de modelización teórica?*

Se ha argumentado mucho y bien respecto a la importancia de los 'modelos' en la enseñanza de las ciencias y se ha propuesto el proceso de 'modelización científica' como estrategia de enseñanza que debería favorecer la competencia en 'hacer ciencia' para lo cual es necesario que haya actividad científica escolar. Este proceso debería proporcionar a los alumnos la experiencia de conocer de la que hablamos. La experimentación debe formar parte del proceso de 'modelización teórica' que ha de ser diseñado cuidadosamente para que las acciones, lenguajes y manera de pensar vayan evolucionando a la vez.

La modelización científica escolar pretende conseguir que las teorías científicas y los lenguajes con los cuales éstas se expresan tengan significado para los alumnos, que han de ser protagonistas de la actividad que llevan a cabo. A diferencia de las propuestas docentes de 'teoría' y 'experimentos' que no funcionaron, se trata de identificar situaciones / fenómenos que el alumno reconozca y que permitan las preguntas que se consideran adecuadas para llegar a construir un **discurso** en el cual se construyan los lenguajes apropiados para los **nuevos conocimientos científicos**.

No esperamos que los alumnos reinventen los términos científicos pero sí que hacemos del lenguaje el método de la ciencia escolar : la 'modelización' de algunos fenómenos incluye hablar de la actividad experimental mediante las palabras cotidianas, que introducen las palabras de la ciencia. Es necesario, para ello, plantear situaciones susceptibles de ser modelizadas y orientar la atención de los alumnos hacia los aspectos/ relaciones que son clave porque requieren la introducción de entidades que dan razón y explican lo que ha sido detectado como problema.

Las dos preguntas dan por supuesto que la enseñanza de las ciencias ha de ser contextualizada y experimental, pero mi hipótesis aquí es que los contextos que promuevo la emoción genuina no son los mismos que introducen el nuevo lenguaje científico, teórico. Y que ninguno de los dos, por separado, cumple nuestras expectativas de aprendizaje, que queremos que sea a la vez genuino y científico. Este es el problema. Porque nos damos cuenta que si nuestro punto de mira es el alumno y no las disciplinas científicas, si de verdad queremos que el aprendizaje de las ciencias contribuya a humanizar a nuestros alumnos (a educarlos) y, a la vez, que no se pierdan la riqueza cultural que entrañan las ciencias, debemos hacer que los dos tipos de contexto converjan o al menos coexistan de manera adecuada . Esto es difícil, aunque confiamos en que no sea imposible.

Los sistemas de conocimiento , los lenguaje… los contextos

¿No será que los lenguajes que se utilizan en ambos contextos son 'inconmensurables', en palabras de Kuhn? Según él, el lenguaje de las ciencias cambia de significado cuando se produce un cambio de paradigma, es decir, un cambio en 'la manera de mirar' , en las categorías que se toman en cuenta en la experimentación y esto dificulta (o puede llegar a impedir) la comunicación entre científicos de uno y otro paradigma.

También las ciencias cognitivas nos hablan de dos sistemas de conocimiento diferentes, en los seres humanos: el sistema creencial o de 'sentido común' y el sistema de conocimiento científico. Como que el problema que estamos analizando aquí se plantea en la iniciación científica de nuestros alumnos, podemos partir de la hipótesis de que ellos se sienten cómodos en su sistema de sentido común (que les permite interpretar el mundo en que viven) y que los profesores les hablamos de este mismo mundo desde un sistema de conocimiento científico que desconocen. Probablemente, cada uno de ellos se asienta en experiencias diferentes. La actividad 'emocionante' y sus lenguajes se situarían en el sistema creencial y el lenguaje científico y la actividad científica, en el otro.

Anticipo aquí la solución que perseguimos: como que el lenguaje humano es uno solo y con él las personas transitan de un Sistema al otro, ésta es la competencia que nuestros alumnos deben conseguir. Exploremos pues la relación entre 'contexto' y lenguaje en ambos sistemas de conocimiento

a. En el sistema creencial

Establecemos vínculos con las cosas cuando aprendemos a nombrarlas. Y aprendemos los nombres en el seno de una cultura, que junto con las palabras y las cosas que nos ofrece nos proporciona elementos de juicio para saber lo que se considera valioso y lo que no lo es. Es decir, nos da un sistema de valores que nos permite tomar decisiones, comunicarnos vivencias que sabemos compartidas o, al menos, comprendidas por todos. El lenguaje 'social', cotidiano, se genera en un sistema de creencias que llamamos 'sentido común'. Según Gutiérrez (2012) su ontología y su epistemología es la propia de la tradición cultural en la cual se vive. Es un conocimiento privado, consensuado de manera implícita, abierto al ritmo de la vida de cada cual.

b. En el sistema científico

El sistema de conocimiento que corresponde a los saberes científicos se genera en el seno de una comunidad, pero es diferente del conocimiento 'de sentido común': es público, explícito, pretende ser cerrado y se consensua en el seno de una comunidad restringida a los que piensan de una determinada manera, según determinadas reglas de intervención en los fenómenos, que permiten conocerlos. Su ontología y su epistemología dependen de la tradición científica que acepta unas determinadas reglas y no otras.

La clase de 'ciencias escolares obligatorias' ha de introducir a nuestros alumnos a unas ciencias que son como son (y no pretendemos cambiarlas en clase al tenor de los resultados obtenidos en la actividad escolar) ; no van a generar ellos una ciencia a partir de una dinámica social concreta, como nos cuenta la historia de las ciencias que se generó el 'contexto del saber sabio'. Sin duda, los científicos se emocionaron con ello. ¿Pero puede emocionar a los alumnos algo que aún no conocen y que ya no pueden cambiar?

Nos resistimos a responder con una negativa, no abandonamos el reto: creemos que la solución está en utilizar el lenguaje de manera diferente, propia de la ciencia escolar.

Si la clave está en el lenguaje ¿cómo se introducen las palabras de la ciencia? ¿Cómo hablar cuando se hace ciencia sin renegar del sentido común? No podemos hacerlo como cuando se 'da nombre a las cosas' en la vida cotidiana; en este caso el nombre, el valor asociado a los objetos y la manera de actuar van unidos. 'Las cosas de la ciencia' también van unidas a valores y maneras de actuar que son específicas, que la comunidad científica debe conocer para que el lenguaje tenga sentido. Si no es así, palabras como 'energía' o 'átomo' pueden definirse y ser utilizados para describir el mundo, pero no para actuar en él; y la descripción del mundo que se consiga con ellas va a ser desenfocada.

Lo que queremos para nuestros alumnos es que se sientan cómodos en ambos sistemas de conocimiento. El mundo en el que ellos viven cumple sus expectativas, se adapta a lo que hacen en él ellos y sus padres y amigos, a cómo ganarse la vida y cómo disfrutar del ocio…¿Por qué necesitan un sistema de conocimiento diferente? ¿Por qué no son suficientes sus creencias implícitas, el sentido común social? ¿Les aporta algo nuevo, saber una ciencia que les habla del mismo mundo que pisan, del mundo del sentido común…pero con palabras diferentes? Estas preguntas deben ser respondidas pensando en 'todos los alumnos', no en las disciplinas que, por supuesto, nos parecen maravillosas a los profesores. En las respuestas que les demos está la clave de lo que va a ser la ciencia escolar, de los valores que le son propios y con los cuales la evaluaremos.

Las preguntas que hemos planteado tienen sentido en esta frontera entre los contextos de 'sentido común' y los contextos científicos, durante los primeros pasos que dan los alumnos en el mundo científico, que puede llegar a ser suyo…o no.

Para comprender mejor en qué consiste esta frontera y qué tiene que ver con los contextos, nos ocuparemos de otra, la que separó a la química teórica de la química artesana.

Consideraciones respecto a la emergencia del lenguaje científico: identificando la frontera, concretando ejemplos, perfilando soluciones

A.L. LAVOISIER (1743-1794) perteneció a un grupo de científicos franceses que, a finales del siglo XVIII, se propusieron reformar los nombres de las substancias químicas, eliminando los repetidos o ambiguos y estableciendo reglas de nomenclatura sistemáticas. Pero fue mucho más allá de este propósito inicial cuando afirmó que 'queriendo reformar el lenguaje, tuve que reformar toda la química'. Y la reforma que emprendió le valió el título de 'padre de la química moderna'.

En su 'Traité Elémentaire de Chimie' nos dice que 'la palabra se refiere a la idea que pinta el hecho'. En efecto, Lavoisier unió de manera estrecha las nuevas palabras que proponía a sus nuevas ideas sobre química y con ello inaugura el lenguaje teórico que es propio de las ciencias: extraordinario para los del grupo científico que comparte los objetivos y la práctica, incomprensible para los demás. Con ello, ciencia (sus reglas para operar) y lenguaje establecen una alianza que caracterizan la manera de hacer ciencia en la modernidad. El lenguaje razonado de la 'Encyclopédie', que todos podían comprender, ha quedado superado.

La más importante de sus ideas es que 'todas las substancias químicas tienen masa'. Así, las substancias simples pasan a ser los elementos de la química y el flogisto, uno de los materiales más importantes en química en aquel momento, deja de existir, porque su masa no puede medirse. Kuhn considera que el nuevo lenguaje no se puede traducir al anterior, que dice cosas diferentes y probablemente fue así para algunos científicos relevantes como Priestley, que nunca abandonó el flogisto ni se convirtió al oxígeno.

Desde Lavoisier, ingresar en el sistema de la química es adoptar una perspectiva cuantitativa que se convierte en una regla para la acción: las transformaciones químicas se producen conservando la masa total; las proporciones de masa en la interacción química de las substancias es fija. Y de estas proporciones fijas surge el átomo de la química y, más adelante, la simbología propia de la química, elaborada para el trabajo de quienes trabajan en química o se forman para ello, pero no para el gran público: fórmulas y ecuaciones químicas en las que los protagonistas son los símbolos que representan átomos.

Ahora bien, en la química para todos (que no han hecho de ella su profesión) este átomo ha pasado a ser un objeto que se representa en los libros de texto de Q como una bolita de colores diferentes según sea el elemento. Es una 'cosa' que 'se dice' como si fuera una pelota o un ladrillo. ¿Es esta una manera adecuada de hablar del átomo? Veremos rápidamente que no lo es, porque escamotea lo más importante del lenguaje de la química y conduce al olvido de su magnitud principal, la cantidad de substancia y su unidad, el mol. Pasar de 'pelotas' a 'átomos químicos' es cambiar de sistema de conocimiento de manera inadecuada: sabemos qué hacer con las pelotas en el sistema de sentido común, pero no sabemos qué hacer con los átomos en este mismo sistema, ni con las pelotas en el sistema científico. Los químicos sí que saben que los átomos químicos son para hacer otras cosas muy diferentes a las que se pueden hacer con las pelotas[2].

¿Qué contexto es adecuado para empezar a hablar de los átomos en química? Si es de 'sentido común' (el átomo es una pelotita) nos conduce por un camino que pronto embarranca; si es para introducir la 'química', no sabemos aún qué es lo que se espera de él. Parece prudente no precipitarnos a hablar de átomos químicos[3].

Consideraciones acerca de cómo se traduce el lenguaje científico a cotidiano y el lenguaje cotidiano a científico

Lo que es maravilloso del lenguaje (y por esto nuestro grupo de investigación se dedica a su estudio) es su capacidad de crear nuevos mundos, de abrir horizontes, de comunicar vivencias. Esto vale para los profesores y aprendices de ciencia, no sólo para los poetas y para los filósofos. De ahí la dificultad de referirnos al lenguaje cotidiano como algo que debe ser abandonado para dar lugar al lenguaje científico. No debería ser así, no queremos que sea así; no podemos dejar de ser 'cotidianos' por el hecho de ser 'científicos' ; y cuando me refiero a 'cotidiano' estoy pensando en el lenguaje que cada persona utiliza para decir lo que quiere decir. Para simplificar , creo que nuestro objetivo en las clases de ciencias **es enriquecer este lenguaje para decir, con él, las entidades de las ciencias y para llegar a entender sus símbolos**. La cuestión es cómo hacerlo.

Podemos insertar los átomos (o las fuerzas, o la energía, o el ecosistema) en la vida cotidiana como si fueran 'cosas que están ahí' ; los signos que los representan (iconos, indicios, símbolos) se toman entonces como 'entidades reales' y se manejan como tales. La emoción se desplaza a situaciones que hay que controlar, a decisiones a tomar…pero no al gozo de comprender, de crear vínculos entre fenómenos, de utilizar la matemática para ordenar el mundo. Por esto no nos interesa convertir las entidades científicas en 'cosas' (los átomos de la química en pelotitas), porque perdemos la emoción genuina de comprender. Podemos perder la esencia de los objetos científicos que manejamos. Dice Marina (2005), citando a Machado:

[2] Lo que no hacen las pelotas es interactuar entre ellas en proporciones de masa fijas y cambiar como consecuencia. El átomo es algo así como la unidad (elmol) de 'la masa de interacción' (la cantidad de substancia)

[3] Lo mismo podemos decir de muchas otras entidades científicas

El ojo que ves no es
Ojo porque tú lo veas:
Es ojo porque te ve

¿Por qué el átomo es átomo, la fuerza es fuerza? Esta es la pregunta que debería guiarnos para acertar a diseñar contextos propios de la ciencia escolar, que (si hemos aprendido la lección de Lavoisier y de Dalton, el inventor de los átomos químicos) requieren pensamiento matemático, el básico, el que deben adquirir los alumnos de ESO. Además, han de ser contextos en los cuales desarrollar una actividad emocionante. ¿Es posible?

Debería serlo. Al fin y al cabo, los términos científicos son el resultado de un 'juego de lenguaje' entre otros de los muchos que podemos jugar las personas. Citamos a Wittgenstein cuando habla de la multiplicidad de los juegos de lenguaje: ordenar y obedecer; informar de un acontecimiento, hacer conjeturas sobre un acontecimiento, establecer y probar una hipótesis, exponer los resultados de un experimento, inventar una historia, hacer teatro, hacer un chiste y explicarlo…Desde esta perspectiva, la frontera entre 'sistemas de conocimiento' se desdibuja, el peligro de inconmensurabilidad de los lenguajes desaparece, pero resulta obligado jugar el juego adecuado para disponer del lenguaje justo.

Y aquí tenemos, de nuevo, el problema del contexto. Si el contexto es sólo el de los conceptos científicos, del cual surgen los términos científicos, ¿cómo pueden comunicarse vivencias que no han sido vividas? Si el contexto es sólo cotidiano ¿cómo pueden plantearse preguntas científicas que lo hagan problemático?

Parece que la solución es generar contextos cotidiano científicos, que sean sólo propios de la ciencia escolar . Porque la tarea actual de los profesores de ciencias de la ESO es nueva en la historia de la educación: nunca había sido propuesto seriamente que todas las personas sepan ciencias. Lo que vamos viendo es que las ciencias que han de saber no es un amasijo de disciplinas científicas: es algo inédito, que requiere una actividad genuina en la cual se experimente y se genere lenguaje y que enriquezca el panorama de los alumnos con entidades nuevas que le proporcionan nuevos recursos para razonar.

Si esto es así, será imprescindible cambiar los criterios de evaluación de los alumnos. ¿Qué es lo que es imprescindible que sepa hacer, hablar y pensar un científico escolar? No va a ser que conozca las que hasta ahora han sido consideradas ' palabras justas de las ciencias', las que 'eran la ciencia': saber las palabras era saber ciencias, como pensaba Lavoisier. Pero tampoco va a ser una ciencia sin sus propias palabras…

¿Seremos capaces de identificar qué es lo irrenunciable de un concepto científico, aquello que abre la mente no para dejar lo cotidiano sino para insertar en la vida de cada cual nuevos fenómenos, nuevos mundos que amplían las capacidades humanas de emitir juicios razonables?

Intento de conclusión

La actividad científica escolar debe llevarse a cabo en un contexto significativo tanto para los alumnos como para la ciencia y por ello debe ajustarse a dos premisas: ha de 'enganchar' y ha de ser una experiencia de 'conocer'. Sabemos que es difícil: la emoción propia del conocimiento científico (la matematización del mundo, la abstracción que esto supone y los símbolos que de ella se derivan) no es la propia del conocimiento cotidiano, ni a la inversa (una buena barbacoa no va a generar conocimiento fisicoquímico) aunque tanto la barbacoa como la física sean actividades profundamente humanas.

Volvamos al ejemplo del átomo. Comprender la masa atómica como masa de interacción permite operar en química pero es muy probable que esto no interesa para nada al alumnado…que sí se interesa por obtener preciosos cristales en una interacción química que quizás no entiende. Los símbolos (fórmulas) propias del lenguaje químico van a ser utilizados de manera diferente en ambos casos. En el primero, el símbolo va a denotar una masa de interacción, en el segundo el símbolo será un número a utilizar para hacer cálculos, pero no formará parte intrínseca de la actividad de provocar cambios y obtener cristales. Si ahora colocamos el átomo fuera del laboratorio escolar, podemos rememorar las aventuras intelectuales de los pioneros de la estructura atómica que ataron cabos y dieron el significado químico adecuado a las partículas eléctricas que iban siendo detectadas y a los cambios de energía que se producen cuando esta estructura cambia. O se podría generar un debate sobre la carrera por obtener armamento nuclear, con lo cual la emoción suscitada es muy diferente.

Sin embargo, no nos resignamos a renunciar a la convergencia de contextos que ha de hacer posible una auténtica ciencia escolar.

Volviendo a la aportación de Gutiérrez (2012) , la ciencia cognitiva no sólo nos habla de las diferencias entre el sistema de conocimiento creencial- de sentido común y científico, sino también de sus semejanzas. Porque en ambos se manejan las mismas categorías y casi las mismas creencias aunque organizadas de manera diferente y variable a lo largo de los tiempos. Son la materia (permanente o cambiante, destructible o no), el espacio (absoluto, relativo, lugares naturales...), el tiempo (lineal y cíclico), las relaciones (causales, funcionales, estructurales..) la vida (creada, espontánea, evolutiva..) las cualidades (cantidades, formas, estados..), los juicios de valor (lo bueno, lo bello, ser, poder ser...), la conciencia (relación mente-cerebro-espíritu, alma, cuestiones éticas, autoconocimiento), la libertad (capacidad de decidir, destino, fatalidad, providencia)...Creo que por ahí podemos encontrar el camino para inventar contextos que no sean puramente 'cotidianos' ni puramente 'científicos' ...que ayuden a pensar en estas categorías 'naturales' que permiten pensar el mundo diseñando para ello contextos específicos aunque resulten algo artificiales; debemos reconocer que la vida en la escuela también lo es.

Estos contextos especialmente diseñados para aprender a vivir una 'ciencia para todos' han de fidelizar a los alumnos como científicos escolares, han de evitar que se hablen lenguajes inconmensurables, han de facilitar el tránsito en dos sentidos: enriquecer lo cotidiano y dar sentido práctico, en sus propias vidas, a lo científico.

Mientras no seamos capaces de gestar este 'contexto científico escolar' deberemos movernos en los contextos que correspondan a los diferentes 'textos' que proporcionemos de manera significativa a nuestros alumnos. Pero no seamos ingenuos: difícilmente vamos a conseguir que todos los alumnos adquieran conocimiento científico a partir de algo cotidiano o conocimiento cotidiano a partir de algo científico: aunque sea doctor honoris causa, Ferran Adrià es un cocinero y Claudi Mans, su mentor, es un científico.

La conclusión de estas consideraciones es que si ambos 'títulos' son igualmente importantes. (y lo son) los profesores deberemos aprender a valorar la totalidad de conocimientos que se derivan de una enseñanza de las ciencias que prioriza la actividad científica para adquirir competencias. No sabemos aún, creo, cuáles son las esencias científicas a las que no podemos renunciar y las fortalezas cotidianas que se adquieren y que nos pueden pasar desapercibidas, pero debemos pensar seriamente en ellas.

La cuestión es llegar a comunicarse si no se juega el mismo juego, acertar en el tránsito de una actividad a la otra, compartir vivencias específicas …gracias al lenguaje. . Cuantos más juegos aprendamos a jugar, más fácil nos resultará este tránsito que es propio de las personas cultas. Esta capacidad de transitar entre actividades y sus lenguajes es, sin excluir las ciencias, es la que queremos proporcionar a nuestros alumnos.

Para ello la mente de los alumnos debe ampliarse en todas las ciencias: la literatura, el cine, la historia... Va a ser necesario manejar la diversidad de textos y contextos en los que deberán ejercitarse a lo largo de su vida adulta para sostener el 'vuelo de la inteligencia humana' (Marina, 2005), que ayuda a vivir de manera humana. Lo que deberán aprender a rechazar es a tener un texto sin contexto o a aferrarse a los signos (fósiles ya) de un texto que tuvo contexto pero lo perdió y se transformó en pretexto (¿para suspender? ¿para dogmatizar?) Porque los contextos son efímeros y necesitan signos que los consoliden, siempre y cuando no se transformen ellos mismos en una 'cosa' que escamotea la idea principal.

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Text 4

La dimensió psicològica de Context i les seves implicacions en l'Ensenyament i Aprenentatge

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L'ús del concepte *context* s'ha incrementat de manera significativa en els darrers anys en un nombre variat de disciplines, però de manera especial en aquelles disciplines relacionades amb l'educació. Malgrat aquest increment,sembla que cada autor l'utilitza atorgant-li matisos diferents,probablement degut al fet que es parteix de la base que tothom entén el seu significat. Paradoxalment, quan s'utilitza el concepte, la pròpia definició depèn massa del context en el que s'utilitza sense una definició prèvia consensuada i objectivada.

Per exemple, quan parlem del context de l'individu que s'educa, en referirem al context escolar, al context familiar, etc. però també ens referíem al context cultural o al context sociohistòric al qual pertanyen aquests contextos. Inclús podrem matissar detalls educatius del context aula, podrem parlar d'un context de treball cooperatiu a l'aula, d´´un context de resolució de problemes, context d'avaluació, etc. Quin és doncs el criteri subjacent a aquestes definicions? És un context el marc per un individu? Correspon al conjunt d'elements que tenen influència aquest individu? És possible definir context "a priori" o només es pot definir a posteriori, un cop se n'han vist les conseqüències? És quelcom estàtic o dinàmic? Quan s'estudia una persona realitzant una tasca, el context és la persona, la tasca o el producte de la interacció entre els dos? On i quan comença i acaba el context? És físic (característiques espacials, materials i equipaments de l'aula, etc. o és mental (representacions, expectatives, afectes, emocions, etc. (Cole, 2003; Edwards & Mercer, 1988)?

Hi ha múltiples conceptes en diverses branques de la Psicologia que es consideren pròxims a context. Per exemple, *situació o camp* en la teoria dels estils cognitius, *medi (millieu)* en la psicologia animal*, background* en la teoria de la Gestalt, *distract*or en teories sobre la percepció. Quan parlem de cognició humana, un criteri subjacent a aquests conceptes és si presenten una naturalesa interna o externa. És a dir, context és quelcom extern en relació al individu, com un habitat; o bé, el context pertany a un individu i és una part integral de la representació que aquest individu es fa de la situació en la que participa. El primer és més o menys equivalent a l'expressió "entorn", i es refereix a les circumstàncies, separades de l'individu, amb les quals es diu que aquest interactua i que el poden influir de diverses maneres (i.e. context familiar, el context aula, etc.) i fer afirmacions sobre com un o altre influeix en el seu desenvolupament. Segons el segon ús del concepte, aquest es definiria com el tot connectat que integra les seves parts per "teixir junts" (del Llatí: contextere). En aquest sentit, és molt complicat separar individu de context. La separació implica aïllar un gran nombre de factors que es retroalimenten al llarg del temps (Bazire & Brézillon, 2005). Aquestes dues aproximacions al concepte deriven cap a la distinció entre entorn i context. El psicòlegs del desenvolupament i l'educació contraposen clarament aquests dos conceptes. D'una banda s'entén el desenvolupament com una activitat individual en la que l'entorn és simplement una influencia externa, un hàbitat amb les condicions favorables per el desenvolupament de l'individu. O bé, de l'altra banda, es defensa que la ment de l'individu és teixeix conjuntament. Segons aquesta perspectiva, els humans ens troben immersos en una matriu social (context), de forma que la nostra conducta no pot ser ni separada de, ni compresa de manera independent d'aquesta matriu. En aquest sentit, tot i que Vygotsky no utilitza explícitament el terme context en les seves obres (Cole, 1993), cal citar l'èmfasi que V posa en la idea d'entrellaçament entre l'individu i context a partir de la interacció a través de l'activitat[4]. El context es va reconstruint a mida que es desenvolupa l'activitat.

En la línea de la teoria de Vygotsky, des d'una perspectiva marcadament ecològica, Bronfenbrenner (1989) estableix la diferència entre "ambient" i "context" per explicar el desenvolupament y l'educació dels individus. No tots els ambients que envolten l'individu que s'educa funcionarien com contextos educatius. Per Bronfenbrenner, el desenvolupament psicològic s'explica a partir del resultat d'un procés d'interacció al llarg del temps en el que l'ambient ecològic juga un paper fonamental. Per entendre el desenvolupament de l'individu cal analitzar la progressiva acomodació mútua entre aquest i les propietats canviants dels entorns més immediats, tenint en compte que aquests estan envoltats pels contextos més amplis en els que estan immersos, i que constituirien l'ambient ecològic de l' individu. Per Bronfenbrenner, l'ambient ecològic és un conjunt d'estructures en sèrie, de forma que cada una de les quals cabria dins de la següent com un conjunt de nines russes. En el nivell més intern troben l'entorn més immediat de la persona en procés de desenvolupament i en el que aquesta participa activament, i que Bronfenbrenner denomina microsistema. Poem prendre com exemple de microsistema l' aula de ciències. El microsistema, com la nina russa més interna, es troba en estreta interacció amb el mesosistema (nina següent) definit a partir de la interacció de entre dos o més microsistemes. Per exemple, la relació entre l'aula de ciències i l'aula de matemàtiques. Bronfenbrenner no es queda en aquest nivell i

[4]El concepte *d'activitat,* basat en el terme hegelià *Unitat dialèctica,* es defineix actualment des de la Psicologia Cultural com la relació transaccional inseparable, contínua i mútuament transformadora entre l'organisme i l'entorn [Clara, M.(2013). The concept of situation and the microgenesis of the conscious purpose in cultural psychology. *Human Development, 56,* 113-127.

contempla l'efecte d'altres ambients en el desenvolupament, que no inclourien la persona en desenvolupament com participant actiu, però en els que s'hi produeixen fets que afecten, o es veuen afectats pel que té lloc en l'entorn. Per exemple, la situació financera del país afectarà els recursos escolars (biblioteca, laboratori, mestres de reforç, visites al Museu de la Ciència, etc.), l'efecte de la qual acabarà afectant l'individu que s'educa. Finalment, Bronfenbrenner també contempla l'efecte de l'organització de la societat en els nivells anteriors, la política educativa (i.e. LOMCE), la teoria i pràctica educativa dominant (treball cooperatiu, aprenentatge basat en problemes, etc.), o inclús filosofia de la ciència imperant que determinarà què ensenyar sobre el que és la ciència, afectant finalment el desenvolupament dels processos educatius al nivell de microsistema, passant pels nivells entremitjos. Finalment, el model també contempla l'efecte del temps, que defineix com cronosistema. Per a l'autor, per comprendre els processos de canvi conductual en l'individu (aprenentatge, desenvolupament, etc.) és fonamental analitzar els efectes de tots el nivells ecològics que l'envolten (microsistema, mesosistema, exosistema y marcosistema, i transversalment als anteriors, el cronosistema).

Ara bé, segons Bronfenbrenner, un individu pot estar envoltat per diversos microsistemes o entorns més propers que no actuïn com context de desenvolupament i educació. La qüestió essencial és justament la que fa referència a la diferència esmentada més amunt entre "entorn", i "context". Quan i per què es pot considerar que l'entorn més proper a l'individu en el que té lloc una pràctica educativa (microsistema) es converteix en una context potencial de desenvolupament i aprenentatge? (Bronfenbrenner, 1987). La idea clau per poder establir que un entorn és un context és la presència d' una relació dinàmica entre l'individu i l'entorn. L'autor estableix que aquesta relació dinàmica depèn dues condicions complementàries:

(1) L'individu ha de poder observar i incorporar-se a patrons d'activitat progressivament més complexa, sota el guiatge i amb el suport educatiu de persones més expertes (creant un context de desenvolupament primari).
(2) S'han d'oferir a l'individu oportunitats, recursos, per a que s'impliqui en les activitats que ha après en els contextos de desenvolupament primari, però retirant el guiatge per part de l'expert (creant un context de desenvolupament secundari).

Només quan es compleixen aquestes condicions, el microsistema funciona com a context de desenvolupament i educació. Són condicions que, d'altra banda, mostren la idea subjacent vygotskiana de la necessitat d'educar actuant en la zona de desenvolupament proper, així com la idea originada en l'anterior de la metàfora de *la bastida* de Bruner (1992) o la idea similar de Rogoff (1993) de *participació guiada*. Des de la psicologia de l'educació, Solé (2003) estableix que els contextos de desenvolupament no s'han d'entendre com entorns rígids, sinó que es caracteritzen per la seva plasticitat, pel fet que poden posar els mitjans per "estirar "i afavorir l'actuació autònoma. En aquesta perspectiva, el concepte de participació guiada, proposat per Rogoff (1993), adquireix tot el sentit per explicar l'actuació compartida, que pot prendre formes diferents, però que s'orienta al desenvolupament del nen en el sentit marcat per la cultura. ''La participació guiada es presenta com un procés en el qual els papers interpretats pel nen i la persona que està al seu càrrec estan entrellaçats, de manera que les interaccions rutinàries entre ambdues i la forma en què habitualment s'organitza l'activitat proporcionen al nen oportunitats d'aprenentatge tant implícites com explícites." (Rogoff, 1993, p. 97).

Vygotsky (1931/1978) estableix que el procés d'aprenentatge no és espontani sinó que és el fruit d'un procés intervingut socialment en el qual juga un paper de primer ordre l'ajuda d'elements o instruments de mediació, entre els quals el llenguatge s'erigeix com l'instrument mediador per excel·lència. Veiem doncs com la definició de context de Bronfenbrenner descansa en les idees bàsiques de la perspectiva vygotskiana: (1) l' infant-en-activitat con unitat d'anàlisi; (2) la zona de desenvolupament pròxim; (3) l'origen sociocultural del funcionament mental; i (4) la mediació instrumental del desenvolupament intel·lectual a partir d'instruments que proporciona la cultura (1993).La regulació interpsicològica és essencial en la definició del concepte de context. És a dir, al paper regulador d'una segona ment, més experta, en l'individu que aprèn.

Ara bé, cal emfasitzar en la idea que aquesta regulació requereix l'anàlisi de l' individu-en-activitat (Vygotsky, 1931/1978). És en l'anàlisi de les relacions entre context i cognició que la perspectiva vygotskiana planteja la importància de l'activitat com part de la unitat d'anàlisi. L'èmfasi del plantejament anterior en la idea que el què s'aprèn és indissociable del com s'aprèn i, sobretot, de com s' utilitza el què s'aprèn dóna lloc a la perspectiva de la cognició situada. Per el corrent de la cognició situada (Brown, Collin i Diguid, 1989; Hutchins, 1994; Lave, 1988; Luria, 1979; Nardi & Miller, 1990; Newman, Griffin, & Cole, 1989; Salomon, 1993; Scribner, 1984; Vygotsky, 1978), l' activitat i les situacions són parts integrals de l'aprenentatge. Segons aquesta perspectiva, tot aprenentatge està imbuït en l'activitat utilitzant el context físic i social. Si ignorem aquest fet, els aprenents no sabran utilitzar el coneixement, i per tant, serà com si no haguéssim après res. Brown, Collins i Diguid (1989) defensen que el coneixement és com el llenguatge, que per ser comprés cal que estigui contextualitzat. Els conceptes no són entitats abstractes, sinó situades i que es construeixen progressivament a través de l'activitat. L'aprenentatge és un procés continu que resulta d'actuar sobre les situacions. Només es coneixement conceptual, si s':

> Its (knowledge) constituent's parts index the world and so are inextricably a product of the activity and situations in which they are produced. A concept, for example will continually evolve with each new occasion of use, because new situations, negotiations, and activities inevitably recast it in a new, more densely textured form. So a concept like the meaning of a word, is always under

> construction. This would also appear to be true of apparently well-defined, abstract technical concepts. Even these are not wholly definable and defy categorical description part of their meaning is always inherited from the context of use (Brown, Collins, & Diguid, 1989, p.33).

El concepte de context des d'aquesta perspectiva és defineix com *Context d'Activitat*[5]. S'entén com una xarxa complexa de la que els aprenents obtenen suport. Les activitats d'aula s'han de dur a terme de manera integrada amb l'entorn, més enllà de la ment individual de cada aprenent. L'entorn ajuda a clarificar l'activitat i per tant, ajuda a solucionar el problema. Segons Brown, Collins i Diguid (1989), això seria el que els físics fan quan a traves de formules, visualitzen el problema, i poden fer inferències per solucionar-lo. Tota aquesta activitat només pot ser entesa a partir de la relació amb el context. Segons la perspectiva de la cognició situada, podem trobar a alumnes que utilitzen definicions, formules i algoritmes de manera aparentment competent però que no sabrien què fer quan el context de la tasca canviés. Per aquest motiu, des de la perspectiva de cognició situada (Lave, 1984) es defensa que cal ensenyar els conceptes des de la situació específica en la que s'hauran d'aplicar, ja que en cas contrari, els alumnes no els sabran transferir a situacions quotidianes més enllà de l'escola.

Des d'una posició contrària i crítica amb la instrucció basada en la cognició situada, Anderson, Reder i Simon (1996), analitzen críticament les idees subjacents a aquesta noció d'acció en el context: 1. L'acció ha d'estar immersa en la situació concreta en la que té lloc. 2. El coneixement no transfereix entre tasques abstractes (escolars) a tasques pràctiques (vida quotidiana); 3. La instrucció mitjançant l'abstracció és de poca utilitat educativa. Segons Anderson, et al. (1996), l'argument que cal ensenyar de manera situada perquè en cas contrari el coneixement no s'aplica a situacions quotidianes fa referència al problema clàssic de la psicologia cognitiva sobre la transferència de coneixements d'un context a un altre, i a la necessitat d'ensenyar des de la concreció, per poder realitzar el procés d'abstracció i generalització, un cop el concepte s'ha generalitat, es pot produir la transferència a altres contextos. S'ha d'aconseguir que el disseny de tasques per ensenyar conceptes abstractes es faci de forma situada, és a dir fent que aquestes siguin funcionals i aplicables fora de l'aula. Ara bé, tal com apunten algunes posicions contràries a l'aplicació radical de la perspectiva situada a l'aula, quan s'apliquen els principis a la instrucció a l'aula, ens podem trobar amb el problema que deixem de tractar el conceptes de manera explícita per afavorir la seva abstracció, amb la posterior generalització per finalment fer possible la transferència de coneixement entre contextos i situacions:

> Often real-world problems involve a great deal of busy work and offer little opportunity to learn the target competences. For instance, we have observed in high school mathematics

[5]Per una anàlisi crítica comparant el concepte de context des de la perspectiva de la cognició situada, la teoría de l'activitat i la cognició distribuida veure l'anàlisi de Nardi (1996).

> classrooms--where we have introduced longer, more real-world-like problems to situate algebra, that much of student time is spent on tasks such as tabling and graphing, which rapidly become clerical in nature. On the other hand, relatively little time is spent relating algebraic expressions to the real-world situations they denote. To summarize: abstract instruction combined with concrete examples can be a powerful method. This method is especially important when learning must be applied to a wide variety of (frequently unpredictable) future tasks (Anderson, Reder i Simon, 1996, p. 9).

El tema de transferència de coneixement entre contextos ha estat des dels inicis, i encara ho és actualment, un tema polèmic en la psicologia cognitiva. El seu tractament ha de partir de la definició rigorosa de context, d'activitat, i d' interacció.

D'una manera general, y per concloure, la perspectiva sociocultural defensa que no és possible entendre com aprenem si prenem com unitat d'anàlisi la ment de l'individu. Cal considerar les dimensions psicològiques de context més enllà de l'individu. En primer lloc, la regulació interpsicològica (entre dues ments),implícita en la definició de Bronfenbrenner,que té lloc en el durant el desenvolupament de l'activitat. En segon lloc, l'activitat, la qual està mediada per instruments. En tercer lloc, doncs, els instruments que regulen l'activitat. El llenguatge és l'instrument per excel·lència en tant que eina semiòtica per construir coneixement (Vygotsky, 1939/1978), i finalment, la dimensió més important, la relació entre totes les dimensions anteriors formant l'entramat, i amb ell, el context. Per aquest motiu es defensa que és essencial estudiar el context, però no com un objectiu addicional, o circumstancial, sinó que a l'estudiar l'entramat, la xarxa d'interaccions visualitzades en l'activitat. Analitzant l'activitat estudiarem la interacció entre l'aprenent, el què aquest aprèn, i l'agent educatiu. Els matisos vindran determinats per les tasques que proposem, les situacions en les que les proposem, les condicions que establim, i els instruments que utilitzem.

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Text 5

Contextualizing Practices Across Epistemic Levels in the Chemistry Laboratory

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ABSTRACT: The process of construction of meanings for the concepts of concentration and neutralization is explored in terms of *contextualizing practices* (Lemke, 1990, *Talking Science. Language, Learning and Values,* Norwood, NJ: Ablex) creation of meanings through connections established among actions and their context. This notion is expanded to include the connections established among concepts and their context of use, a solving problem task in a laboratory. The purpose is to document the process of meaning construction for these concepts and their transformation from mere terms into decisions and practical actions in a chemistry laboratory. We sought to combine this analysis with an epistemological focus, examining the relative epistemic status of the contextualizing practices. The conversations and actions of four grade 10 students and their teacher (second author) were recorded while solving an open task: to find the concentration of an HCl solution. The results show a progression in the process of contextualization, from an initial inability to use the concepts as part of the resources to complete the titration task, to the transformation of definitions into shared meaningful concepts that allow to take actions, combining theoretical resources with physical ones to solve the problem. A frame for categorizing contextualizing practices across epistemic levels is proposed and applied to the data.

CONTEXTUALIZING PRACTICES AND MEANING MAKING: BACKGROUND AND OBJECTIVES OF THE STUDY

The purpose of this paper is to examine the construction of knowledge in a classroom, in particular to document meaning-making practices in a laboratory. Meaning-making practices are receiving increasing attention in science education research (for example, Molander, 1997; Mortimer & Scott, 2003; Ö stman, 1998). In a book exploring the links between classroom talk, learning, and meaning making, Mortimer and Scott (2003) see meaning making and understanding as fundamentally dialogic processes, suggesting that "if the aim of teaching is for students to develop an understanding of some topic, then those students must engage in some form of dialogic activity" (op. cit., pp. 69–70). The four students participating in this study are engaged in jointly designing and carrying out an experimental procedure to find the concentration of an HCl solution, a dialogic activity consisting not only of performing physical tasks, but also of proposing ideas, arguing, and contradicting one another. We agree with Kelly and Duschl (2002) about the need of redressing the imbalance in science learning between the opportunities to use scientific instruments and the opportunities to use and develop discriminating scientific language, or more generally to engage in discourse practices. As Mortimer and Scott point out learning science involves learning its social language, and what is documented in the present study is an instance of it for the concept of neutralization: not just how students can recall it or

apply it in hypothetical settings, but how its meaning shifts as students use it—as chemists do—as a resource for solving the problem, how they situate this knowledge in its *context of use*.

The framework is drawn from Lemke (1990), assuming that meanings are *made* or constructed by people, rather than being something "built-in" inwords, diagrams, or actions. Lemke defines meaning-making or semiotic practices as the ways in which members of a community perform actions that are meaningful in the community. The question then is what makes an action a semiotic practice, or how an action becomes meaningful in a community:

> Every action is made meaningful by placing it in some larger context. In fact, we place every action or event in many contexts in order to make it meaningful. The meaning we make for an action or event consists of the relations we construct between it and its contexts. Making meaning is the process of connecting things to contexts. We make actions and events meaningful by *contextualizing* them. The most important of all semiotic practices are these *contextualizing practices*. (Lemke, 1990, p. 187, author's emphasis)

Meanings can change depending on the context to which a word or action are connected. Each person talks and acts in a meaningful way using the resources available in her or his community and according to patterns that make sense in this community, the meaning of a word being made both of the words in its definition, and of the way these are used in relation to each other and to the context (O¨ stman, 1998). Although Lemke refers mainly to the contextualization of actions (and words), here the notion is used to explore the contextualization of concepts, the process of constructing relations between the concepts of molarity and neutralization, and the context of solving a problem in a laboratory setting. Reference to the school laboratory as a context means not just a physical environment but, as Goodwin and Duranti (1992) point out in their discussion of context, a social one. The laboratory and the tasks set for students constitute a dynamic context, shaped, as these authors note, by the specific activities being performed, and changing depending on how these activities progress.

Lemke distinguishes among *paradigmatic* and *indexical* contexts. Paradigmatic contexts are other words or actions that might have taken the place of the ones that occurred, the contexts of "what might have been." Given that the processes studied are framed in the school science, the paradigmatic contexts are not infinite possibilities, but limited. It is our assumption that the implicit paradigmatic contexts were different for teacher and students. For the teacher, the actions or steps to be performed are those expected from an expert: first to restate the problem, second to recognize both the conceptual and procedural resources necessary to solve it, and third to deploy these combined resources for determining the HCl concentration, as summarized in Figure 1. On the other hand, for the students, the paradigmatic context evoked for a chemistry laboratory task would be first to follow step-by-step instructions and second to substitute one (and only one) unknown in an algorithm.

Indexical contexts are social contexts usually associated with an action in a particular community, so action and context index or point to one another. What matters in indexical contextualization (Lemke, 1990) is the pattern of actions, the systematic relations of actions to each other and to other sort of contexts: steps for titration may seem similar in a scientific laboratory, in a school laboratory, or in an office monitoring the situation of the water supply in a city, but their social meaning is different.Aspecial case of indexical contexts is thematic contexts: members of a social group identify themselves by how they talk about a subject, constructing or reconstructing in their speech the different thematic patterns that index their social group. The focus of this study is a particular type of *thematic context*: the school laboratory, the practical work, in particular a problem-solving context in a laboratory setting. The contextualization is explored through the connections established between the knowledge and the practical task. It has to be noted that, although we draw from Lemke the construct of *contextualization*, we do not necessarily share his objections to the term *concept*.

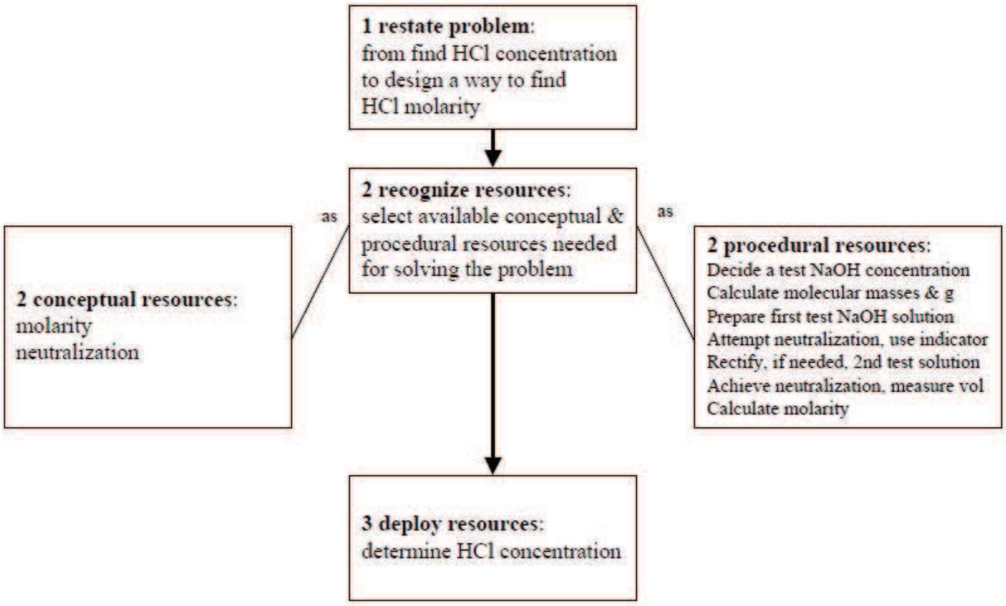

Figure 1. Teacher (implicit) paradigmatic context for the task.

For Toulmin (1972) *concept* integrates the aggregates, systems, or conceptual populations collectively used by the community of concept users. Two relevant members of this community in science education, Novak and Gowin (1984), define it as a regularity in events or objects, designated by some label.

The knowledge, the concepts of concentration and neutralization, are studied in their context of use in a complex task. The students have to use them in order to solve an authentic problem, and for this they need not just to recall the definitions, but to employ the concepts as part of the resources, of the thematic context in which decisions and practical actions become meaningful, to construct for these concepts a meaning connected to the *practice* of chemistry. These meaning constructions and transformations by the students across epistemic levels are the focus of the study. In it we are guided by Toulmin (1972) who in his work about the collective use of concepts pointed out that we only understand the scientific meaning ofwords when we learn to apply them, including the practical procedures associated with this application.

We sought to combine the analysis of this connection to the context with an epistemological focus, examining the relative epistemic status of the contextualizing practices. Duschl (1990) proposes to pay attention to the epistemological dimensions in science teaching and learning, to the generation and evaluation of knowledge. For Kelly and Duschl (2002) epistemic practices are central to knowledge production, communication, and appropriation, and they suggest three issues as potentially fruitful for epistemological studies in science education: representing data, persuading peers, and observing from a particular point of view. Chinn and Malhotra (2002) constructed a frame for analyzing the differences in the epistemology promoted in authentic inquiry, carried by scientists, and in school inquiry, for instance the theory–data coordination and the response to anomalous data. The epistemic status of students' claims, from lower to higher induction level, has been examined by Kelly and Chen (1999).With a focus on evidence and evaluation, Kelly and Duschl (2002) propose a continuum model to examine the transformations of data to evidence, evidence into patterns and models, and patterns and models into explanations. Here the students'practices have been distributed according to its epistemic status in categories, elaborated in interaction with the data, from practices interpreted as translation from observational to theoretical language, to the use of concepts to interpret results or to frame anomalous data.

In the study we combine the social semiotics perspective from Lemke (1990) and the situated cognition perspective, viewing conceptual knowledge as a set of tools which, according to Brown, Collins, and Duguid, (1989), need to be used in order to be fully understood. For Collins, Brown, and Newman (1989) learning takes place through contextually integrated processes, and apprenticeship embeds knowledge and skills learning in its social and functional context. We agree with Kelly and Crawford (1997) about the need of drawing from both perspectives, sociocultural and cognitive, for analyzing the processes of learning sciences in the classroom.

When studying the meaning construction for these concepts, we have to be aware of the learning difficulties. Nakhleh and Krajcik (1994) explore the comprehension of 11thgrade students during the performance of acid–base titrations, concluding that they have difficulties interpreting the neutralization in terms of the microscopic system. In their study, the students were not asked to design the procedures andNaOHsolution 0.1Mwas provided, while in ours they have to design the procedures and decide a molarity value for NaOH. Tan, Goh, Chia, and Treagust (2003) also found comprehension difficulties in the students' understanding of acids and bases, and Erduran (2003) points to the mismatch between pupil and teacher knowledge in this topic, as the pupils' knowledge seems based on their empirical laboratory experience, while the teacher interprets their discussions in terms of textbook information. About the improvement of the comprehension, West and Sterling (2001) reported that the students' analysis of the changes in the pH of rainwater as it is filtered by soil allowed an improvement of their understanding of the related knowledge. In a study about open-ended problem solving in chemistry by 14–17 year-old students, Reid and Yang (2002) found that the students had difficulties both in linking what they call different "islands" of knowledge and in planning, something required by open problems and tasks, as the one used in the present study. Reid and Yang discuss open paper and pencil problems, while our study explores students' performances in a practical task in the laboratory.

The purpose of the study is to document the *process of meaning construction* by the students for the knowledge involved, the concepts of concentration and neutralization, and their *transformation* from definitions into decisions and practical actions in the chemistry laboratory. In particular, we address these objectives:

- to document the meanings constructed for the concepts of concentration and neutralization in this local context of solving a practical problem;
- to document the changes in meaning of these concepts through its connection to the laboratory context or, in other words, its transformation into decisions and practical actions undertaken by the students;
- to examine the relative epistemic status of these contextualizing practices.

METHODS, PARTICIPANTS, AND EDUCATIONAL CONTEXT

Participants, Context, Task

The participants are a group of four grade 10 students (15–16 years), one girl and three boys, and their teacher (second author) in a public High School in Lugo, Spain. All the students enrolled in the physics and chemistry course, taught 3 h a week, had to complete five laboratory tasks, designed as problems, as part of their regular coursework. As for the teacher the main purpose was the participation in the practices of the scientific community, the emphasis was on the resolution process, not in arriving at a precise numerical result. The students, working in groups, had to complete the task, to write an individual report, and to construct a "heuristic tool," a reflection about the question posed, the knowledge and resources used in the process and the actions performed. The tasks took 13 sessions, and the third, the one analyzed here, took four consecutive 1-h sessions, two complete and part of the other two, as summarized in Table 1. The first 218 turns in session 4 were devoted to finishing the report of a previous task, and the last turns in session 7 to constructing the heuristic tool.

For the purposes of enculturating students in the social language of science, practicalwork could offer different learning opportunities from the ones provided in theoretical lessons. At least it could be so if the science curriculum were coherent with the construction of scientific knowledge, as advocated by Hodson (1988). But the relations among theory and empirical evidence are problematic (Gil P´erez & Carrascosa Alis, 1994): empirical tests are seen as objective observations not framed in a theory, and practical work does not

TABLE 1
The Titration Task: Sessions and Turns Number

Monday, Dec. 14	Thursday, Dec. 17	Friday, Dec. 18	Monday, Dec. 21
Session 4 Turns 219–998	Session 5 Turns 1–1110	Session 6 Turns 1–605	Session 7 Turns 1–174

always fulfill its objectives. Hodson (1988, 1990) proposes to reconceptualize practical work, to design it in accordance with philosophy of science, attending to objectives as practicing science and learning its nature. In line with Hodson's recommendations, the task was designed as an authentic problem, with the features of being a *problem* for the students; *open*, here meaning different paths for finding the solution, as the students were not given steps or instructions to follow and had to design the procedure themselves; framed in *a real context*, how to find use or dispose of a potentially dangerous substance, and involving a *process of resolution* which required the students to act as a knowledge-producing community, using their resources (cognitive and material) or developing them, discussing proposals, testing them, finding reasons for failures and reporting the results. It has been suggested that students should have the opportunity to work with open-ended problems but, as Reid and Yang (2002) show, doing so has positive outcomes and also faces difficulties. The present study pretends to add to the knowledge of the difficulties encountered when solving open tasks, exploring them in a laboratory setting.

In the laboratory sessions all the students worked in groups of four. The cooperation in small groups raises issues about social interactions for, as Kelly and Crawford (1997) point out, students could share tasks or activities and not share knowledge. To facilitate the unraveling of the social dimensions, the transcriptions are presented in separate columns, which allows the analysis in terms of dialogic (the participants paying attention to what others say) or not-dialogic interactions (Mortimer & Scott, 2003), in other words if the students are talking *in parallel* or if they are sharing meanings.

The first paragraph in the handout is reproduced below:

> Experiments were carried in a laboratory using acid and basic solutions, formed by acid and basic substances dissolved in water. After the experiments were completed, the people carrying them were gone and they forgot to label a big bottle with hydrochloric acid dissolved in water. We cannot dispose it directly through the sink, because it could cause pollution, and we want to keep and use it in the future. But before placing it in a shelf we need to know its concentration in molarity. Working in groups you have to find a way of knowing the concentration of this solution.

Although the steps were not given or suggested, the handout provides written hints, explaining the meaning of neutralization with the example of HCl and NaOH and listing the materials, including a jar of solid sodium hydroxide. The task was inspired on a SEPIA unit (Duschl & Gitomer, 1994; Erduran, 1999) requiring identification and neutralization of unknown substances, but the teacher modified it, asking to find the concentration and so increasing its difficulty.

Data Collection and Analysis

The data include the students' and teacher conversations and actions recorded in audio and video, the individual reports, and heuristic tools. For the purposes of this study, the main source is the audio transcriptions incorporating notes about the students' actions from the video recordings. The students talked in Spanish and their conversations have been translated, trying to preserve the register (formal, slang) as far as possible. In this topic, translation does not entail particular problems as happens for instance with *velocidad* a single Spanish term both for *speed* and *velocity*.

The study is framed in the qualitative methodologies, and the method is discourse analysis, using conversation analysis with the purpose of studying the processes of knowledge construction in its context. As Lemke (1998) points out, language is used as part of a complex cultural activity, verbal data make sense only in relation to this activity context, and the meaning of any text or discourse event depends on how we connect it to some other texts and events. For Gee (1999), discourse analysis is the analysis of language as it is used to enact activities, perspectives, and identities. From these our focus is primarily on *activities*, viewing language, as Gee suggests, having primarily the functions of scaffolding both the performance of social activities and human affiliation within cultures, social groups, and institutions. In this laboratory sessions language is scaffolding the performance of activities related to a practical task, and the students' affiliation to a culture—that could be described as shifting between the school culture and the scientific culture, as discussed later—and to the social group of students in a particular institution, secondary school. But the students' interactions cannot be exclusively viewed from the perspective of the scientific meanings and the academic tasks. Social dimensions also play a part in them, and here the interactions are analyzed in terms of the communicative approach (Mortimer & Scott, 2003), dialogic versus not dialogic and the differences in contributions. The method is holistic, trying to capture interconnected dimensions, and contextual because the observed actions and behaviors are not dissociated from its context, but interpreted within it (Egan-Robertson&Willett, 1998). Discourse analysis has the purpose of understanding the meanings constructed by the participants, their culture, rather than comparing their performances against an ideal one. These meanings are situated, being the notion of situated meaning a tool of inquiry (Gee, 1999), a way of looking at how speakers give language specific meaning within specific situation.

One problem when analyzing verbal data is segmentation, and although boundaries across texts are not definite and units of meaning can have fuzzy boundaries (Lemke, 1998), we have found useful to divide the sessions in episodes. Two concurrent criteria have been used for considering a set of turns an episode: activities performed and/or topic or theme discussed. So a new episode is initiated when the students begin a new activity and/or when they shift from one topic (or subtopic) to another. In these criteria we have been guided by Gee (1999) building tasks, asking both about activity building (what activity is going on) and about semiotic building (what situated meaning is constructed), and extending Gee notion of stanza as a set of lines devoted to a single topic, event, image, perspective or theme, to larger units, the episodes within a session.

The tapes were transcribed and both authors read the broad transcriptions (Gee, 1999), identifying the main activities and themes and negotiating the resulting segmentation. The interpretations in terms of contextualization, of transformations of the concepts from decontextualized terms or definitions to decisions and actions were also negotiated, modified, and refined through the process. The contextualization process is discussed in chronological order for both concepts, and excerpts of the transcriptions (included in full as appendix to the doctoral dissertation, Reigosa, 2002) are reproduced to illustrate the analysis. All names are pseudonyms respecting the gender; actions and clarification, for example [reads handout], are inside square brackets, and = indicates overlap of speakers' utterances. Some turns are omitted to reduce the length, in most cases corresponding to repetitions or incomplete sentences, the omission is represented by [...].

In view of the third objective, the contextualization practices identified were examined with a focus in the coordination among data and theory and they were assigned labels as "data transformation," "translation from one language to another," "connection of a concept to a choice or action," "framing anomalous data," or "results interpretation." These labels were not established a priori, but emerged in interaction with the data, being partially based on Chinn and Malhotra (2002) frame. The resulting labels were grouped in three broad categories that sought to represent the relative epistemic status of the practices in three levels, the lower being closer to data and observation and the higher closer to theoretical constructs.

RESULTS: CONTEXTUALIZATION OF THE CONCEPT OF CONCENTRATION

To situate the process of connection of the concept of concentration to the task, the segmentation in episodes of sessions 4 and 5 is summarized in Tables 2 and 3.

Concentration as a Definition

At the beginning of session 4, in episode 2 there is a sequence of turns that we interpret as two parallel, not dialogic, discourses, one by Susana, who is attempting to restate the problem “we are supposed to find the concentration” and the other by the three boys trying to identify the base among the equipment and manipulating the litmus paper. These three students follow a pattern of manipulation of material indexed by the context of “laboratory” and supported by some implicit assumptions as (a) all the materials provided are useful for some step in solving the task and (b) manipulating the equipment according to the instructions in the handout the task will be successfully completed. These assumptions point at an implicit paradigmatic context different from the teachers’ one. Susana does not participate in the search for sodium hydroxide, and in the last turns challenges Sergio about why to use the litmus paper without a purpose, to which he acknowledges that he does not know. This is interpreted as Susana’s awareness of their inability to connect the *material resources* to the *relevant concepts*; they do not have an appropriate indexical context to place their actions. We could say that the conceptual resources are not available for them, so—even with the material resources available—they cannot construct relevant meanings for the task. This episode could illustrate how at the beginning the concept of concentration is not connected to the task context. In episode 3 Santiago asks the teacher about the concentration, and he provides a clarification, defining molarity as moles of solute divided by liter of solution. In this preliminary stage the concept of concentration is merely a definition.

Molarity as a “Formula”

In episode 4, Santiago makes an attempt to transform this definition (calling it “formula”) in actions for preparing a solution of NaOH, in other words, to connect it to the context of the task.

Session 4, episode 4

Susana	Sergio	Santiago	Simeón
		415 Look... Well. We have to find... Let me see this nice little formula he has there. I don’t know, molarity and its... Here! [reading in notebook]	
			416 Eh, eh
	417 Come on. Let me find out the moles		
		418 Hush, hush	
	419 Moles of solute...		
420 Right, by...			
	421 ... litres of solution		
422 Exactly			
		423 Good. We have to prepare a solution, find out =the moles=	
424 = Of course=			
		425 ... then divide it among the liters, right?	
426–439 [...]	[...]	[...]	[...]
440 First to grab sodium hydroxide			
		441 Mixing it with =the=...	442 =No=
443 No, no, putting it with the acid			
		444 With the acid eeeh Wherever is it, with zero five liter or whatever	

Continued

(Continued)

Susana	Sergio	Santiago	Simeón
445 Very well. Santiago			
		446 Then... finding the... with the formula if hach ce el and en a o hach	
			447 But how...
448 But: What are you going to find with this, if you don't know the proportions?			
		449 To find the moles	
450–454 [...]	[...]	[...]	[...]
455 I know the liters of solution, but not the grams. I have to weight it			
	456 But you have to do it		
457 You have to weight this crap [vessel] empty and then weight it with the grams and it will give you the weight			
		458 Good	
	459 We have to find =the grams=		
		460 =Yes of= course	
461 Ten			
		462 We have to calculate the grams	
463 No, we have to calculate the grams in order to find the moles of solute			

But the attempted transformation is mechanical: moles of solute divided by liter of solution is converted (423, 425) into "find the moles" and "divide it among the liters," using the definition as an algorithm with unknowns that should be substituted by figures, as if the volume were known, not something that they should *decide*. Santiago (446) appeals to the "formula" (the reaction between HCl and NaOH in the handout) as a tool, but without knowing how to organize these elements. This could be seen as an attempt to reduce a task designed as an open one to what they see as the paradigmatic school lab task, that in Chinn and Malhotra (2002) terms would be a simple experiment. Sime´on and Susana object Santiago's approach, he points out (432, omitted) that "he [the teacher] didn't say how much" (we interpret that he refers to the amount of NaOH), and she (448) questions the steps proposed by Santiago, because he does not know the proportions. Susana seems aware of their inability to use conceptual tools, that the proposed action cannot be thematically contextualized, and she ends proposing "calculating the grams in order to find the moles of solute," what we interpret as a reference to molecular mass. She also proposes (457) a procedure for weighting the NaOH, mobilizing practical knowledge from task two, incorporating it to the thematic context that they are building for the task.

The students are beginning to take little steps, recognizing their knowledge deficiencies and trying to decompose the objective of the task, finding the concentration, into finding the moles and asking about amount or proportions. This decomposition in partial subtasks could be considered as pertaining to the thematic pattern of the school laboratory context, although Sime´on refers to the amount (432) as if it were a

TABLE 2
Episodes, by Criteria of Activity and Theme, in Session 4 (All Activities in Session 4 are Mental or Paper and Pencil)

Episode (turns)	Activity (T: teacher, S: students)	Theme/Topic
1 (219–288) **Setting**	T distributes & lists equipment	Material resources: reactants, indicators...
2 (289–343) **Attempt to restate problem**	–S (Susana) restates problem –S manipulate equipment	–lack of connection concepts/ task –Where is the NaOH?
3 (349–414) **Concept as definition**	S/T define concentration/molarity	Relation concentration/ molarity
4 (415–473) **First attempt to contextualize concentration**	S attempt to give meaning to "molarity" transforming it in actions planned (weighing)	Molarity, moles, grams/use of formulae
5 (474–515) **Obstacle: S paradigmatic context**	S ask precise steps (attempt to transform open design into step-by-step task)	Amount of NaOH
6 (516–575) **Connect molarity to task context**	S transform *molarity* in determination of molecular mass	Molecular mass, mol
7 (576–635) **First attempt to decide values**	S (Sergio) proposes design decision: test value for NaOH	Is the concentration the same for the two solutions?
8 (636–675) **Scaffolding**: Neutralization as conceptual resource	T provides scaffolding (solicited help)	How to use the idea of neutralization for our objectives
9 (676–766) **Connect neutralization to task context**	S (Sergio, Susana) transform *neutralization* in decision about test value	Test value for NaOH solution (0.5 M, 20 g)
10 (767–877) Student scaffolding/ **Obstacle: Confusion molarity/moles**	–S use the calculator –S (Sergio, Susana) unintentional scaffolding for Santiago	Moles, molarity
11 (878–998) **Contextualization:** Neutralization to an amount of NaOH	S convert moles into NaOH grams	Relation moles, molarity, grams

TABLE 3
Episodes, by Criteria of Activity and Theme, in Session 5

Episode (turns)	Activity (T: teacher, S: students)	Theme/Topic
1 (1–100) **Setting**	S retrieve task	Molarity
2 (101–135) **Attempt to weigh**	S initiate procedures to weigh 0.01 g of NaOH	Weighing procedures
3 (136–198) **Overcome scales constraint**	S (Susana) solves constraint: Multiply by 10	Constraint: scales only weighs tenths of grams (not hundredths)
4 (199–331) **Prepare NaOH solution**	S measure H_2O volume, prepare NaOH solution	Solving procedures
5 (332–402) **Connect material resources to task**	S prepare equipment for neutralization	Equipment: litmus paper, burette, procedures (acid, not NaOH in burette)
6 (403–421) **Connect "neutral" to task context**	S identify "neutral" with green color in litmus paper	Neutralization: Use of litmus paper
7 (422–499) **recapitulate steps**	S recapitulate past actions for teacher	Amounts measured, actions
8 (500–526) **Teacher suggest new resource**	T suggest using phenolphthalein	Procedures: Use of phenolphthalein
9 (527–754) **Attempt to perform neutralization**	S drop with burette acid into NaOH solution	Procedures, fail to achieve color change
10 (755–784) **Revision of errors**	S reflect about the reasons of the failed neutralization	Measures of volume (water, not solution)
11 (785–897) **Teacher's help: Conceptual resource**	T frames question about fail in neutralization & concentration	Different concentrations; ways of solving it (use less volume of NaOH)
12 (898–926) **Neutralization**	S achieve neutralization	Procedures
13 (927–1091) **Interpret results**	S begin to interpret color change in terms of chemistry concepts	Volume used, correspondence in grams, moles, molarity
14 (1092–1110) **Washing equipment**	S wash glass equipment, range other equipment	Equipment

datum that the teacher should provide. At this point, they do not seem to be able to arrive at an operative definition of the independent and dependent variables, another relevant component of the thematic pattern, perhaps because they do not identify the concentration of NaOH as independent.

Molarity Connected to the Calculus of Molecular Mass

In episode 5 they ask the teacher about the amount (concentration) of NaOH and he answers that they must "think about it" by themselves. At this stage, it seems that they do not contemplate the possibility of deciding themselves about one to be used as a testing value, but they are attempting to connect this concept to the task, recognizing "concentration" as a resource for solving it. In episode 6 they calculate the molecular mass of NaOH and HCl. This could be a first stage in the contextualization of the concepts to the laboratory task; the definition of molarity is transformed into one step for solving the problem, the calculus of molecular mass, a resource needed for preparing the NaOH solution with a given concentration. An alternative explanation should also be considered: calculating the molecular mass is a preliminary step in many chemistry exercises.

Molarity Connected to the Choice of a Test Value

Once they have calculated the molecular mass, in episode 7 Sergio attempts to implement the practical actions: weighing a certain amount of NaOH.

One of the problems that they have to solve in order to progress in the task is their inability to select and use the concept of neutralization as one of the resources and, related to it, to decide the concentration of NaOH. These difficulties in relating both concepts, neutralization and molarity (relation that is part of the indexical context), are apparent in turn 587, where Santiago implies that the molarities for both reagents should be the same, perhaps because of the wording of the definition of neutralization used in school, although Susana (588) contemplates the possibility of different concentrations. Santiago's statement (598) "there are two unknowns" reveals the paradigmatic context to which he is comparing the task: an algorithm allowing for substitution of signs by figures, with only one unknown. He considers that, not knowing either of the concentrations, there is nothing to do "mathematically speaking," what indexes an implicit paradigmatic context of quantitative problems to be solved by substitution of unknowns, not a practical task with a certain degree of openness. The acknowledgement of the openness of the task belongs to another dimension of the indexical context: the participants' epistemological commitments.

Session 4, episode 7

Susana	Sergio	Santiago
586 How do you know the grams that we have to put? ...		
		587 First, I don't know, they should be the same
588 No! They shouldn't, because it may be a different concentration		589 Good
590 Do you understand?		
591–596 [...]	[...]	[...]
		597 We don't know the proportion [pause]
		598 And in order to know it... Shit, there are two unknowns
599 I don't know		
	600 Look. We take...	
		601 There is nothing we can do [pause]
		602 Mathematically speaking. Shit

Continued

Susana	Sergio	Santiago
603–619[...]	[...]	[...]
	620 First we have to find the moles... of solute that are there	
621 Very good		
	622 Mmmm...	
623 =Of course=	624 =And you= find it...	
		625 The solute is in ...eh
626 But for finding the moles we have to find the grams		
	627 Sure. We put here whatever =we want=	
628 =And to find= the grams... damn it		
	629 We put whatever we want here	
630 Whatever we like?		
	631 I think so. It doesn't say how much we should put in	

Sergio (627, 629) proposes, "to put whatever we want," justifying it in the lack of specified amount in the handout, not in an application of the neutralization concept. Although this proposal about a testing value could lead to a solution, its development is interrupted because Susana and Sime´on (who has little participation in the discussion) ask the teacher for help. The choice of a test value for the NaOH is an important step, and although they are not able to complete it without the teacher's help, we consider it the first *transformation* of the conceptual tool (molarity) into decisions and actions. Other steps in the progression are discussed, with the contextualization of the concept of neutralization, in the next section.

Molarity as a Conceptual Resource to Frame Anomalous Data

In session 5 (see episodes in Table 3), they begin to drop the acid on the NaOH solution but being the concentration of the base much higher, the neutralization does not occur. In episode 10 they revise possible errors, and in episode 11 the teacher provides unsolicited help:

Session 5, episode 10

Susana	Sergio	Santiago
		755 You know what? Some measurement must be wrong because it should give precisely two hundred shouldn't?
757 =[inaudible]=	756 Sure, you have to have the... =the thing=...	
		758 [Drops more acid in burette] No, close it.
	759 If the other thing [NaOH] was solid it should increase a bit	
760–764 [...]	[...]	[...]
	765 Being solid the other it takes a place all the same	

Santiago (755) suggests that their measurements were wrong. When discussing responses to anomalous data, Chinn and Brewer (1993) distinguish between simply ignoring them, and rejecting them, like Santiago does, responses that differ because the second attempts at articulating an explanation. Sergio (759, 765) reacts with a reflection about how they prepared the NaOH solution, measuring 100 mL of water, not of solution, repeating it as an explanation for the failure "but we should also consider that if the other was solid it takes more place. It doesn't take just one hundred" (episode 11, turn 794). Although this is not the cause of the problem, the remark is interesting as a contextualizing practice, implicitly relating the definition of molarity with the actual preparation of the solution, and seems provoked by the failure, pointing to the important role of errors in learning. Questioning the results and exploring errors occurs (Chinn & Malhotra, 2002) in inquiry and not in school experiments, and it can be interpreted as a step toward building the epistemological dimensions of the indexical context.

In episode 11, seeing that they are blocked, the teacher provides unsolicited help: "Then what does it mean? [failing to neutralize it] Which one has a higher concentration the sodium hydroxide that you prepared or the hydrochloric acid that was there?" (turn 789), framing the failure in terms of concentration, and suggesting them to try again with a smaller volume of the NaOH solution. Using less volume of the NaOH solution, the neutralization occurs at the end of session 5.

These transformations of the concept of concentration (and its measurement as molarity), as the students connect it to the task context in sessions 4 and 5, from a mere definition or "formula" to a resource for determining molecular mass, choosing a test value and even framing errors, are summarized in Figure 2.

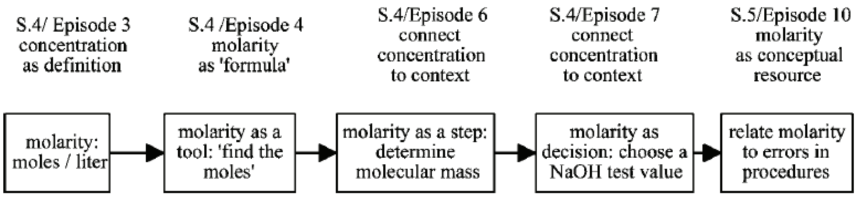

Figure 2. Transformations of the concept of concentration.

RESULTS: CONTEXTUALIZATION OF THE CONCEPT OF NEUTRALIZATION

The segmentation in episodes of sessions 4 and 5 (see Tables 2 and 3) and 6 and 7, summarized in Tables 4 and 5, provides an overview of the students' actions needed to situate the process of connection of the concept of neutralization to the task.

Neutralization as Literal Definition

During most part of session 4, the meaning of "neutralization" is just a literal definition that the students have in the handout and, before episode 8 they only mention it twice (one when reading the handout), but not as a resource for the task.

TABLE 4
Episodes, by Criteria of Activity and Theme, in Session 6

Episode (turns)	Activity (T: teacher, S: students)	Theme/Topic
1 (1–105) **Relate macroscopic to symbolic**	S strive to relate macroscopic events to symbolic representation	Actions remembered; moles in 108.5 mL
2 (106–207) **Connect actions to concepts**	–S transform empirical data to figures, volume to moles –S (Simeón) breaks burette while playing	How were data originated? Volume, moles
3 (208–283) **Discussion moles/molarity**	–S (Santiago-Simeón) disagree about volume –S (Susana-Sergio) disagree about moles used/molarity of acid	What was found were the moles of NaOH used to neutralize/was the molarity of the acid
4 (284–343) **Selective recapitulation**	S recapitulate calculus for T (omitting actions and conceptual discussions)	Result: 0.00001199; calculations
5 (344–409) **Revision of errors**	S recapitulate actions for T, retrieve procedural error (solution partially neutralized)	Procedures, which volumes, from where
6 (410–583) **Repeat neutralization**	S repeat actions, drop acid in NaOH solution, achieve neutralization	Neutralization; use of litmus paper
7 (584–605) **Calculate HCl concentration**	S calculate HCl molarity from volumes used and molarity of NaOH	[First part of audio record missing, actions retrieved from video]

TABLE 5
Episodes, by Criteria of Activity and Theme, in Session 7

Episode (turns)	Activity (T: teacher, S: students)	Theme/Topic
1 (1–65) **Interpret results in terms of concepts**	S (Susana) corrects another S: equal amounts, moles (not equal molarities)	Molarity, amounts, moles; format for writing report
2 (66–117) **Connect neutralization to daily context**	S (Santiago) tests saliva pH (alkaline) and proposes to neutralize acid with it	Alkaline, acid, scale in litmus paper
3 (118–174) **Write conclusions**	Susana finishes report and other S copy it	Number of decimals in figure (0.0059 M), molarity, report format

Neutralization as a Resource: Decision About Concentration of NaOH

Episode 8 in session 4 is an instance of the students soliciting teacher's help and his attempt to make them aware of the available resources.

Session 4, episode 8

Susana	Sergio	Teacher
		657 Yes, but you couldn't do it like that, because you don't know the moles [of HCL] that are here
658 Yeah		
	659 Sure because grams...	
		660 But what you... do have to get information is that about the acid and the sodium hydroxide neutralizing each other
661 Neutralizing, what does it mean?		
		662 It means that... mixing them, one is no more an acid and the other no more a base. That is, they lose... between them they lose their properties. Neutralizing, canceling each other
	663 The sodium hydroxide, you say?	
665 =Yes, so=... the sodium hydroxide and the... hydrochloric acid		664 =Yes=
		666 Yes
	667 They cancel each other, so we join them	
668 Yeah		
		669 Yes... but you have to think: what's the use of that... for our objective that is to know the concentration of this? Ok?
670–673 [...]	[...]	[...]
	674 Ah. And how much do we put? How much should be in?	
		675.1 Well, what you want. You have to think: What can we do with the sodium hydroxide, and with everything we have, with the litmus paper, etcetera, to know the concentration of this? 675.2 Taking into account that for each mole of sodium hydroxide it consumes one mole of hydrochloric acid and these two moles neutralize each other

Sergio and Susana establish a dialogue with the teacher, while the other two students do not participate. The teacher provides four elements of support: (1) he suggests to use the knowledge about neutralization as a *conceptual resource*, as a tool in the sense of Brown et al. (1989) advising them to think "what is the use" of it in view of the objective (669); (2) he offers a hint about the use of *material resources* (the equipment) in order to know the concentration (675.1). These suggestions about resources are complemented with (3) what could be interpreted as a reduction (for the students) of unknowns "the sodium hydroxide we can prepare it, put the amount that we want" (671), and with an idea, part of the concept of neutralization, useful for the task: the equivalence 1 mole/1 mole (675.2). We interpret that this support is in the ZPD because it does not give precise steps, attempting instead to provide scaffolding, and that is situated in Sergio's and Susana's ZPD because it seems that the other two students would not be able to solve it even with that help. On their own they have been able to relate concentration to molarity and to determine the molecular masses, but without the teacher's help theywould not be able to complete the task. Our interpretation of the question "neutralizing, what does it mean?" is not that Susana does not know the definition (written in the handout) but that they do not know, in Toulmin's terms (1972) how to *use* it. This shows that the processes taking place here are not only of contextualization but also of knowledge construction. The students are building conceptual knowledge as part of a thematic context, and the meaning of "neutralization" is now a notion that relates the amount of HCl to the amount of NaOH, enabling the students to perform actions aimed to solve the problem.

After this support Sergio and Susana attempt in episode 9 to use the idea of the equivalence 1 mole/1 mole in operations, and he proposes to pick "twenty" pointing out that it is 0.5 mol of NaOH, moving from theory to practice. He is not proposing an *amount* of 20 g of NaOH, but a *testing value* (20 g/liter) for the concentration of the solution. This decision is interpreted as a contextualizing practice, connecting the conceptual knowledge— neutralization, concentration, molarity—to the context of the practical task and so shaping the thematic context. Is this context what indexes "twenty," giving it a meaning (0.5 mol) that would not have in another. Susana proposes to prepare 10 mL of solution, appealing to procedural knowledge constructed in the second task. In episode 10 Santiago realizes that they are choosing a testing value: "Listen, then: What happens? That beginning from the molarity that we want, what are we doing? tests, one, two, until we got it, one that we want?" (779), showing that the ZPD of the participants in a group could be different, and that he has been supported in his ZPD by Sergio and Susana's discussion and decisions (in this case an unintentional support). Only now is he understanding that they are running a test. This episode supports the notion that the meanings constructed by each participant are different, and the relevance of peer support. It has to be noted that Santiago is the first student talking explicitly about tests, while Sergio and Susana are running them. The four students initiate the calculations of how much NaOH do they need to weigh (episode 11).

Neutral as Green/Transparent

In session 5, the students prepare the NaOH solution and the equipment for the neutralization, burette and indicators, litmus paper, and phenolphthalein and achieve it. While in session 4 all activities were mental or paper and pencil, here they perform physical actions.

Session 5, episode 6

Susana	Sergio	Santiago	Teacher
403 It has to =be=	404 =neutral= [pause]		
	405 It has to be neutral		
			406 What has to be neutral?
		407 That...	
	408 The hydroxide and the acid must...		
409... cancel each other			
410–411 [...]	[...]	[...]	[...]
	412 It has to be green		
413 That is what it has to be			
			414 Yes, it has to be green or yellowish
415 Yeah			
	416 So, one of these three [points to the color scale in the litmus paper]		

Susana and Sergio predict the outcome, first in terms of the theory "it has to be neutral," and then he (412, 416) expresses it as "it has to be green," contextualizing the hypothetical observation of a green color of the litmus paper in the thematic context to which the concept "neutral" belongs, and so progressing both in the transformation of the concepts and in the building of a thematic context of the lab work including conceptual and material resources. In episode 8 the teacher (501) suggests using phenolphthalein and Susana wonders about how to measure the amount of acid, to which Sergio proposes the burette. Then Sergio contextualizes the concept "neutral" to "transparent" for the phenolphthalein: "We put here the acid, this down inside we begin dropping acid until it turns transparent" (527). Taking as departing point the concept of neutralization, they transform a theoretical resource "neutral" into a tool for practical decisions and actions: "green" or "transparent" take a new meaning as signs for neutralization. They are connecting concepts to the context, material resources, burette, and indicators, undertaking semiotic practices useful for solving the problem. In episode 9 they begin to pour the acid, but neutralization does not occur because the concentration of theNaOHsolution (0.025 M) is much higher than the one of HCl (0.005 M); although they do not realize it, and they revise possible errors (episode 10) until the teacher guides them (episode 11), as discussed in the previous section. The neutralization takes place at the end of session 5.

Representing Neutralization Through Different Systems

In session 6 (see episodes in Table 4) they recapitulate all the actions, performing in a way a reverse transformation of meanings, from practice to theory: This process requires them to move between representation levels (Nakhleh & Krajcik, 1994) or languages, from macroscopic (observation of change in color) to symbolic (formulae) and algebraic (mathematical calculus). In episode 2, they begin to transform the empirical data, translating the "volume" of HCl used in terms of "moles" (using too the molarity of the NaOH solution that they had prepared). Transformation of data is a process that, according to Chinn and Malhotra (2002), occurs in inquiry, but not in school experiments. It proves to be not a straightforward process for the students, with Santiago confusing moles and molarity, or trying to operate with the added volumes of both solutions (episode 3). They calculate a value of 0.00001199 M for the HCl, showing it to the teacher. Instead of telling them that it is very different from the expected value (0.005 M), he asks them to recapitulate all the process (episode 4), what they do only in terms of mathematical calculations. This, in the other hand, is something that happens in research reports. From the recapitulation, the teacher realizes (episode 5) that they used NaOH solution that was partially neutralized and tells them to repeat the neutralization, what they do, this time without problems, and in episode 7 they begin to interpret the results (change of color) in terms of neutralization, and to calculate the concentration of the acid. In other words, they are using the concept of neutralization to interpret the results, and to represent the data in different languages. These data, for example "volume," have a precise meaning ("moles") indexed by the new thematic context.

Deploy Neutralization as a Resource to Interpret Results

In session 7 (see episodes in Table 5) they complete the interpretation, the calculations, and the report. In the first episode they continue the interpretation of the results.

Session 7, episode 1

Susana	Sergio	Santiago
	34 Damn it that we =need=	
35 =I say=		
	36 ... the same, the same molarity as =that one=	
37 =So with= zero zero one		
	38 ... to cancel the other	
		39 [laughs]
40 I don't like it 41 We need the same amount of this to cancel the other one		
		42 Thus [inaudible] conclusion
	43 Don't touch my... Damn it! That we need the same molarity of. What was it? Of, of, of soda...	

Sergio (34, 36) says that "we need... the same molarity as that one," confusing the moles equivalence with the molarities. To this Susana (41) answers that "we need the same amount of this to cancel the other one," giving "mole" the meaning of "amount" of substance, that corresponds to its canonical definition (although Sergio, line 43, repeats again that it is the same "molarity"), and contextualizing the definition of neutralization to their data in the context of the task, what we interpret as a refinement of the thematic context. They are interpreting the data, contextualizing practical actions in the frame of theoretical concepts.

In the second episode, Santiago spits in a piece of litmus paper, pointing out that it is alkaline (saliva pH goes from 6.8 to 7.8 and may be higher after a meal). It may be said that he is applying what he learned about acid, bases, and indicators to daily life. All the students show great interest and go to the sink to see it, what points to the motivation and interest that secondary school students experience when confronted with data showing that everyday objects and substances *have chemical* (or physical, or biological) properties. In other words, chemistry concepts, as indicator, neutralization, acquire meaning in the context of everyday events or actions. Sergio, joking, proposes to use saliva instead of acid. Santiago corrects him, indicating that it is the opposite of acid, and reformulates the proposal of neutralizing a drop of acid by spitting on it: "So... if we grab a drop of acid... Do you hear me? No kidding! We grab a drop of acid, I spit on it and it stays neutral." The arrival of the teacher ends the conversation. The teacher, who does not point to the deviation from the preparedsolution, considers their result, 0.0059 M, adequate. Susana writes the report and the other three students copy theirs from hers.

In our opinion these two episodes show that the students are able to contextualize events to the neutralization both in the laboratory task (Susana, 41), giving it the meaning of same amount of acid and bases that react, and in daily life (Sergio, Santiago), using in an imaginary proposal the concepts of acid, base, neutralization, and indicators, in what constitutes an instance of situated knowledge. This does not always occur, as situations conform interpretations, and students (or people) use concepts and skills in different ways in everyday life and in academic tasks (Lave, 1988).

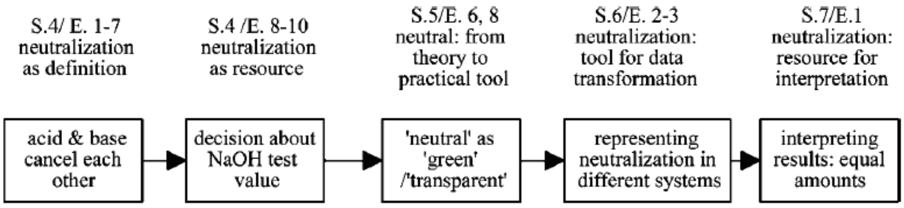

Figure 3. Transformations of the concept of neutralization.

These transformations of the meaning of the concept of neutralization in the four sessions, as it is connected to the task context, are summarized in Figure 3: from a literal definition, to a resource for decisions, then a new meaning for "green," a tool for data transformation and a resource for the interpretation of results.

DIFFERENCES IN STUDENTS' PARTICIPATION

The processes of meaning making are not only a matter of concepts and task, the social dimensions, inclusion and exclusion of group members also play a part in them, and the meaning could be different for individual students. Although most of the interactions in this group are dialogic and students take into account the utterances and actions of the others, there are a few episodes of not dialogic discourse, for instance episode 2 in session 4, when Susana is trying to restate the problem and the other students are manipulating the equipment, or episode 2 in session 6 (see Table 4) when Sime´on is playing with the burette (and breaks it) because he is at that moment out of task, excluded from the dialogue between Susana and Santiago, who are trying to interpret the empirical results from neutralization. But there are other data that point to inclusion of the students as members of the group, as the peer support in session 4, episode 10, or the four reports, identical because they were copied from the one written by Susana. Molander (1997) has explored the connection among students' participation in classroom communication and learning success. An approach to the participation of students is the summary of the number and proportions of utterances in the four sessions (and roughly the same for each one) represented in Table 6.

The participation is unequal in quantitative terms, with greater inputs from Susana and Sergio. There are also qualitative differences, as seen in the transcriptions, because most substantive contributions, allowing progress in the construction of meanings, are also from Susana and Sergio or, sometimes, co-constructed between them. But although the contributions of the other two students are smaller, they are rarely out of task. Both of them cooperate, discuss the difficulties, and even Sime´on corrects the others and is, on two occasions, the only one able to retrieve data. In summary, even with unequal participation we interpret that they are sharing meanings.

TABLE 6
Number and Percentage of Utterances in the Four Sessions

Students' turns in task 3: 2.340			
Susana	Sergio	Santiago	Simeón
742	722	586	290
31.7%	30.8%	25%	12.4%

CONTEXTUALIZING PRACTICES ACROSS EPISTEMIC LEVELS

The process of connection of the concepts of concentration and neutralization to the titration task can be examined with reference to their epistemic status, because these practices can also be seen as epistemic practices, involving coordination among data and theory or data representation. The examination of the different contextualizing practices in the task lead to their distribution in three broad categories according to their epistemic level, from lower to higher, that is from closer to observations and data, to closer to theoretical constructs: (1) practices that involved translating from observational to theoretical language, as for instance when they give “green” the meaning of “neutral,” or when they move between different systems to represent data; (2) practices that involved using concepts as resources to plan and perform actions, such as choosing test value or preparing solution; and (3) using concepts as resources to interpret results and frame anomalous data, as for instance to explain why the neutralization did not occur or to interpret neutralization as reaction among equal amounts. The categories and instances of contextualization practices in each of them are summarized in Figure 4.

The frame has been built in interaction with the data of our study, but we believe that it could be adapted to account for contextualizing practices in other laboratory (and perhaps other problem-solving) tasks. It has to be noted that higher epistemic levels are not equivalent to “better” practices, because, as Kelly and Takao (2002) point out in their study about epistemic levels in written arguments, it is desirable the combination of practices across different levels.

DISCUSSION

The purpose of this paper is to document processes of meaning construction and change, in particular howare

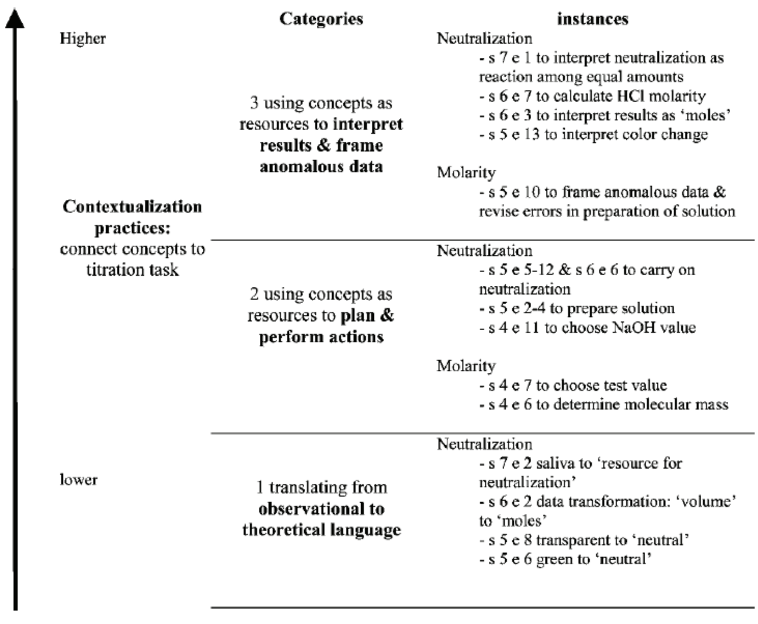

Figure 4. Use of contextualization practices across epistemic levels (s = session, e = episode).

meanings constructed for the concepts of molarity and neutralization in a chemistry laboratory, and howthese meanings change through its *connection to the context* of a problem of titration. In the process the concepts are transformed into decisions and practical actions. These contextualizing practices are for Lemke (1990) the most important semiotic practices. Although other ideas from Lemke, such as "talking science," have been put to use in educational research, we believe that ours is the first study to use the notion of *contextualization* and contextualizing practices to frame an in situ exploration of meaning construction and change in the classroom. When the students begin to deal with the task, they are not able to connect the meaning of neutralization to the practical problem of titration. Some obstacles encountered are that the school laboratory—as a social context—indexes for them patterns as manipulation of equipments, fixed steps, or substitutions in algorithms or formulae with only one unknown. One epistemological obstacle may be the degree of openness of the task. In the first session they repeatedly ask the teacher for directions, particularly about the amount of NaOH. It takes them most part of this session to realize that they could decide about a testing value. The knowledge is viewed in a finished format, not as a process involving trials and errors.

On the one hand, these problems show that perhaps the degree of difficulty of the open task, to design a titration,was too high for the 10th grade. On the other, they point, as the science education literature about students' ideas has shown (see for instance Driver, Guesne,& Tiberghien, 1985), that teaching a topic in the classroom does not guarantee meaningful learning, as the studentsmaynot be able to apply the relevant knowledge to a newsituation, to use it.Wewould say that the concepts have been incompletely built, because they are not connected to the activity. During the four sessions, the students construct meanings connected to the practice of chemistry: we think that the meaning of "neutralization" for themwould be different if they had not the opportunity of connecting it to that context. At the same time the social context of the laboratory itself has changed, has been reshaped (Goodwin & Duranti, 1992) from a meaning of illustration experiences, or step-by-step tasks to a problem-solving environment. This process of change is not a clear linear progression, but rather we would describe it saying that the students discourse shifts between the school culture and the scientific culture, from filling blanks in formulae to selecting and deploying conceptual and procedural resources, part of the cultural resources of the school science community (Lemke, 1998), in a way that is context dependent, in order to solve the problem. The meaning of neutralization in a different environment may have been different because meaning making (Lemke, 1998) is not independent from the local contexts where it takes place.

At the end of session 4 Sergio proposes to choose a testing value for the NaOH, decision that we interpret as the first connection among the meanings of molarity and neutralization and an action useful for finding the concentration of the acid. The last episodes in session 4 mark the moment when the neutralization is not only a literal definition and begins to have the meaning of a theoretical tool, a *cognitive resource*, that can be used for solving a problem, as the situated cognition (Collins et al., 1989) proposes. Is this process what we understand by situating the knowledge in its context of use.

The processes involve contextualization of knowledge and also its construction, building an indexical context from which the concepts make part. In other words, we do not consider that the students master the concepts of molarity and neutralization from the beginning and that they only put them in practice, but rather that they construct and create meanings for them as they connect them to the titration task, translate observations through them, transform them into actions, and use them to interpret results. As Toulmin (1972) points out, we only understand the meaning of concepts when we learn to apply them, including the practical procedures involved in its application. Understanding, meaning construction, and contextualization go together. Figure 5 synthesizes some instances of processes of construction of meaning, transformation, and connection to the ontext of different concepts in the four sessions. Perhaps it could be said that, besides the conceptual knowledge that has acquired new meanings when used, the meaning of practical work, and even of the science lessons is also changing for the students, getting connected to the context of solving problems. This, as Perales Palacios (2000) suggests is a way to blur the school distinction among theory, practice, and problem solving, in an effort to integrate them.

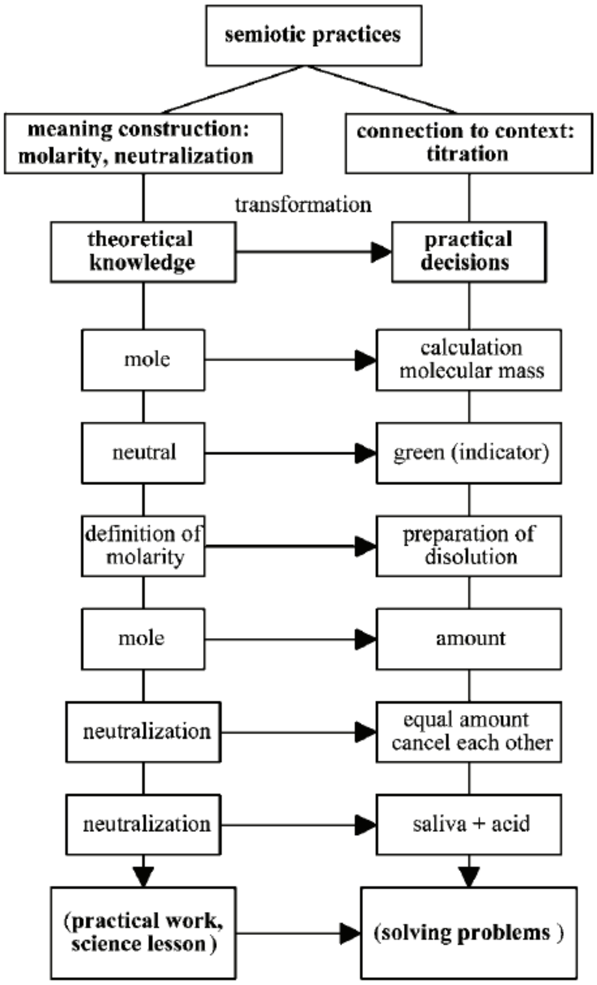

Figure 5. Summary of semiotic practices.

Building the indexical context involves several interconnected dimensions and, from the data in this study, we suggest at least three:

- building meaning for the concepts and establishing relationships among them, as relating neutralization and molarity, or molarity and moles;
- taking decisions about heuristics: planning actions and procedures, use of equipment, as the proposal to weigh the empty vessel first, the discussion about errors in the preparation of the NaOH solution, the proposal of a testing value, the running of tests, the use of indicators;
- keeping (or changing) the epistemological commitments about adequate knowledge construction practices in the laboratory. For instance the assumptions about problems as always algorithmic, about equipment, the stumbling block about the existence of "two unknowns."

This difficult task, a titration, not just a neutralization, for which they must design the process, requires the teacher's support: adopting a constructivist perspective does not mean that students should work without guidance. The mediation of the teacher (second author) was planned as scaffolding in accordance with the Vygotskian zone of proximal development, the area where the students may not be able to solve tasks on their own, but may be able to do it with the cooperation of more competent members of their community. This mediation is the subject of another paper (Reigosa, Jim´enez-Aleixandre, & Garc´ıa-Rodeja, submitted). Such performances can be problematic for teachers because, as Erduran (2003) points out, they may not be aware of the differences between their own frames of reference and the students' frames. An obstacle, both for teachers and students, can be a (implicit) paradigmatic context of school laboratory work where the goal is "to get the task done" and not the learning process while solving problems. The difficulties voiced by the students in our study raise the question of whether other students understand the meaning of what they are doing when performing a titration in a standard "follow recipe" way. The support provided by the teacher in this case study was intended as scaffolding, suggesting lines of advancement, without giving the concrete directions that the students sometimes demanded. But reflection about the data suggests that perhaps he took for granted steps 1, restate problem, and 2, recognize resources (see Figure 1) assuming them as unproblematic, and expecting students to go straight to the decision about a test value for the NaOH concentration. These steps, and the difficulties that students experience with them, have to be considered when designing open laboratory tasks.

It has to be noted that the objective of studies like the one reported here is not to show that this approach is better or compare it with others, but to document the process of meaning change through the contextualization. It has been suggested (see, for instance, Reid & Yang, 2002) to give students the opportunity to face open problems and, agreeing with it, we believe that it is useful to explore the particular difficulties that students experience in these less conventional environments, like the one in this study. The examination of the contextualization practices across epistemic levels helps understand the meaning making processes. The students are connecting concepts to the context, and this involves also epistemic practices as coordinating data with theory, representing, and transforming data or reacting to anomalous data. We suggest that, while sharing some features with other learning contexts, the three categories that emerged from the results could account for particular ways of structuring knowledge in the laboratory, although studies with other tasks and in different settings are needed to test this suggestion. Contextualization, combined with the examination of the epistemic levels, can be a fruitful notion for discourse analysis studies that attempt to capture different dimensions of the rich and complex interactions involved in learning science, trying to produce a picture as holistic as possible.

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Text 6

La evolución de la noción de contexto en la didáctica de las ciencias.

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Introducción

En la década de los 70 apareció el movimiento ciencia-tecnología-sociedad (CTS) y se publicaron los primeros proyectos que usaban como contextos escenarios con componentes tecnológicos y sociales para aprender ciencias (Solomon y Aikenhead, 1994). Los proyectos de ciencias en contexto se desarrollaron a partir de estas ideas y han ido creciendo en difusión y popularidad por todo el mundo. Algunos de los ejemplos más paradigmáticos son:

- El proyecto PLON (1972), (Proyecto de Desarrollo del currículum de Física). En el marco de este proyecto holandés se han desarrollado materiales para la enseñanza de la física y la química contextualizados. Hay numerosas investigaciones en torno a él, hecho que ha posibilitado una evolución fundamentada en sus resultados.
- Los proyectos de la familia SALTERS de física, química y biología (Campbell et al., 1994) también fueron de los pioneros en el uso del contexto en Europa, tienen materiales muy completos publicados para secundaria. Estos proyectos han sido revisados periódicamente y tienen una cuota de mercado considerable en Inglaterra y Gales.
- En Estados Unidos destacan el proyecto *Chemistry in the Community* que va por su sexta edición en inglés y el proyecto *Chemistry in Context* para estudiantes de primero año universitario. En Alemania también se han desarrollado los proyectos *Chemie im Kontext* y *Physik im Kontext.*
- El proyecto *Twenty First Century Science*, en el Reino Unido, dirigido a alumnos de 15-16 años. Su objetivo principal es conseguir la alfabetización científica de todos los alumnos.

Otras iniciativas de la didáctica de las ciencias que también apuestan por el uso de contextos son el aprendizaje basado en problemas (ABP), la ciencia basada en proyectos o el uso de cuestiones sociocientíficas (King, 2012). Aunque existe un razonable consenso entre los investigadores sobre la validez del contexto como apuesta didáctica, existen puntos de vista diferentes sobre su fundamentación teórica, sobre sus objetivos y sobre como utilizar en la práctica docente esta potente herramienta didáctica sin olvidar que los alumnos han de aprender ciencia (de Freitas y Alves, 2010). Ya en 1988, Fesham clasificó en 7 categorías las distintas aproximaciones CTS y diversos estudios posteriores han aumentado la tipología. Así, unos proyectos se orientan más a desarrollar el conocimiento sobre ciencia (NOS), mientras que otros se enfocan al aprendizaje de conocimientos de ciencias y, aun otros, del contexto seleccionado, algunos optan por separar claramente los contenidos de ciencia y los contextuales sin establecer conexiones explícitas; o en otros, el contexto es solamente una actividad atractiva al principio o una mera aplicación al final.

A partir de esta enorme variedad de enfoques, el objetivo de este seminario es discutir sobre la diversidad de aspectos didácticos asociados al aprendizaje y la enseñanza de las ciencias a través de contextos. Algunas cuestiones clave que hemos identificado son:

- El contexto como práctica auténtica que permita aprender a indagar a través del conocimiento sobre la naturaleza de la ciencia.
- El contexto como oportunidad para hacer participar al alumnado en las prácticas científicas de construcción de un conocimiento significativo y complejo basado en modelos teóricos clave de las ciencias
- El contexto como facilitador de la capacidad de transferir el conocimiento científico, es decir, como promotor de la competencia científica.

Definiendo contexto

Es conveniente ser conscientes de la enorme polisemia existente alrededor del término “contexto” y de lo difícil que resulta consensuar una definición que puede ser de utilidad en todas las ciencias sociales. Para evitar diálogos de sordos entre especialistas de diferentes áreas de conocimiento, es muy importante hacer un esfuerzo por concretar y compartir significados. En psicología y en pedagogía general el contexto se asocia al entorno físico, social y cultural formado por la institución educativa, el profesor y los alumnos (y sus familias, e incluso vecinos). Sin embargo, en didáctica de las ciencias, a menudo se entiende por contexto un campo de aplicación específico de una teoría científica.

Por ejemplo, los diferentes proyectos de la familia Salters (para química, biología y física), que surgieron en la década de 1980, resumían el principio básico para su diseño en la siguiente frase: *"Las unidades del curso deben empezar con aspectos de la vida de los estudiantes, que ellos hayan experimentado personalmente o través de los medios, y los conceptos científicos deben irse introduciendo a medida que son necesarios"* (Campbell et al., 1994).

Persiguiendo el objetivo de consensuar una definición, Duranti y Goodwin (1992) propusieron la siguiente basada en sus investigaciones en lingüística y antropología: "*Un contexto es un episodio o suceso incrustado en su entorno cultural sobre el que centramos nuestra atención. Tiene cuatro características: el escenario, las acciones, el lenguaje y el conocimiento".* Gilbert (2006) cita las metas que deberían conseguirse a través del uso de los contextos: 1) Promover un aprendizaje más significativo de las ciencias; 2) Percibir que aprender ciencias es relevante para las vidas de los alumnos; 3) Capacitar al alumnado para construir "mapas mentales" coherentes con las ideas científicas que se van aprendiendo.

Por este motivo, desde la didáctica de las ciencias interesa más una definición de las metodologías que utilizan los contextos como herramientas para enseñar y aprender. En esta línea King (2012) propone: *"Una metodología basada en contextos (MBC) consiste en aplicar la ciencia a una situación del mundo real que se usa como estructura central para la enseñanza. Los conceptos científicos se enseñan a medida que son necesarios para entender mejor la situación planteada".*

Pero esta relación entre contexto y aprendizaje de conocimientos científicos en el marco de un currículum coherente es algo controvertido. Por ejemplo, Kortland (2007), analiza el diseño y aplicación de algunas UD del proyecto PLON y constata que no acaba de estar bien resuelto el paso de la fase en la que se presenta el contexto y su interés y motivo global, a la que se restringe lo que se va aprender de ciencias; y tampoco el paso de esta fase a la siguiente, en la que se profundiza en dicho conocimiento pero de forma que buena parte de lo que se aprende no es necesario para la comprensión de la situación de partida y es muy similar a un currículo tradicional. Por ello propone que "*en lugar de ver el 'contexto' como algo de la vida cotidiana a la que el conocimiento científico se puede conectar de un modo u otro, se debería referir a una práctica que tiene como propósito resolver un problema específico relacionado con la ciencia y la tecnología y la ciencia, aplicando un procedimiento para la solución del problema que comporta aprender el conocimiento científico/tecnológico, habilidades y actitudes necesarias para resolverlo"*. Es lo que define como prácticas auténticas.

En la misma línea Lemke (1990) discute sobre la idea de contexto asociada a lo que él llama, prácticas semióticas, que son aquellas acciones que los miembros de una comunidad llevan a cabo y que son significativas para dicha comunidad. Afirma que para que esto ocurra es necesario contextualizar las acciones y los sucesos. Dos ejemplos de prácticas auténticas serían, por un lado, la estudiada por Jiménez-Aleixandre y Reigosa (2006) basada en la resolución de un problema basado en encontrar la concentración de una solución de ácido clorhídrico. Un segundo ejemplo es el analizado por Bulte et al. (2006) sobre la resolución del problema de la evaluación de la calidad del agua según sus usos (beber o nadar). A través de varios ciclos de investigación-acción, muestran una manera de construir un currículum de química contextualizado a base de prácticas auténticas que siguen el principio del "need-to-know". Según este principio, el contexto *"debe legitimar el aprendizaje de las teorías de la química desde la perspectiva de los estudiantes, haciendo que este aprendizaje sea intrínsecamente significativo".*

Si ponemos la lupa en qué entendemos por "conceptos científicos" (definición de Salters) y concretamos que significa "aplicar la ciencia a una situación" (definición de King), la definición de la MBC se alarga pero se llena de matices interesantes. No es lo mismo que la ciencia que se aprenda sea "sobre ciencia" que "de ciencia", ni que sean conceptos más o menos aislados que modelos teóricos complejos, ni tampoco que la aplicación se relacione con interpretar nuevos hechos o con la toma de decisiones socialmente relevantes. Así, para Sanmartí et al. (2011) el aprendizaje a partir del contexto se relaciona con: *"El análisis de una situación o problema complejo, relevante socialmente y del entorno del alumnado, que se realiza durante un largo periodo de tiempo (semanas). A partir de su estudio se van modelizando conceptos-clave necesarios para comprenderlo y para tomar decisiones, interrelacionándolos y organizándolos junto con las experiencias y el nuevo lenguaje que se va generando alrededor de modelos teóricos claves de la ciencia".*

Integrando contexto y actividad científica escolar (Izquierdo et al., 1999) se podría hablar del contexto como *"el conjunto de factores que dan sentido a la actividad que se realiza en el aula",* entre los que se pueden identificar: la situación o problema, la actividad –las distintas tareas y su secuenciación-, el uso de sistemas de representación, las ideas científicas y su estructuración en modelos teóricos, y la metacognición.

Contexto y prácticas auténticas

Buena parte de los trabajos recientes sobre enseñanza de las ciencias en contexto se basan en el uso de prácticas auténticas. Autores como Prins et al. (2008; 2009) hablan de la finalidad de modelización, entendiendo como tal que los estudiantes desarrollen y utilicen conocimientos sobre la naturaleza de la ciencia. Así, en su primer artículo exploran, analizan y seleccionan prácticas auténticas de modelización para enseñar química y, a partir de su propuesta de criterios para analizarlas, concluyeron que la potabilización del agua y la evaluación de la exposición a contaminantes para los humanos eran dos prácticas auténticas adecuadas para modelizar. En el segundo artículo (Prins et al., 2009), investigaron el grado de implicación de los alumnos en estas prácticas modelizadoras y concluyeron que este tipo de prácticas científicas motiva a los estudiantes y les permite utilizar de manera correcta las estrategias de modelización

En el caso de la práctica expuesta en Jiménez-Aleixandre y Reigosa (2006), la investigación profundiza en el proceso de reconstrucción y refinamiento del conocimiento alrededor de dos conceptos de química que los estudiantes ya han trabajado pero del que no tienen inicialmente un conocimiento significativo. El hecho de tener que resolver un problema real, obliga a los estudiantes a contextualizar, es decir a transformar de manera progresiva conceptos, enunciados o conocimientos teóricos en decisiones y acciones prácticas en la realización del experimento.

Parece que en estas prácticas auténticas se parte de la premisa que los conceptos científicos ya han sido construidos previamente (al menos en una primera aproximación y probablemente a través de una enseñanza descontextualizada) y la práctica auténtica sirve para poner en práctica y desarrollar estos modelos en una situación real con la finalidad de que lleguen a ser significativos para la persona que aprende. Por lo tanto, no se aborda el reto que supone integrar la contextualización y la modelización desde el inicio del proceso de aprendizaje.

Contexto y modelización

Una MBC habría de posibilitar la construcción de modelos teóricos que fueran aplicables a la interpretación de muchas otras situaciones o a la resolución de problemas. De hecho, tal y como muestra la definición de Chamizo (2013) el auténtico valor de los modelos emerge cuando estos se contextualizan con una finalidad: "*Los modelos (m) son representaciones, normalmente basadas en* *analogías, que se construyen contextualizando una porción del mundo real (M) con un objetivo específico".*

Un resumen muy útil sobre la naturaleza y el uso de la modelización en la enseñanza de las ciencias fue realizado recientemente por Seok y Jin (2011). En dicho trabajo los autores discuten sobre cinco aspectos de los modelos:

- Su significado. Los modelos son representaciones de un sistema que actúan como puentes entre la teoría y los fenómenos.
- Su propósito. Sirven para describir, explicar y predecir fenómenos naturales, así como para comunicar ideas científicas a otros.
- Su multiplicidad. Se pueden usar diferentes modelos para estudiar un mismo sistema y cada uno de ellos se centra en uno de los aspectos del sistema siendo su validez limitada a un objetivo concreto.
- Su modificación. Los modelos se someten a pruebas empíricas y conceptuales que pueden traducirse en cambios del modelo, siendo la parte esencial de la evolución del conocimiento científico a lo largo de la historia.
- Su uso en las clases de ciencias. Las actividades de modelización que se realizan con el alumnado deben incluir explorar, expresar, construir, aplicar y revisar modelos.

A pesar de la evidente relación entre la contextualización y la modelización no existen muchos trabajos que hayan investigado la construcción de modelos teóricos iniciales en unidades didácticas contextualizadas. En la mayoría de proyectos, los conocimientos se aprenden previamente al estudio del problema contextualizado o de forma paralela, sin que se planteen alternativas desde el inicio del proceso a qué ciencia se enseña, para que es importante aprenderla y cómo llegar a su conocimiento. O, cómo señala Kortland (2007), cuando se pretende hacer de forma más integrada, muchas de las ideas que se enseñan no son necesarias para interpretar la situación, resolver el problema o tomar decisiones.

Contexto y transferencia

Es bien sabido que el tiempo de que disponemos para enseñar ciencias es muy limitado y es imposible abordar todos los contextos que se conocen en la actualidad y mucho menos predecir los futuros. Pero la competencia se demuestra sabiendo movilizar saberes diversos y de forma interrelacionada en la resolución de problemas o en la toma de decisiones en relación situaciones diversas e imprevisibles (Perrenoud, en Eurydice, 2002). Por este motivo, en estos momentos adquiere importancia la necesidad de desarrollar la capacidad de aplicar lo que se ha aprendido en un determinado contexto a otros distintos, capacidad que se conoce como transferencia. A pesar de que esta línea de investigación aparece desde principios del siglo XX en el campo de la psicología de la educación, su presencia hasta el momento es mucho menor en la didáctica de las diferentes disciplinas.

Recientemente Gilbert et al. (2011) han reflexionado sobre el problema y sobre las características de unidades didácticas contextualizadas que posibiliten la transferencia. Su tesis se centra en la necesidad de ayudar a los estudiantes a construir mapas mentales coherentes con las ideas que aparecen en un contexto (los representan gráficamente como un mapa conceptual). Partiendo de esta idea, definen transferir como la capacidad de utilizar partes de estos mapas de manera significativa en contextos nuevos, y distinguen tres tipos de transferencia: cercana, lejana y muy lejana. Para evitar lo que ellos llaman “innnovation without change”, proponen criterios para el diseño de dichas unidades didácticas. Pero aun no hay estudios que demuestren que realmente se transfiere a partir de ellas.

Desde la psicología, actualmente se está estudiando con más profundidad qué aspectos de un modelo se transfieren y en qué condiciones desde una perspectiva que Lobato (2003) ha llamado “de actor orientado” (*“transfer orient-actor”*, AOT). Sus investigaciones llevan a reconocer la función de las imágenes construidas a partir de situaciones reales –contextualizadas-, que son las que posibilitan conectar con nuevos episodios, desde una perspectiva dinámica. Es decir, las relaciones y similitudes entre lo aprendido en un contexto inicial y uno nuevo de transferencia necesitan de una reconstrucción y no simplemente son activados y aplicados.

De estos trabajos se puede deducir que imágenes mentales, mapas mentales, bases de orientación u otros constructos, son instrumentos que se consideran necesarios para orientar la trasferencia sabiendo, pero, que en este proceso se va reconstruyendo el modelo teórico y la misma imagen, mapa mental o base de orientación utilizada para expresarlo. Por ello, en los procesos de modelización es importante poner a prueba las representaciones iniciales a partir de actividades que comportan secuencias en espiral de contextualización-abstracción-aplicación a un nuevo contexto-abstracción, y así sucesivamente, como condicionamiento metodológico para aprender no sólo el modelo teórico (de forma que cada vez sea más complejo), sino también a transferirlo.

En este proceso faltaría introducir el componente axiológico, es decir, que esta transferencia sea además fruto de un pensamiento crítico y orientado a una toma de decisiones responsable socialmente, finalidades que una educación en contexto no puede obviar y que está en la base de las líneas de trabajo basadas en el uso de contextos CSC (Controversias Sociocientíficas) en la enseñanza de las ciencias (King, 2012).

Propuestas para la discusión

Los aspectos señalados son sólo algunos de los que se habrán de tener en cuenta al investigar sobre la enseñanza de las ciencias "en contexto", "a partir del contexto" y con la finalidad de "transformar el contexto". En la línea de lo planteado, y sin descartar otras aproximaciones al problema, algunas de las cuestiones para la discusión pueden ser:

1. ¿Se puede construir conocimiento científico significativo a través de prácticas auténticas? ¿Cuáles son las condiciones? ¿Qué aspectos se han de tener en cuenta?
2. ¿Es posible integrar en la práctica docente la contextualización, la indagación y la modelización? ¿Cómo? ¿Qué obstáculos se han de superar?
3. El uso de contextos ¿promueve o dificulta la capacidad de transferir un determinado conocimiento? ¿Se debería trabajar con un contexto o con varios? ¿Un contexto y problemas distintos sobre él –e incluso modelos teóricos distintos-, o varios problemas contextualizados alrededor de un modelo teórico?

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Text 7

Text and context according to discursive approaches: Readings, appropriations and implications for research and practice in Science Education

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Abstract

In this paper we discuss the notion of context, often mobilized in research about relationships between language and science education. Referenced by the field of discourse analysis, we present different definitions of context and comment upon their appropriations by and their implications for science education research. We argue that, although the analysis of context acknowledges relevant, though often neglected, aspects in the study of meaning making in science education, in the absence of deeper theoretical and methodological discussions, there is a risk of disregarding fundamental aspects of the link between meanings and contexts in data analysis and, in this way, of establishing linear relationships of cause and consequence between textual and contextual aspects

Motivations, objectives and framework

The dialogue between the fields of Science Education and of Language and Discourse Studies has been consolidated over the past two decades. To a greater or lesser extent, the notion context has often been mobilised in the analysis of verbal data so as to discuss relationships between forms of verbal expression and aspects of social practices in which these expressions occur. Indeed, and according to van Dijk, "the task of discourse analysts is to investigate the ways in which the social context and beliefs influence the use of language and/or vice versa"(Van Dijk, 1997). Thus, the interdependence between text and context, found in many strands of Discourse Analysis, justifies the effort described in this paper to explore aspects of the polysemy around the notion of context and to discuss both the nature and consequences of its appropriations in Science Education.

The polysemy around context

The idea of context as a fundamental element in meaning making dates back to Malinowski's work in the field of Anthropology, which established the importance of (i) descriptions of the of spatiotemporal features of situations of language use and well as of (ii) knowledge about relations between participants and about the habitual and ritualised character of the situations’ cultural history. Approaches linked to theories of Social Semiotics (Hodge & Kress 1988) and Systemic Functional Linguistics and (Halliday 1978) have systematically explored such notions. For instance, Halliday unfolded the analysis of contextual variables in several aspects related: (i) to what is happening and the actions involved in the discourse situation (field); (ii) to the social roles of participants (tenor), and (iii) to the (rhetoric) mode and the role assigned to language. Halliday and Hasan (1985) have argued that notion of context not only helps explain idiosyncratic constructions of meaning and specific difficulties in communication but also accounts for how shared meanings and anticipations make effective communication possible.

It is possible to say that, in one way or another, discursive approaches have mobilised the idea of context in analyses of meaning making and that it is probably in Bakhtin that we can find the earlier formulation of the ideas about the inseparability of language, history and society that would later on flourish in the twentieth century. The rupture with the abstract objectivism allowed Bakhtin and his circle to define the sign, beyond the Saussurean signified-signifier relationship, in terms of ideological investments and of social organization and the participants' own discursive interaction (Bakhtin 1997).

Another approach linked to the field of Discourse Studies that treat meaning making as inextricably linked to the practices, structures and social systems is Critical Discourse Analysis (CDA). In CDA, the notion of context appears indirectly in the frequent references made by Fairclough to the concept of recontextualization of Basil Bernstein (Fairclough 2003 p. 33). In these formulations, the definition of context proper is less important than the analysis of the principles governing the processes through which texts, discourses, and other elements of a given social practice are appropriated and transformed when they are incorporated into another social practice. Context is usually qualified (social context, political context, public context etc..) and is used in a way that blurs the boundaries between the notions of 'context of situation' and 'context of culture'. Then van Dijk is another author linked to critical studies of discourse but, unlike Fairclough, he introduces a cognitive dimension to the study of context by proposing the idea of contextual knowledge as a factor that influences the way participants perceive and position themselves in discursive interactions. For van Dijk, although communication does have a sociocultural nature, it is not completely determined either by the characteristics of the here-and-now of the discursive interactions or by macrosocial structures that regulate these events. Instead, participants’ mental representations play the role of sociocognitive interface in verbal expression and discourse processing (van Dijk 2001). This would explain why even participants who share experiences of sociocultural and situational nature still produce different responses to discursive situations they take part in.

In terms of the strand of discourse analysis that is referenced to the work of Michel Pecheux, and developed in Brazil by Eni Orlandi, references to the notion of context lie in discussions of what is called the 'conditions of discourse production' (Orlandi 1983). These include the historical, social, ideological elements that are constitutive of the situation of enunciation and make reference to what discourse analysts call exteriority. From this perspective, there is no split between text and context, though both Pecheux and Orlandi admit the idea of extra-linguistic context. Differently, for Maingeneau, the notion of context, although not pre-established or stable, corresponds to what goes beyond the physical environment and circumstances of utterances and concerns both the verbal statements which immediately precede themes well as knowledge that is shared by the participants. Context is thus essential to analyse meanings as well as to resolve ambiguities in text(Maingeneau 2008).

Synthesis

Even in this abbreviated and schematic presentation, one can see similarities with respect to what is meant by context in the different formulations presented. A crucial similarity is that none of the approaches admits independence or autonomy of meaning over context. However, some aspects are not shared by all strands. For example, the dialectic nature, characteristic of CDA approaches, does not map entirely the mutually constitutive character between text and context that characterises, albeit differently, Pecheux's discourse analysis (Pecheux) and Bakhtinian approaches to the study of language. While some strands admit that meanings can be determined by context, be it of a sociohistorical (like in Pecheux and Orlandi) or cognitive (like in van Dijk) nature, others consider this relationship simply as one of influence (e.g. Fairclough).Besides, even postulating dependency relationships between text and context, the approaches differ with respect to how each one relates to linguistic and extra-linguistic elements in the analysis of meaning making. For example, Hallidean attempts to establish correspondences between textual and contextual features contrast with approaches where conceptual definitions are theoretically sound but do not make analytical devices explicit.

Discussion

To a greater or lesser degree, research on aspects that relate language, science and science education has sought to understand such relationships by making reference to context. However, in many cases, Science Education researchers do not explicitly adhere to epistemological or methodological assumptions which guide each of these approaches (Pinhão & Martins 2009). This is reflected by the undifferentiation and lack of specificity that the term context acquires in several publications, where it merely denotes what is "around" the discursive interaction under analysis. The nature of this "environment", nonetheless, oscillates between linguistic (what was said immediately before or after), discursive (memories or meanings shared by participants), social (information about participants' professional experience and/or socio- economic background), psychological (data concerning participants' expectations, interests, beliefs and attitudes), among others.

Having said that, dialogue with approaches related to the field of discourse and language studies has allowed explicit consideration of elements that had long gone unnoticed in the study of the processes of learning and meaning, such as lexical choices, patterns of interaction, and alternating dominance shifts. These factors relate to aspects that concern not only the characteristics of the immediate discourse situation (e.g. lesson duration, role of textbooks etc.) but also to other relevant, yet more remote, factors (e.g. initial training, organizational culture of the school, representations of science in society). In some cases there is an effort to build methodological tools to make the dialectic nature between text and context explicit. An example are maps of events, in which the definition, meaning and organisation of units of analysis emerge according to the nature, form and dynamics of interactions (Martins 2006; Macedo, Mortimer & Green 2004). Other examples include references to analytical frameworks that incorporate contextual elements explicitly, either in the form of a description language episodes (Ogborn, Kress Martins & McGillicuddy 1996) or as analytical tools that problematize relations between dialogism and interactivity in the classroom (Mortimer & Scott 2002). Nevertheless there is a need for further analysis of the relationship between text and context, especially because they often find, in some cases, evidence of attempts to establish direct linear causal relationships between textual and contextual aspects, without due consideration of theoretical and methodological aspects that mediate connections between meanings and contexts.

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Text 8

Sociocultural perspectives of context in science education research and practice

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Putting "context" into context

Recently I came across an article from the journal Research in Science Education, written by Richard White, and published in 1985. He elaborates on the potentials for a new revolution in science education; one that he sees as having been "overlooked by theorists as well as researchers". This factor that he claimed has a great potential for promoting revolution is the ***context***. Unfortunately, almost 30 years later, we have yet to see this revolution in science education on a large-scale. But before we can think about why this "revolution" hasn't happened, perhaps first we need to reflect what we even mean by this term context, and why is it important to our research and practice? In the sections that follow, and I introduce my perspectives on how this construct of context can be framed. In the accompanying presentation, I intend to elaborate on the importance of context in education research and practice. I hope that in doing so, we can work together towards the revolution that Mr. White called us to in 1985.

What is the meaning of the term context?

<u>Context:</u> The interrelated conditions in which something exists or occurs[6].

There are many traditions of educational research that can be considered to be "sociocultural", including hermeneutic, dialogic, discursive, activity theoretically, phenomenological, and more. On the overall, education research that is conducted through sociocultural lenses typically is grounded on examining the social and cultural factors that are at play in a given situation, whether it be on the micro-, meso-, or macro-levels. The interconnectedness of social and cultural factors within the social sciences necessitates an understanding of the interrelated conditions that are occurring; in short, an understanding of the context. But how do we work towards representing, and understanding, context? Can we even ever truly understand the contextual complexities of a given place and situation? Researchers sometimes frame the context of their work through small descriptive pieces of context that we might see described in papers, such as

[6] http://www.merriam-webster.com/dictionary/context

the specifics of the classroom, the backgrounds of the students, the demographics of the schools, etc. These can be important for understanding what is able to be accomplished in the place and situation being researched. However, I argue that it is critical to also conceive of context as much larger than simply the details of the "where" and "who" of the research study in order to be responsive to the people involved with, and implicated by, the work that we do.

Context is introduced above as the interrelated conditions in which something exists[1]. As a cultural studies researcher grounded in hermeneutics, I frame this as encompassing the situatedness of a given experience for a participant; as connected to their historically and culturally constituted positionality. Hermeneutics is the art of understanding, as well as the theory of interpreting. Thus, there is a distinct difference between explaining the events that happen, and trying to understand them. Through hermeneutics we can work towards understanding, and thus understanding (what Gadamer has called *Verstehen*) is primarily the process of coming to an understanding ***with others*** (*Verständigung*). The hermeneutic circle requires that understanding be built up from an understanding of the parts that come together to create the whole. Thus we can work towards understanding what a given action is, for example, and also try to understand **why** that action occurs. To do this, one must place the events within the context in order to better understand them. Placing events within the context in which they occur is quite a complex process. Through this process, one can emerge with research that is sensitive to context, and then engage in hermeneutic interpretation to make sense of it through our own perspectives and also through the contextualized presentation of the experience. But how do we do this?

The relevance of context

A quick review of the literature in the field of science education with the key words "context" and "science education" over the past 5 years brings up a variety of research papers that in one form another are focused on ways to "provide" contexts to children for learning.

Why does context matter?

Through a grounding in dialectics, my research practice considers the relationship between agency and structure. The structures of a given situation impact the ways in which a person can, or cannot, take agency. In other words, the contextual aspects of a situation can shape what can actually occur at that time. Context matters. The ways in which we shine a light on context can also impact what we are able to see, and thus what we are able to understand. As such, there is no complete understanding possible. Rather, we can work towards understandings of specific components, to work towards making sense of what we are experiencing. Important to all of this is that there is no overarching truth. "Truths" are "conditioned by the cultures to which we belong and the historical circumstances in which we find ourselves" (Warnke, 1987, p. 1). These are the locally contextualized ways of being that we can try to make sense of through research and practice.

In my presentation, I will elaborate on some of the different ways that context **matters** in sociocultural research. I will introduce some of the different ways in which context matters; each of which shape the research that can be done and the story that can be told in different ways. In particular, I will explore how we can consider the context-bound nature of research analysis and interpretation. Placing events within the contexts in which they occur can lead us to different understandings, as the act of interpretation is context bound. As we ask specific questions within our research, contextual understandings become produced, and context can even become transformed in the process. The following points will guide the discussion around the role of context in sociocultural research:

How does context matter?

- <u>Context of the school and the classroom</u>

Institutions reflect, and even represent, the sociopolitical context in which they function. This may not be aligned with the contexts that the learners are from. Thus, we must work to unpack ideologies, as we approach the collective necessity of defining the sociopolitical contexts in which our work is done.

- <u>Context of the subject</u>

Science that is out of context tends to result in instructional and evaluation moments that require 'correct' answers. Decontextualized science leads to fragmented, simplified, and abstracted notions of scientific contexts and phenomena. One of the ways in which we can consider the context of the subject is through curricula that is based upon real-world context. Such context-based curricula, for example, focuses on the "application of science in such a way as to develop students' capacities to function as responsible participants in their everyday lives" (King, Bellocchi, Ritchie, 2008, p. 366). In such curricula, for example, context is considered to be instructional and learning experiences that relate key concepts to situations in real life.

- <u>Context of the child</u>

Most importantly, there is the child that we must consider. The relevance of taking the contextual specificities of the child as central is, in my opinion, the most critical aspect of examining context. I mean by this that we need to look closely at the context in which our students are positioned, as well as the contextual complexities that they bring to their classrooms.

Considerations of *context* as researchers in cultural studies

"We are situated in history and historically conditioned. This means that our conception of rationality is subject to the limitations of the historical experiences we have inherited" (Warnke, p. x). Historical / social / political / interpersonal / cultural / epistemological contexts… all of these are important in our interpretations. Needless to say, it would not be possible to engage in research that is completely adapted to contextual understandings on all these levels and through all these lenses. However, if there are great discontinuities between contexts, deficits can emerge (Nieto). As researchers, we can attempt to interpret what we see, hear, or read, but when we are confronted with material that is not clear or even contradictory to what we have been experiencing, we may turn to context. But what would happen if we always begin by situating our participants and our data resources within the context in which they are positioned?

Research is a way of making meaning. Of understanding. In the hermeneutic tradition, it is in bridging part to whole. A central part of this hermeneutic process is considering the meanings that are given to actions and moments by those who are participating in them. Some have chosen to use the metaphor of an onion in working towards contextualized research (e.g., Mac Naughton, Rolfe, and Siraj-Blatchford, 2010), as there are multiple layered meanings that are to be uncovered, and these are positioned by the differing viewpoints and experiences of our participants. With a grounding in critical theoretical perspectives, it is central to situate work within an understanding and an appreciation of difference. The lenses and foundations that I will introduce and that I bring to research require me to acknowledge context. However, my ethical perspectives obligate me to not only acknowledge it, but to insist on having a responsibility to highlight and unpack the complex role of context in our interactions as teachers and learners.

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Text 9

(Incluye versión en castellano)

La inclusió del model de gènere en el context

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En diferents oportunitats, hem tingut ocasió d'analitzar el gènere i l'ensenyament de les ciències (Izquierdo i al, 2009) i d'analitzar amb mirada no sexista les classes de Ciències Experimentals (Fernández i al, 1995). En el marc del Seminari de Doctorat sobre "Perspectives sobre el context en educació científica: Aproximacions teòriques i implicacions per a la pràctica educativa" voldríem afegir una reflexió sobre el model de gènere.

D'acord amb la teoria semàntica dels models teòrics, el model de gènere agrupa els següents fets:

1. La ciència escolar se centra en "l'alumne". Hi ha consens en la comunitat didàctica en assenyalar que "l'alumne" no es pot identificar amb l'existència d'un subjecte universal que aprèn. Les personen que aprenen, és a dir estudiants, alumnat, noies i nois presenten diferències en funció del seu origen social, familiar o socioeconòmic. Entre les diferències presents en l'alumnat que plantegen la necessitat de treballar amb una perspectiva inclusiva, hi ha una diferencia prèvia a totes elles constitutiva de la seva identitat personal: el sexe que se li assigna en el naixement o durant la gestació. El gènere és una construcció social que associa i estableix per cada sexe unes normes i comportaments. El gènere es construeix mitjançant la socialització primària i secundària rebuda en el medi familiar i amb el reforç de les institucions escolars. Aquestes diferències anomenades de "gènere" esdevenen estereotips i es "normalitzen", és a dir es consideren "normals", tot i que afecten al procés d'aprenentatge i al procés de construcció dels models científics escolars.
2. La ciència escolar, de forma similar a la ciència erudita és androcèntrica, és a dir considera "l'home" el centre de referència o nucli dur de les activitats i pràctiques científiques. Per tant, l'home és el subjecte d'anàlisis en el procés d'ensenyament i construcció dels models científics escolars.
3. L'activitat científica escolar s'articula entorn a un discurs entre l'alumnat i la professora o professor que incorpora instruments mediadors com els estereotips de gènere, de manera inconscient, però "naturalitzada".

4. El procés d'aprenentatge inclou un conflicte emocional i un conflicte cognitiu. Atès que les emocions i actituds de les noies i els nois es presenten de forma diferent, tan pel fa a la naturalesa de les emocions com al seu grau d'intensitat, molt probablement aquestes influeixen de forma diferencial en el procés d'aprenentatge i de construcció dels models científics escolars.
5. La majoria de noies i nois presenten característiques diferencials en les habilitats i experiències prèvies relacionades amb l'aprenentatge científic, fruït del procés de socialització primari i secundari i dels mandats de gènere assignats.

En aquest marc teòric, lògicament la majoria de contextos d'aprenentatge dels llibres de text i materials didàctics són majoritàriament androcèntrics. És a dir posen en primer pla fets i activitats científiques considerades pròpies dels homes i l'anomenada cultura masculina. I això no facilita les millors oportunitats d'aprenentatge dels models científics escolars, tan en les noies com en els nois, ja que s'utilitzen perfils cognitius diferents, en la majoria d'elles i ells. En les noies predominen els perfils cognitius holístics, contextuals, relacionals i interactius,… mentre que en els nois predominen els perfils cognitius teòrics relacionats amb l'abstracció i la separació...

Per impulsar contextos d'aprenentatge inclusius del model de gènere cal treballar amb:

1. Una Ciència escolar no androcèntrica, que no jerarquitza ni valora de forma diferent els fets i activitats científiques associats a les cultures femenina i masculina, en el procés de modelització i en els contextos d'aprenentatge dels models científics escolars.
2. Una Ciència escolar no androcèntrica centrada en l'alumnat, que té en compte les diferències de gènere, que cal diagnosticar en cada classe concreta, però que no acata els mandats de gènere ni els estereotips prefixats.
3. Una Ciència escolar no androcèntrica que treballa de forma equilibrada els fets i activitats científiques considerades pròpies de la cultura masculina i femenina, ressaltant quan sigui possible les aportacions i activitats científiques de les dones realitzades al llarg de la història i en el moment actual, atès que a més serveixen de model de imitació i referència per a la continuïtat d'estudis científics, en les noies i en alguns sectors de nois.
4. Ciència escolar no androcèntrica sense biaix de gènere que promou la gestió i avaluació de l'aula tenint en compte les diferències de gènere, per tal de no aprofundir en els estereotips de gènere. I que diagnostica les diferències en el tipus, grau i forma de manifestació de les actituds i emociones en noies i nois, en el context escolar per a poder reconèixer les diferències en els conflictes emocionals i cognitius en el procés de modelització científica.

Per això, cal promoure contextos sense biaix de gènere amb activitats escolars holístiques, contextuals, relacionals i interactives i no només amb activitats teòriques i que comporten abstracció. Aquests contextos han d'incloure la màxima diversitat d'activitats científiques escolars per potenciar indistintament els perfiles cognitius majoritaris en les noies i nois.

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La inclusión del modelo de género en el contexto

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En diferentes oportunidades, hemos analizado el género y la enseñanza de les ciencias (Izquierdo y otras, 2009) y hemos introducido una mirada no sexista en las clases de Ciencias Experimentales (Fernández y otras, 1995). En el marco del Seminario de Doctorado "Perspectives sobre el context en educació científica: Aproximacions teòriques i implicacions per a la pràctica educativa" quisiéramos añadir una reflexión sobre el modelo de género.

Siguiendo la teoría semántica de los modelos teóricos, el modelo de género agrupa los siguientes hechos:

1. La ciencia escolar se centra en "el alumno", pero varias investigaciones muestran que "el alumno" no se corresponde con la existencia de un sujeto universal que aprende. El alumnado presenta diferencias en función del origen social, familiar o socioeconómico, pero hay una diferencia previa a todas ellas constitutiva de su identidad personal, que es el sexo que se le asigna en su nacimiento. Para ello necesitamos más investigación con datos desagregados.
2. La ciencia escolar, de manera semejante a cómo se construyó la ciencia erudita es androcéntrica, es decir considera "el hombre" el centro de referencia de las actividades y prácticas científicas y el sujeto de análisis para la construcción de los modelos científicos escolares.
3. El proceso de aprendizaje comporta un conflicto emocional y un conflicto cognitivo. Dado que las emociones en las chicas y en los chicos se presentan de forma diferente, en su naturaleza y en su grado de intensidad, éstas muy probablemente influirán de forma diferencial en la construcción de los modelos científicos escolares.

4. En la mayoría de chicas y chicos, las habilidades y experiencias previas relacionadas con el aprendizaje científico presentan características diferenciales, en función de las socializaciones primaria y secundaria. Estas diferencias llamadas en principio de género se convierten ene estereotipos y afectan el procesote aprendizaje y la construcción de los modelos científicos escolares.

En este marco teórico, lógicamente la mayoría de los contextos de aprendizaje de los libros de texto son androcéntricos, en general, es decir ponen en primer plano hechos y actividades científicas consideradas propias del hombre y de la cultura masculina. Y esto no facilita el aprendizaje de los modelos científicos escolares que se realiza siguiendo perfiles cognitivos diferentes, en la mayoría de niñas y niños. En las chicas predominan los perfiles cognitivos holísticos, contextuales, relacionales e interactivos,… mientras que en los chicos predomina los perfiles cognitivos teóricos, relacionados con la abstracción y la separación...

Para impulsar contextos de aprendizaje inclusivos del modelo de género debemos trabajar con:

1. Una Ciencia escolar no androcéntrica, que no jerarquiza ni valora de forma diferente los hechos y actividades científicas asociados a las culturas femenina y masculina, en los modelos científicos escolares.
2. Una Ciencia escolar no androcéntrica que diagnostica las diferencias de género, en cada clase concreta, pero que no acata los mandatos de género ni los estereotipos prefijados.
3. Privilegia de forma equilibrada los hechos y actividades científicas consideradas propias del hombre y de la cultura masculina, resaltando cunado sea posible las aportaciones científicas de las mujeres realizadas a loa largo de la historia y en el momento presente, ya que éstas sirven de modelo de imitación y referencia para las chicas.
4. Promueve actividades científicas escolares y secuencias de aprendizaje, realiza la gestión y evaluación del aula teniendo en cuenta las diferencias de género, para no profundizar en los estereotipos de género.
5. Diagnostica las diferencias en el tipo, grado y forma de manifestación de las emociones en las chicas y los chicos, para poder reconocer las diferencias en los conflictos emocionales y cognitivos.

Para ello, debemos promover contextos sin sesgo de género con actividades científicas escolares que potencien de forma equilibrada los perfiles cognitivos mayoritarios en las chicas y en los chicos. Es decir promueve actividades holísticas, contextuales, relacionales e interactivas y no sólo actividades teóricas y de abstracción.

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