Assessment for Learning in Inquiry Based Science Education

Fornaguera, Cristina Carulla

DOI (link to publication from Publisher):
10.5278/vbn.phd.engsci.00066

Publication date:
2014

Document Version
Publisher's PDF, also known as Version of record

ASSESSMENT FOR LEARNING IN INQUIRY BASED SCIENCE EDUCATION: FROM INDIVIDUALISTIC TO SOCIO-CULTURAL PERSPECTIVES

BY
CRISTINA CARULLA

DISSERTATION SUBMITTED 2014

AALBORG UNIVERSITY
DENMARK

Assessment for Learning in Inquiry Based Science Education: From Individualistic to Socio-Cultural Perspectives

Evaluering for Læring i Inquiry Based Science Education – Fra Individualistiske til Sociokulturelle Tilgange

Cristina Carulla

PhD Thesis

Department of Learning and Philosophy
Aalborg University

March 2013

Thesis submitted: 20 March 2013
Defended: November 29 2013

PhD supervisor: Professor Paola Valero

PhD committee: Professor Luis Radford
Laurentian University, Canada

Associate Professor Malin Ideland
Malmö University, Sweden

Associate Professor Kurt Dauer Keller (chairman)
Aalborg University

PhD Series: Faculty of Engineering and Science, Aalborg University

ISSN: 2246-1248
ISBN: 978-87-7112-197-1

Published by:
Aalborg University Press
Skjernvej 4A, 2nd floor
DK – 9220 Aalborg Ø
Phone: +45 99407140
aauf@forlag.aau.dk
forlag.aau.dk

Printed in Denmark by Rosendahls, 2014

Assessment for Learning in Inquiry Based Science Education: From Individualistic to Socio-Cultural Perspectives

Evaluering for Læring i Inquiry Based Science Education – Fra Individualistiske til Sociokulturelle tilgange

CV DESCRIPTION

Cristina Carulla is a researcher in mathematics and assessment at IRDP — Institute of Pedagogical Research and Documentation in Neuchâtel, and is collaborating as specialist in education at 'Enfants du Monde' in Geneva. She has a professional degree in Mathematics and epistemology of science from Paris VIII, a Master in Mathematics education from Paris VII, a Master in Education from Andes University in Bogota- and a PhD degree in Technology and Science of the Faculty of Engineering and Science from Aalborg University in Denmark.

Her professional experience as a professor, researcher, project leader and teacher educator at "Universidad de los Andes" in Bogotá Colombia, at Aalborg University and at IRDP focuses on the area of mathematics and sciences education as well as in evaluation and assessment. The main interest and publications of her research and teacher education have being on learning functions in mathematics with technology, the role of representations in mathematics learning, the process of learning citizenship competences trough inquiry and assessment of inquiry learning.

She has communicated her work in international research meetings such EAPRIL 2013, and ICAP 2014, and realized publications such a chapter in the book *Educación para el siglo XXI* in 2011, from the CIFE at Andes University. She is a member of the SMERG -Mathematics Education Research Group of Aalborg University- and the SSRDM —The Switzerland society of mathematical didactics-, and the ADMEE —The international French speaking association of assessment and evaluation in education.

To Alejandro, Mateo and Miguel

Table of Contents

ACKNOWLEDGMENTS

I acknowledge that this thesis is a product of my effort and thinking but also that it has been possible because of the support, ideas, images and generosity of many people and institutions around me. I will explicitly mention some of them, but I know that there are many more people involved and I hope that those reading these first pages, even thought they might not be mentioned, will know they made part of this process and that I am gratefully.

I am particularly grateful to my family that allowed me to fly away and focus my life on the research process. But also I say thank you to Alejandro, because he was there supporting me every day, making being far from my country and family bearable, and sharing passion for knowledge, psychoanalysis, music and the arts. I also recognize the effort made by Mateo and Miguel to support and encourage me to finish this process.

Other members of my family were important in this process. Olivier Chouchena contributed with his knowledge about philosophy, his books, and his abilities to find relevant information in relation to my inquiry. I also acknowledge the support of Martha, Daniel and Emmanuel Chouchena by opening their house in Switzerland each I needed the warmth of family. I also say thank you to my brothers and sisters that took care of the family and the last days of my sister Marta Carulla.

The arrival to Aalborg University, the possibility for me to do a PhD, and all the support needed in order to finish the thesis were given by Paola Valero, my friend, Aalborg family, and supervisor. She told me when I started the research that she believes that to learn is to change the identity. I hope that my teacher educator identity is now transformed to a research identity. I thank her for that and acknowledge that without her, this thesis would never have been achieved. I say thank you for the excellent academic advice, the affective support and for all the editorial work done on my writing.

I am especially grateful to Inés, the teacher that opened her classroom and walked with me in the research process. I learned with her a new meaning for the role of socio-cultural context in assessment for learning within IBSE frame. Thank you. I also acknowledge the generosity of the educational institution

where I did my research and all the administrative people that made experiencing the everyday activity in a classroom possible. I also thank the 42 children of the classroom because they received me with an open mind, they supported me, they assisted me, and they showed their natural way of being in their classroom.

I received technical support for my writing. I acknowledge the work of Veronica Fornaguera, and I thank her for being there all the time I needed. I acknowledge the support of Anne Marie Truscott de Mejía, Mateo Rojas, Paula Melendez, Paola Valero and Susana Borda Carulla. I also acknowledge the grate work done by Catalina Sandoval transforming pictures of events from IBSE Colombian classrooms to the representation of the spaces in chapters eight and ten. I acknowledge Martin Krabbe and Anne-Mette Bladt for their translation of my abstract to Danish, and the technical support of Pedro Gómez in the construction of the final document.

I acknowledge and thank the readers of my work, Ole Ravn, Malin Ideland, Luis Radford, Kurt Keller and Paola Valero.

I also acknowledge that the ideas of inquiry and assessment for learning that are in my thesis were learned from many researchers, teacher educators and teachers belonging to the Latin America, American and French inquiry network. I particularly recognize that my knowledge came from the academic interaction with teacher educators of the IBSE projects. I acknowledge their generosity by sharing their knowledge of Karen Worth —she taught me the most important ideas about inquiry—, María Ruiz-Primo, Richard Shavelson and Wynne Harlen —they opened the door of assessment for learning in the IBSE context—.

But I also recognize that with out all the teachers that participated in my workshops, my knowledge would only be theoretical. It is in the interaction with those teachers, and by visiting their classrooms that I learned to contextualize my knowledge. Then, I say thank you to the teachers from Colombia, particularly Ruby Gil, Nuri Quintero, Sonia Hernández, Yudy Carrillo —I took inspiration from their work to illustrate Inquiry-based teaching—, and many others that contributed to my learning process of IBSE. I acknowledge also that I learned from teachers in Panamá, Bolivia, Perú, Denmark and Chile.

I acknowledge that some scholars at the PhD courses impacted my thinking particularly: Paola Valero, Ole Skovsmose, Luis Radford, Michael Roth, Etienne Wenger, Roger Säljö and Phil Scoth.

I also acknowledge the institutional support given by Annette Lorentsen, Paola Valero, and all the administrative staff from Alborg University, and Carlos Angulo, Juny Montoya, Jose Rafael Toro and administrative staff from Universidad de los Andes. I also thank the support of Matthis Behrens from IRDP.

Finally, I want to say thank you to my colleagues and friends that made the every day at Alborg University a good moment to think and to be: Paola Valero, Martin Krabbe, Jette Reuss Schmidt, Annica Andersson, Peer Daugbjerg, Karin Højbjerg, Alexandre Santos Paiz, Diana Stenford, Carola Hernández, Margarita Canal, Lars Domino, Maziar H. Etemadi, Nanna Friche, Lone Krogh, Ulla Burskov and Palle Rasmussen.

ABSTRACT

The research is situated within the field of science education and assessment. In particular, this study concerns Inquiry Based Science Education —IBSE— and assessment for learning research. IBSE research and practice have been producing an ideal classroom scenario envisioned to support learners' conceptual change of school scientific concepts. It is expected that the child learns by testing explanations and ideas about natural phenomena, through the interaction with objects, reflection and sharing of ideas about observations with peers and the teacher. Assessment for learning is the series of activities that teachers and learners engage in, with the aim of producing valuations and judgments about the work of children in IBSE science classrooms. The purpose of assessment for learning is to enhance learning by giving feedback and transforming teaching accordingly.

Nowadays assessment for learning and IBSE are both research fields and associated pedagogical proposals having an impact on a diversity of countries, cultures and educational systems. Organizations such OECD, and Science Academies "Inter Academic Panel" —IAP— have been promoting the adoption of these ideas and their implementation in many countries as a way to tackle the apparent disinterest of youth in studying science. These expert organizations as well as the researchers supporting IBSE and assessment for learning expect that these pedagogical perspectives can be transferred, implemented and developed within the diversity of educational systems that characterize each country in the world. Thus, the IBSE Network, a group of scientists, science education researchers, science teacher educators and practitioners in different countries developing and practicing IBSE, provides activities and materials that support teachers' implementation of IBSE principles. More often than not, however, the good and clear intentions of these people come to be transferred and implemented unproblematically by the many teachers who different national IBSE projects target. The interest in the topic of this study emerged from the researcher's experience in a Colombian IBSE teacher education project, and the difficulties faced by the researcher as teacher educator when trying to communicate to the teachers the ideas of those pedagogies.

This research studies assessment for learning and Inquiry Based Science Education as historically constructed discourses in a process of social interaction among researchers, teacher educators and teachers. Discourses are the formulations in written and spoken language that repeatedly express and construct the actions and values conforming educational practices. Assessment for learning in IBSE is a discourse emerging at the meeting of discourses on assessment for learning and discourses on IBSE. The educational discourses of the IBSE Network that I studied are influenced by other discourses about how learning happens and should happen based on developmental psychology, cognitive learning theories, educational assessment and, science education research.

Instead of constructing the thesis around a particular problem and well-delimited questions, the research is structured as an exploration of a research 'problematique' (Warfield & Perino, 2009), which spans a fil of different argumentations by which the object of research is approached and configured during the inquiry. The problematique includes purposes and significance, background information related to the need for the research, as well as background information and rationale for the research showing the complexity of the social phenomena under study. The problematique was delimited by the needs to research within the field of assessment for learning and IBSE, to understand the complexity shaping classroom activities across diversity of socio-cultural conditions, and to explore my subjective changes when adopting socio-cultural theories of learning.

It seems problematic that ideal discourses about Inquiry Based teaching, learning and, assessment do not consider the classroom practice as social and cultural phenomena. The ideal activities of teachers and learners are clean of social and cultural conditions that shape everyday activities at school. It seems as if the environment where those practices are envisioned to occur is neither taken into consideration to design and plan the teaching, nor to describe the ideal activities within the IBSE principles. I expected that socio-cultural theories of learning would have tools to consider socio-cultural everyday conditions of the teacher and students, when including in their current school practice assessment and inquiry-based teaching and learning principles.

I configured the research objects in my probelmatique with the use of cultural-historical activity theory (Leontyev, 2009; Roth & Radford, 2011). There are three research objects and needs that make part of the problematique. The first one is the characterization of assessment for learning within IBSE research as a social activity. I explored researchers' modes of reasoning with theories of learning and the constitution of their research objects. The second one is the characterization of my process of transformation in order to participate in this social activity. I explored my changes from researching assessment with an individualistic perspective towards researching it with socio-cultural

perspective. The third one proposes a cultural-historical way of thinking about assessment classroom activities, when it is recognized teachers and students modes of life situated in a set of socio-cultural conditions.

Methodologically, this research follows a critical paradigm. Assessment for learning within IBSE research was identified as a 'social activity' and its corresponding 'object/motive' (Leontyev, 2009) that could be shaped by concepts coming from cognitive learning approaches or socio-cultural ones. The study captures and promotes the cognitive and epistemological changes of the researcher, initially immersed in cultural sensibility focusing assessment activity in mental processes, with its understandings in order to open the possibilities to appropriate socio-cultural concepts, assumptions and tools to use them in constructing, from a critical perspective (Skovsmose & Borba, 2004), a hypothetical situation of assessment for learning within an inquiry-based classroom. Five analytical strategies, identified as *sensibility spaces* (Radford & Empey, 2007), were conceived as spaces for subjective change. Cultural sensibility (Radford & Empey, 2007) was interpreted as the researchers process of learning in constant interplay of objectification and subjectification (Radford, 2008).

There are three major contributions of the thesis. The first is the identification of diversity of learning spaces within inquiry-based classroom where individuals' interactions are considered as joint actions in terms of Radford and Roth (2010), recognizing the inseparability of collective an individual consciousness. There is a theoretical proposal to conceive assessment for learning activities within inquiry-based classrooms from as a cultural-historical activity theory perspective (Roth & Radford, 2011). There is an attempt to move from considering learning as an individual cognitive process towards a considering it as a subjective change in a dialectical movement of objectification and subjectification (Radford, 2008) within collective spaces were learners' subjectivities are shaped.

The second is the description of researchers' subjective change based on Radford' and Empey's (2007) view of the self and social praxis. Three categories objectified the process of the researcher's learning: Naturalizing, De-naturalizing, and Producing. *Naturalizing* involved several mechanisms of the researcher's learning process: identifying assumptions, differentiating assumptions and linking assumptions with ideas found in assessment for learning and IBSE researchers' artifacts. *De-naturalizing* is the mechanism of the researcher's learning constituted by the identification of researcher ideas; the questioning of these ideas linked with socio-cultural assumptions; and disturbing the ideas by living classroom everyday activity and re-construct the events in the light of socio-cultural assumptions. *Producing* is the learning mechanism by which the researcher explored the implications of the assumptions in the configuration of assessment classroom activities.

The third is the description of two forms of subjectivity doing research on assessment for learning, and the implications of this for researching assessment for learning within inquiry-based classrooms. Assessment for learning within IBSE is mainly portrayed as a research field using results of psychology and developmental theories based on a cognitive approach, and supported by a socio-constructivism paradigm. Learning is conceived as individual brain processing using environmental feedback (social and natural) to build the individual's concepts, reasoning and ideas about natural phenomena. This is named the *individualistic view* of assessment for learning in IBSE. This view is contrasted with a *socio-cultural view*, which proposes to research assessment for learning using theories such as situated cognition, and socio-cultural theories of learning. Learning is viewed as the collective process where the individual's subjectivity changes while is interacting with others. Knowledge is considered as constituted by artifacts with meanings constructed by individual involve in a social activity, with forms of social relations, beliefs and validated forms of production by individuals engaged in the activity.

RESUMÉ

Denne undersøgelse har sine rødder inden for forskningsfeltet naturfagsundervisning og evaluering. Endvidere har dette studie særlig fokus på undersøgelsesbaseret naturfagsundervisning - IBSE - og formativ evaluering. IBSE er et akronym for Inquiry Based Science Education. IBSE-forskning og praksis har resulteret i et ideelt klasserumsscenarie, som har været anvendt til at støtte elevers forståelse for videnskabelige begreber. Det forventes, at barnet lærer ved at teste forklaringer og ideer om naturlige fænomener gennem anvendelse af objekter, refleksion og deling af ideer om observationer med andre elever og læreren. Formativ evaluering er en række aktiviteter, som lærere og elever engagerer sig i med det mål at værdisætte og vurdere elevernes arbejde i naturfagsundervisning organiseret efter principper fra IBSE-didaktikken. Formålet med formativ evaluering er at forstærke læring i en formativ proces ved at give løbende feedback og tilpasse undervisningen.

Formativ evaluering og IBSE er forskningsfelter, som gennem forskellige pædagogiske programmer har en indflydelse i forskellige lande, kulturer og uddannelsessystemer. Organisationer som OECD og Videnskabernes Akademi Panel (IAP) har været med til at fremme implementeringen af disse ideer i mange lande som en måde at tackle børn og unges vigende interesse for naturfag i skolen. Disse ekspertorganisationer såvel som forskere, der støtter IBSE og formativ evaluering, forventer, at disse pædagogiske perspektiver kan overføres, implementeres og udvikles i forskellige uddannelsessystemer. Derfor tilbyder IBSE-netværket (En gruppe naturvidenskabelige forskere, forskere i naturfagsdidaktik, naturvidenskabelige læreruddannere og naturfagslærere i forskellige lande, som anvender IBSE i undervisningen) aktiviteter og materialer, som støtter læreres implementering af IBSE-didaktikken i deres undervisning. Men ofte bliver de gode intentioner fra IBSE-netværket overført og implementeret ukritisk af naturfagslærere i IBSE-projektet verden over. Interessen for det forskningsmæssige fokus i denne undersøgelse opstod, da forskeren arbejdede i et colombiansk IBSE-projekt. Som læreruddanner oplevede hun mange udfordringer, når hun prøvede at kommunikere med lærerne om de pædagogiske ideer.

Det forskningsmæssige fokus er formativ evaluering og IBSE som historisk konstruerede diskurser i en social vekselvirkning mellem forskere, læreruddannere og lærere. Diskurser er det skrevne og talte sprog, som gentagne gange udtrykker og konstruerer handlinger og værdier, der former uddannelsesmæssige praksisser. Formativ evaluering i IBSE er en diskurs, som opstår i mødet mellem diskurser om formativ evaluering og IBSE. Den uddannelsesmæssige diskurs om IBSE-netværket, som jeg undersøgte, er under indflydelse af andre diskurser om læring baseret på udviklingspsykologi, kognitive læringsteorier, evaluering og naturfagsdidaktisk forskning.

I stedet for at bygge denne afhandling op omkring en problemstilling og et velafgrænset forskningsspørgsmål, er forskningen struktureret som en eksplorativ udforskning af et problemfelt: "Problematique" (Warfield & Prino, 2009), som udspænder et felt af forskellige argumentationer, der er genstand for forskningsprocessen. Problemfeltet konfigureres i løbet af udforskningen. Det omfatter både formål og signifikans, baggrundsinformation, som relaterer til forskningsbehovet, så vel som baggrundsinformation og rationaler for forskningen, som viser kompleksiteten af det sociale fænomen, der undersøges. Problemfeltet er afgrænset af behovet for forskning i formativ evaluering og IBSE for at forstå den kompleksitet, der former klasserumsaktiviteter under forskellige sociokulturelle rammer, og for at udforske min egen forandring, når jeg anvender sociokulturelle læringsteorier.

Det virker problematisk, at ideelle diskurser om undervisning designet efter IBSE-didaktikken, læring og evaluering ikke inddrager klasserumspraksis som sociale og kulturelle fænomener. Den ideelle interaktion mellem lærere og elever er renset for sociale og kulturelle forudsætninger, som former hverdagsaktiviteter i skolen. Det virker som om konteksten, hvor disse praksisser foregår, ikke medtages i design og tilrettelæggelse af undervisningen, heller ikke når man skal beskrive ideelle aktiviteter ud fra IBSE-didaktikken. Jeg forventede, at sociokulturelle læringsteorier ville være et værktøj til at beskrive sociokulturelle betingelser for læreren og eleverne, når undervisningens tilrettelæggelse omfattede evaluering og IBSE-didaktik.

Jeg konfigurerede forskningsobjekterne i mit problemfelt ved at bruge kulturhistorisk aktivitetsteori (Leontiev, 2009; Roth & Radford, 2011). Der er behov for tre forskningsobjekter i problemfeltet. Det første er en karakteristik af formativ evaluering i IBSE-forskningen som en social aktivitet. Jeg undersøgte forskeres argumentationsmodus med læringsteorier og konstitutionen af deres forskningsobjekter. Mit andet forskningsobjekt var karakteristikken af min egen transformationsproces for at kunne deltage i denne sociale aktivitet. Jeg udforskede min egen undersøgelse af evaluering ud fra et individuelt perspektiv til en undersøgelse af evaluering ud fra et sociokulturelt perspektiv. Mit tredje forskningsobjekt foreslår et kulturel-historisk perspektiv på evaluering af

klasserumsaktiviteter, som anerkender lærerens og elevernes livssituation som sociokulturelle betingelser for undervisning og læring.

Metodologisk er denne forskning placeret i det kritiske paradigme. Formativ evaluering i IBSE-forskning blev identificeret som en social aktivitet og den korresponderende "objekt/motiv" (Leontyev, 2009), som kunne formes af begreber fra kognitive eller sociokulturelle læringstrategier. Studiet indkredser og promoverer kognitive og epistemologiske forandringer af forskeren, som fra starten havde en kulturel sensibilitet, der fokuserede på evalueringsprocesser i mentale processer med en forståelse for at åbne muligheden for at anvende sociokulturelle begreber, antagelser og værktøjer til at konstruere en hypotetisk situation om læring på baggrund af formativ evaluering anvendt i et undervisningsrum organiseret efter IBSE-didaktikken ud fra et kritisk perspektiv (Skovsmose og Borba, 2004). Fem analytiske strategier – identificeret som sensibilitetsrum (Radford og Empey, 2007) – blev skabt som rum for subjektive forandringer. Kulturel sensibilitet (Radford og Empey, 2007) blev fortolket som forskerens læringsproces i en konstant vekselvirkning mellem objektivering og subjektivering (Radford, 2008).

Denne afhandling leverer tre hovedbidrag. For det første identifikationen af mangfoldigheden af læringsrum i et IBSE-orienteret klasserum, hvor individernes interaktion er kollektive handlinger (Radford & Roth, 2010), der anerkender, at den kollektive og individuelle bevidsthed ikke kan separeres. Der foreslås en teoretisk fortolkning af formativ evalueringsaktiviteter i IBSE-orienterede klasserum ud fra en kultur-historisk aktivitetsteori (Roth & Radford, 2011). Der er forsøgt at skabe et ændret perspektiv fra læring som en individuel kognitiv proces til at overveje læring som en subjektiv forandring i et dialektisk samspil mellem objektivering og subjektivering (Radford, 2008) i kollektive rum, hvor den lærendes subjektivitet formes.

Det andet bidrag er beskrivelsen af forskerens subjektive forandring baseret på Radford og Empeys (2007) perspektiv på selvet og social praksis. Tre kategorier objektiverer forskerens læringsproces: Naturalisering, denaturalisering og produktion. *Naturalisering* involverer adskillige mekanismer i forskerens læringsproces: Identificering af antagelser, differentiering af antagelser og sammenkædning af antagelser med ideer om formativ evaluering og IBSE-forskerens artefakter. *Denaturalisering* er forskerens læring konstitueret ved identifikation af forskningsideer, stillingstagen til disse forskningsideer sammenkædet med sociokulturelle antagelser samt forstyrrelse af disse ideer med klasserumsforskning og rekonstruktion af begivenheder med udgangspunkt i sociokulturelle antagelser. *Produktion* er den proces, hvor forskeren undersøger implikationerne af antagelserne i konfigurationen af evalueringsaktiviteter i klasserummet.

Det tredje bidrag er beskrivelsen af to former for subjektivitet ved at lave forskning om formativ evaluering og implikationerne af dette for forskning i

formativ evaluering i IBSE-orienterede klasserum. Formativ evaluering i IBSE kendetegnes hovedsageligt som et forskningsfelt ved at bruge resultater fra psykologien og udviklingsteorien baseret på en kognitiv tilgang og støttet af et socialkonstruktivistisk paradigme. Læring opstår som individuel hjerneaktivitet, der bruger omgivelsernes feedback (sociale og naturlige stimuli) til at konstruere individets begreber, ræsonnementer og ideer om naturfænomener. Dette benævnes *det individuelle* syn på formativ evaluering i IBSE. Dette syn på læring kontrasteres af et *sociokulturelt* syn, som foreslår at forske i formativ evaluering ved at bruge teorier om situeret læring og sociokulturelle teorier om læring. Læring ses som en kollektiv proces, hvor individets subjektivitet forandres, når det interagerer med andre. Viden konstitueres af de artefakter, der tildeles mening af de individer, som er involveret i en social aktivitet. Den sociale aktivitet formes af individer engageret i aktiviteten gennem relationer, overbevisninger og anerkendte former for produktion

1. READING THE THESIS

> Dès qu'il prend la plume, à l'instant même où il fait entendre sa voix, l'écrivain repousse les limites du possible. Son imaginaire fait varier les situations à l'infini, son texte déploie l'éventail du virtuel, son corps se tient un pas de côté, ou un pas en avant, par rapport à notre expérience familière […] Cette puissance d'anticipation ne concerne pas le seul genre de la "science-fiction". Tout récit, parce qu'il nous raconte des histoires, dessine les contours d'un autre monde (Birnbaum, 2010).[1]

Welcome to my research journey. Jean Birnbaum proposes that a narrative tells stories and draws new boundaries for another world. My research narrative expects to push the limits of possible, imagined realities, and challenge common sense. My research text tells stories opening up new possibilities for researching assessment for learning within Inquiry Based Science Education —IBSE. It is a story of subjective *movements* from one paradigm to another, from one learning theory to another, and from one way of conceiving assessment for learning within IBSE to another.

I have been travelling for more than six years in the territory of assessment for learning within IBSE. I have made sense of new experiences and found many worlds that I had never dreamt of before. I went from one text to another, from one idea to another, from one discourse to another, from one conversation with a person to another, from a shared dream with teachers, researchers, PhD students, and friends, to sharing ideas with my supervisor. My

[1] As he takes up his pen, the moment he utters his voice (make his voice heard), the writer pushes the limits of the possible. His (imagination) shuffles situations infinitely, his text deploys the range of the virtual, his body remains one step aside, or one step ahead, from our usual experience [...] This power of anticipation does not only concern the "science fiction" genre. All narratives, because it relates stories to us, draw the limits of another world.

journey took me to different ways of thinking, within Spanish speakers' worlds and then to the universes of French and English speakers.

During this journey, I became a new person, full of different experiences that changed my perception of reality. I invite you to read this thesis as the story of that journey. As in any story giving an account of a journey, I made a selection of texts, pictures, dialogues, and events. I will not tell you the story in chronological order, and neither following a linear reasoning process. I will tell you a new story, a story that happens while I am writing it. At this point of my text, I will justify my choices in a reflexive manner. I hope this narrative will succeed in opening up a new possibility of what assessment for learning in IBSE may be and could be investigated. The most important thing for me is to produce a shared thinking, in which my own thoughts will allow you to think and be part of realities that you had not experienced before. This is the way I am becoming a researcher and the way I want to be.

I adopted a critical research perspective. This choice affected the way I shape the object of study, the relation of myself with the research object, the methodology, the analytical process, as well as the communication of my research. Different researchers in mathematics and science education work within this perspective. It is acknowledged that the theoretical choices and research methodology shape the object of study, and the methodological choices. Researchers working within this perspective make the relevance of considering society and culture explicit in their conceptualizations of mathematics and science classrooms, as well as studying educational change and subjective change away from a psychological approach to learning and mind (e.g. Atweh, 2004; Chronaki, 2004; Cotton & Hardy, 2004; T. Popkewitz, 2004; Roth, 2006a; Roth, 2007, 2005b; Skovsmose & Borba, 2004; Valero, 2007; Valero & Zevenbergen, 2004a). Additionally, practitioners are involved in the research process to understand their own practice, and change is seen as a different perspective from the traditional relation of researcher with the object under study (T. Popkewitz, 2004; Roth, 2005a, 2009, 2005b; Skovsmose & Borba, 2004). I borrow Popkewitz (2004) and Cotton and Hardy's (2004) quotation of Foulcault's words as an illustration of my research work.

> The work of an intellectual is not to mold the political wild of others; it is, through the analysis that he does in his own field [sic], to re-examine evidence and assumptions, to shake up habitual ways of working and thinking, to dissipate conventional familiarities, to re-evaluate rules and institutions and starting from this re-problematization (where he occupies his specific profession as an intellectual) to participate in the formation of a political will (where he has his role as a citizen to play) (Foucault, 1989, pp. 305-306)

My research involves my analysis of the way of researching assessment for learning activity in inquiry-based classrooms, the field where I worked as a teacher educator. During my research, the evidence used by researchers to conceptualize assessment activities and the assumptions were reviewed and questioned, and other evidence and assumptions were used to produce a new conceptualization. These analytical processes allow me to review the implications and consequences in researching assessment for learning activity in an inquiry-based classroom when another theoretical view is adopted. In other words and paraphrasing Foucault, my work as an intellectual in my thesis has been to re-examine the evidences and assumptions of the existing research and practices of assessment for learning in IBSE, to shake my familiarity with them, and re-evaluate their rules for thinking my object of study. It is in this sense that I understand my journey into a world of critique in research that an unknown possibility for me.

In this introductory chapter I will discuss the difference between the organization of this thesis, and the traditional form of doing and communicating research. I will explain the characteristics of the thesis, and the connections with the traditional parts of a PhD dissertation. I will present the rationality of the thesis. The discussion is organized around a set of needs to do the research; ideas used in the thesis about reading, thinking and writing; the selection of a methodological style; the presentation of the analytical strategy underlying the thesis; and the research results and contributions. However, the dissertation is not constructed in that way. The different contents of a traditional thesis —state of the art, background, problem, theory, methodology, results and contributions— are fragmented in several chapters, as I will outline below.

In the first part of the chapter, the notion of *research problematique* is used as the concept illustrating the reasoning in the thesis. Rather than following a linear rationality organized around a problem, hypothesis, questions and objectives, the thesis is conceived from a diversity of angles around a complex social situation. Secondly, the methodological style, analytical reasoning and style of writing are differentiated from the traditional linear academic rationality. The analytical strategy is discussed around the relationship between the knower and the known in a research process. Finally, knowledge produced during the inquiry and the contributions are discussed.

NEEDS OF RESEARCH

In guidelines for the construction of thesis argumentation, it is usual to establish a first chapter where the purpose and significance of the study is presented as well as background information and rationale for the research, background

information related to the need, arguments for the research, and research questions and aims (Monash-University, 2007). However, in this document there is a different manner of guiding and communicating the research. Rather than conducting study guided by research questions, delimitated problem, and aims, the thesis is constructed around a set of argumentations expressing the need of the study. The concept *problematique* is borrowed from traditional French school essays to support the development of this thesis. I understand problematique as a set of argumentations supporting the construction and development of the research.

Warfield and Perino (1999) defined problematique as "a graphical portrayal —a structural model— of relationships among members of a set of problems". It is then more than a delimited problem with a precise question. Furthermore the authors maintain that contemporary scholars "first conceived the idea of the problematique simply as a name for the array of problems confronting the world. It was then extended to represent a structural portrayal applicable to specific problematic situations." (p. 221). The term problematique includes a set of structured or related problems. They finally state that there is "ample evidence to suggest that the unaided human mind is incapable of coping effectively with modern societal issues. The problematique has proven to be highly effective in illuminating the structure that underlies problematic situations, thereby increasing the potential for successful human intervention." (p. 226). Their statements highlight the recognition of the complexity of social issues, which need to be approached from different angles and perspectives, rather than by the formulation of a concise and well-delimited problem and question.

In this research the term problematique is adopted as a set of different argumentations by which the object of research is approached and configured during the inquiry. The problematique includes purposes and significance, background information related to the need for the research, as well as background information and rationale for the research. However this is not communicated in the form of a delimited problem, research questions and aims. The focus is to research assessment for learning activity within an inquiry-based teaching and learning situation at school with a different perspective to the usual cognitive approach. It is then, to create new forms of understanding the object of research. The thesis is supported by three angles. The first one is a set of arguments that justify the need for research of assessment for learning within IBSE; a second one is a reasoning about the need for a new research perspective, different from the cognitive approach, and the consequences of such a change in the conceptualization of a classroom activity; and a third is by analyzing subjective researcher changes when a new theoretical perspective for researching assessment for learning within IBSE is adopted.

The three angles are presented in different chapters and not just in one, as it could be usual for a traditional monograph to do. The angles and rationalities configuring the problematique are explained here as a guideline to understand the structure of the study. The first is constituted by documented arguments of the need for research about assessment for learning within Inquiry Based Science Education, recognizing the diversity of societies and cultures where politicians and scientists expect a change in the educational system. The second domain is an argument focused on creating new forms of understanding for assessment for learning activity within Inquiry-based classrooms. Those new forms of understanding should recognize differences of societies and cultures where inquiry-based classrooms and assessment activities are occurring. Finally the third domain is based on the argument of the need for a change of researcher subjectivity to create new forms of understanding assessment for learning within IBSE, including the diversity of cultural and social environments.

THE NEED FOR THIS RESEARCH

The second chapter of this thesis contains the documented argumentation about the need to research assessment for learning within IBSE. It is conceived as a need to understand educational changes, by teaching teachers established ideals of what classroom practices should be at school. This dimension is conceived as a frame within which the research is driven. However, it is not the intention of this thesis to document the complexity of educational changes in IBSE practices, neither to propose new prescriptive solutions for what to do in practice. At the end of the thesis, in Chapters nine and ten, the knowledge produced in the thesis is used to discuss such complexity in relation to the assessment for learning within IBSE with a socio-cultural perspective and subjectivity change.

Assessment for learning and IBSE are two research and developmental fields having an impact on diversity of countries, cultures and educational systems. It is argued that this kind of pedagogical perspective can help solve problems that educational systems are facing. Diversity of organizations around the world —such as OECD (2009), Inter Academic Panel (IAP) (2011)— expect that the pedagogical perspectives can be transferred, implemented and developed within the diversity of educational systems that characterize each country in the world. However, when we focus our attention on certain developmental projects, it seems that the understanding and uses of such pedagogical tools, produced by research, are not so easy to follow and implement. Teacher educators and researchers face a challenge when teachers are trying to make sense of assessment for learning and IBSE principles in their own practices and educational cultures.

On the other hand, researchers trying to measure the impact of such pedagogical perspectives on student's learning and classroom practices

acknowledge that this kind of measurements can be done only when one can be sure that classroom activities are based on IBSE principles. It is well known by researchers that a change of such dimensions takes time. In particular, it is difficult for teachers to adopt inquiry as a strategy to teach science. The projects around the world are conceived within educational cultures, by researchers and teacher educators of the country, to make sure that those principles and pedagogical tools will be adapted in response to specific cultures of a country. This is the case for projects such as Fibonacci in Europe, and the international network supported by La main à la pâte, the French IBSE project.

By recounting my experience in a Colombian IBSE teacher education project, I show the difficulties faced by myself when trying to communicate to the teachers the ideas of those pedagogies. In my practice, I found difficult to visualize with teachers the objectives of learning to be assessed, the expectation for the inquiry skills of children working in groups, the quality of learning by adopting the IBSE perspective, as well of all those elements in order to assess learning in daily teaching activities. I found out, in my visits to many Colombian classrooms, that teachers had difficulties to notice curricular learning objectives, and children were not working with the scientific concepts and using inquiry skills, as I expected to be given the prescription of the IBSE pedagogical principles. However, I perceived a great impact on the attitude of the children and on their capacities to speak. Some children said they were satisfied with the changes introduced by their teacher in science teaching. As a teacher educator, who had been working with teachers in Colombia and Latin America on how to bring assessments for learning ideas within their IBSE classrooms, I started my research from the discomfort of noticing that teachers expressed difficulties in applying research ideas in their classroom.

Looking at assessment, assessment for learning and IBSE as concepts established in a diversity of geographical areas, it seems relevant to look at individuals' experiences of change. Individuals experience assessment activity differently when they are immersed in different cultures. The traditional summative assessment shapes what most individuals share as being experienced as assessment, and this varies from one country to another. Assessment for learning has been introduced by English-speaking researchers immersed in their own educational culture. However, it is claimed that their conceptualization is the result of looking at different assessment practices in the world. Additionally, what is relevant is that assessment for learning is a new culture for some teachers and researchers. Moreover there are in other cultures terms and concepts of assessment cultures but with some differences and interpretations. Thus, individuals are confronted with a tension when trying to make sense in their practices of such theoretical approaches.

Assessment practices have an impact on the way individuals experience such activity. Depending on the cultural traditions of assessment in the

institutions or in a country, the individual learns to act according to a collective way of perceiving such activity. On the other hand, the history of a child or person brings to the individual a possibility of interpretation that can differ from what the collectivity perceives as such. Assessment activity produces judgments and statements about different things related to the process experienced by individuals in a class. Individuals' experiences with such statements are different and receive particular meanings. Within this panorama one can imagine the complexity when individuals are expected to adopt a new assessment culture. To introduce assessment for learning and IBSE in a culture implies a change in individuals' assessment experiences. Such a change is possible when an individual becomes aware of the existence of other configurations of the assessment activity, other interpretations of feedback, and other assessment cultures. It implies also that they are aware of their assessment and teaching culture. For example, in a study in England, Black, Harrison, Lee, Marshall, and Wiliam (2003) report that teachers struggle with classroom control while giving voice to students in the new perspective on assessment. In a developmental project in Colombia, Suarez et al. (2003) reported difficulties to assess students within the inquiry teaching sequences since it was not possible to do it in the same way as they usually did.

Assessment for learning and IBSE are educational fields that use research knowledge about human learning and development in their conceptualization. In order to merge them it is necessary to use the same ideas about learning. When those conceptualizations arrive at the classroom, in a different educational culture, individuals of that culture are supposed to change their own approach to learning. The political statements envisioning a reform, in the educational system in different countries and cultures, seems to ignore teachers' needs for change. To have a new point of view about learning implies that the individual will experience differently both educational goals and the reality in which they are immersed. As it will be argued, such difference in experience is a great challenge since implies that individuals must experience a great epistemological change. The nature of that change cannot be simply understood as the capacity or lack of capacity of a teacher to implement a new pedagogical method.

THE NEED FOR A NEW RESEARCH PERSPECTIVE

This line of argumentation will be found in several chapters since it is the focus, and the light that guided the research process. Each chapter brings new elements and questions adding understanding to the object of inquiry. The focus of the inquiry was to produce a new form of understanding and thinking the activity of assessment for learning within inquiry-based classrooms. It was expected that a new theoretical approach to such activity would recognize the society and culture where individuals live and act every day at school. For example, it was

observed, during my practice as teacher educator in Latin America, that an inquiry-based classroom activity in Chile was not the same as an inquiry-based classroom activity in France, or a classroom activity in Cali, Colombia, was not the same as one in Bogotá, Colombia. In each region, at the moment in which individuals perform the activity, the inquiry-based classroom activity was different, even if they shared some educational principles in common. This research was aimed at understanding such observations from my own practice as a teacher educator.

I participated for 7 years as teacher educator and researcher in an international network of researchers, designers, teacher educators and teachers using a particular set of principles about how children should learn science in primary school. Those teaching and learning principles are brought together under the guise of *Inquiry Based Science Education* (IBSE). Harlen (2007) presented the core element of IBSE as follows:

> Science education begins for children when they realize that they can find things out for themselves by their own actions: by sifting through a handful of sand, by blowing bubbles, by putting salt in water, by comparing different materials, by regular observation of the moon and stars (p. 2).

IBSE classroom practice should reflect this idea. The expected classroom scenario would be to see children interacting with objects, reflecting on and sharing their ideas with peers and the teacher. The IBSE Network, the group of people in different countries developing and practicing IBSE, provides activities and materials that support teachers' implementation of IBSE principles, introducing changes in their practice towards IBSE ideals.

Within the multiple activities of the IBSE Network, I met *assessment for learning* researchers and had the opportunity to use their ideas in my own workshops for teachers. Those research ideas were based on general statements about assessment for learning research used in the inquiry-based teaching. Assessment for learning understood as activities of the science teacher to produce valuations and judgments about the work of children while engaging with them in daily teaching and learning activities, the purpose of which to enhance learning by giving them feedback and transforming teaching (Ruiz-Primo & Furtak, 2006).

This type of assessment is considered an important part of inquiry teaching. It is needed for supporting the conceptual change of each learner during his/her interactional experiences in the classroom. The conceptualization of this kind of assessment research acknowledges that a subject learns by constructing knowledge based on interaction with others and experience in the world. During the research process it became important to understand the links

between interaction of the child with the world —with natural phenomena and with peers— and the assessment for learning activity.

As it will be documented in the thesis, the existing research activity about assessment for learning within IBSE follows an individualistic line of thinking. Roth and Radford (2011) express such thinking as a view extracting "consciousness, thinking, and psychological process from the individual's mode of life" (p. 1) and considering it abstractly. The research journey intended to bring the individual's mode of life —modes of life of teachers and learners living in Cali, or Chile or France— to the assessment for learning inquiry-based classroom activity. A different theoretical landscape about learning, knowledge and human thinking including this dimension in their conceptualization was needed. The research was looking for a change in the theoretical support for assessment for learning activity in an inquiry-based classroom, and the possible impact of such a different conceptualization in classroom activity. However, in the thesis my effort was put on the work of conceptualizing, and not in trying out the impact of such conceptualization in classroom practice. In this sense, my thesis diverts from what is expected to be legitimate science education research, which is research that tests theoretically prescribed arrangements of practice with the intention of both understanding the affordances and limitations of implementation, but also theorizing further the practice.

THE NEED FOR CHANGE IN RESEARCHER SUBJECTIVITY

The last domain, which constitutes the problematique of the thesis, is a set of arguments postulating a need for change in the researcher's subjectivity. This line of argument is present in different chapters. They constitute the analytical strategy of this research. Since the researcher's starting point was an individualistic understanding of assessment for learning activity in inquiry-based classrooms, it was not possible to conceive of such activity with a new theoretical approach without a change in her own subjectivity. While research literature about teachers' change has focused on the changes that teachers experiment on their views of science or on their believes (Cronin-Jones, 2006; Luft & Roehrig, 2007; Mansour, 2009; Pomeroy, 1993), the change in views of the researchers themselves is seldom addressed. The change in the researcher herself is dealt here not in terms of a simple change in beliefs about learning or shift of theoretical frameworks, but rather as a change in the researcher's subjectivity. For me, this research endeavor clearly became the search for reconfiguring the meaning of assessment for learning within IBSE when adopting theoretical assumptions about knowledge and learning from socio-cultural theories. The analytical strategy was constructed to move the researcher's subjectivity. It became clear that a re-thinking of the "object" of research could not be possible without a deep change in the researcher —

myself— as the subject who is knowing and enunciating that object of knowledge. Radford's cultural theory of learning (2008, p. 225) postulates that:

> [...] learning consists of endowing conceptual cultural objects with meaning. In fact, learning is much more than that. Learning rests on an attitude of open-mindedness: it is an opening movement towards others and the objects of culture. It is worth noticing that this is, in fact, the etymological sense of the term *acquisition*. Acquisition comes from the Latin *adquaerere,* which means *to seek*. In this context, to learn is not merely to acquire something in the corrupted sense of possessing it or mastering it, but to go to culture to find "something" in it. This is why the outcome of the act of learning is not the construction, re-construction, re-production, re-invention or mastering of concepts: its true outcome is to be found in the fact that, in this encounter with the other and cultural objects, the seeking individual *finds herself*. This creative process of finding or noticing something (a dynamic target) is what I have termed elsewhere a process of *objectification* (Radford, 2002).

As understood here, objectification thus is more than the connection of the two classical epistemological poles, subject and object: it is in fact a transformative and creative process between these two poles, where, in the course of learning, the subject objectifies cultural knowledge and, in so doing, finds itself objectified in a reflective move that can be termed *subjectification*. The making of the subject, the creation of a particular (and unique) subjectivity is thus a process of subjectification that is made possible by the activity in which objectification takes place, and by the *re-flective* nature of thinking and the possibilities that e.g. language and other cultural instruments of thought offer to distinguish between an "I" and its surroundings (I/non-I; I/you; I/it; we/them, the impersonal discourse of science, etc.).

Learning is thought of as an open-minded process where subjects meet the objects of culture and, while acquiring them, are at the same time becoming subjects. He formulates the inseparability between the subject of knowing —the knower— and the object of knowing —the known. If the activity of researching is seen as the process of a researcher learning and coming to know something about an object, then it is possible to think that there is an inseparability between the "objectification" of the objects of research and the researcher's process of subjectification.

Paraphrasing Radford's words above, research can be seen as a the transformative and creative process where, in the course of the study, the researcher objectifies cultural knowledge and, in so doing, finds herself subjectified. The outcome of the research process (the act of my learning) is not only the construction, re-construction, re-production, re-invention or mastering

of concepts produced in assessment for learning within IBSE research. The true research outcome is to be found in the fact that, in the encounter of the researcher with the other and new educational research objects, she found herself —I found myself—, a new person with new possibilities of doing research, of perceiving the world, and of thinking. In that sense, the process of objectification in the thesis must be regarded as a creative process of finding or noticing something and changing the researcher's possibilities of being.

READING, THINKING AND WRITING

In a traditional thesis some research activities are identified that need to be reflected in the structure of a written document. The presentation of the inquiry usually requires a certain linearity: the presentation of the problem, research questions and aims, the development of a literature review, the presentation of research paradigm, methodology and theory, the description of the analytical process, and the presentation of results, discussion and conclusions (Monash-University, 2007). The researcher's activities of reading, thinking and constructing rationalities are materialized in this way. Those aspects frame the intellectual process that support the knowledge produced during the process.

MATERIALIZATION OF THE RESEARCHER'S READING ACTIVITY

In this thesis another path is followed, as can be seen in the way the activity of the researcher's reading is materialized in the written text. This important activity is understood as activities of the researcher's need for subjectivity change and understanding. The researcher's reading was aimed at different objectives which can be summarized in the following manner: to characterize the object of research, to support the need for research and methodological choices, to carry out the analytical strategy, and to characterize the research activity of scholars investigating assessment for learning. In that sense, there is not a literature review chapter as such, or theory, or background. There are several activities materializing reading inside each one of the chapters.

In the second chapter the literature review presented supports the choice of the research field. There is a first review to present assessment for learning and IBSE as well as to create arguments for researching assessment for learning and IBSE. In the third chapter, theoretical educational research concepts support the methodological choices. An analytical review is carried out in the fourth chapter, as part of the methodology. It allowed the researcher to characterize the line of thinking behind scholars carrying out research in assessment for learning within IBSE, and distinguish it from the socio-cultural research perspective. In the fifth chapter, scholars' texts and ideas are read to identify and document the

individualistic perspective dominating assessment for learning research within the practice where the researcher was involved. From that analytical process, some questions emerge when analyzing it from a socio-cultural perspective. In the sixth chapter some concepts and ideas supporting assessment for learning and IBSE scholars' are questioned by looking at literature in different fields. In Chapters seven and eight there is reference to some researchers' ideas to support the analysis. Finally, in Chapters nine, ten and eleven, the literature review is used to shape the results, the discussion and the conclusions.

RESEARCHER'S THINKING

I am aware that my research process is not linear. I did not want to express ideas and summarize others' research findings. I read and constantly ask myself how I could change my view of the world and understand differently the possibilities of research by looking at others' ideas. I avoided writing concepts or thoughts that I had not experienced or understood.

I was inspired by the concept of network thinking used by Abadi (2007), conceived by her as spaces of collective thinking. In the forms of doing research activity that I had been educated into and I had belonged to at the beginning of my inquiry, research was a logically related sequence of activities that tended to acquire the form of linear process of thinking. That kind of thinking is described by Abadi (2007) as disturbing some kind of creativity and innovation:

> La educación formal, desde la escuela hasta la formación académica, nos condiciona a un pensamiento lineal, que establece sólo conexiones lógicas, secuenciales y relaciones de causa-efecto. Para esto, se suele recortar la tendencia natural de los niños a percibir y pensar en Red. Así, se nos enseña a discernir, analizar, descomponer un problema en sus diversas partes. A discriminar lo verdadero de lo falso, la fantasía de la realidad, lo posible de lo imposible, lo coherente de lo disparatado. En esta poda, vamos mutilando nuestro pensamiento más imaginativo, intuitivo y creativo, ese que se atreve a creer y crear más allá de las reglas establecidas.[2]

[2] The formal education, from the school to the academic formation, conditions to a linear thought establishing only connections logics, sequential and relations of cause-effect. For this, usually one stands out the natural tendency of the children to perceive and to think in networking. Thus, it is taught to discern, to analyze, to disturb a problem to us in its diverse parts. It is, to discriminate the truth from the false, the fantasy from the reality, the possible from the impossible, and the coherent from the crazy. In this pruning, we are mutilating our more imaginative, intuitive and creative thought, that dared to believe and to create beyond the established rules.

For her, the individual's trajectory through the educational system enculturates people in a kind of thinking that somehow closes the door to other possibilities of thought. Academic thinking is seen as linear, looking for logical sequences and relations of cause effect, and shutting down "network thinking". She proposes a 'network thinking' or 'pensamiento en red' concept opening the field of research by acknowledging some diverse and versatile unconscious processes giving a non-ending capacity to bring new links to the network of knowledge. This kind of thinking, aims at an individual mind using the ideas of others and making new connections, always in an interpersonal space connecting minds in a process of thinking:

> La creatividad que lleva a la realización innovadora no acontece dentro de la mente de una persona, sino en el espacio interpersonal. El funcionamiento de los equipos de trabajo, cuando las mentes están realmente conectadas, comienza a sintonizarse potenciando la creatividad a la manera de una banda de jazz o un equipo de fútbol.
>
> Las teorías sobre la conectividad del pensamiento nos llevan a comprender e imaginar la posibilidad de capitalizar y utilizar el saber circulante en una civilización no solo haciendo uso de la información disponible, sino fundamentalmente a través de la capacidad de entrar en sintonía con las ideas de los otros.[3]

My research process must be seen as my effort to build a capacity to enter into sympathy with others' ideas. I saw my inquiry as possible in the interpersonal space, as presented by Abadi, where I lived and experienced research during my PhD. As member of the Science and Mathematics Education Research Group (SMERG) at Aalborg University, I was immersed in an interpersonal space appealing for diversity of creative ways of doing research, and new forms of understanding. So my thinking in the thesis was influenced by this collective space of thinking. But also, my possibilities were enriched by all those researchers' thoughts and texts that I encountered during my PhD: This other collective space of thinking touching my mind. At the same time, in my private space, I also had opportunities of being in contact philosophical, art and psychoanalytical ideas that also impacted my way of thinking in this thesis.

[3] The creativity that takes to the innovating accomplishment does not occur within the mind of a person, but in the interpersonal space. The operation of the work parties, when the minds really are connected, begins to tune itself harnessing the creativity to the way of a band of jazz or a football team. The theories on the connectivity of the thought take to understand and to imagine the possibility to us of capitalizing and of using the circulating knowledge in a civilization not only making use of the information available, but essentially through the capacity to resonate with the ideas of the other.

For my thesis and the inquiry I engaged with the attempt in breaking the linearity is reflected in the structure of this document. My thesis needs to be read with this perspective in mind. Do not expect to find linear thinking, following a strict and necessary logical sequence. This does not mean that the thesis is incoherent, but rather that I strived for a different form of coherence. I used the ideas of others in order to think in a different way, to challenge myself to bring the social and cultural into the research field of assessment for learning within IBSE. I bring to my writing pieces of texts that move my current way of perceiving the world and reality of the assessment for learning within IBSE during my experiences.

DIVERSIFYING THE WRITTEN STYLE

The reader of my thesis should expect a text that reflects my inner-self: my new way of perceiving research and knowledge. Krieger (1991) expresses what I am trying to say and become while I write my thesis. She argues that when

> [...] we discuss others, we are always talking about ourselves. Our images of "them" are images of "us". Our theories of how "they" are like, are, first of all, theories about ourselves: who we are, how we act, and what we are like. This self-reflective nature of our statements is something we can never avoid. (p. 5)

These kinds of words invited me to construct a text that is different from the established academic, objective and detached, 3rd person genre of research. Such choice expressed my wish to be different as a researcher. For Krieger (1991), when a researcher is talking or writing about a subject of study, he/she cannot be detached from the subject of study. She shows the relevance of being aware that when a researcher talks about a social process, he or she must be considered a part of what is being studied. Krieger rejects the idea that in social science the self is a contaminant, separated from the thing under study, as if the observer had to be neutralized, minimized, standardized, and controlled. She works with the idea that "our studies are reflections of our inner lives" (p. 1).

From a disembodied research approach to construct my inquiry, I traveled towards possibilities opened by an embodied one. I decided to be a self-researcher tied to the objects and subjects that I am studying. I cannot see myself detached from meanings constructed during my experiences and participation in assessment for learning and IBSE practices. Several years as a practitioner within the Latin American IBSE network, and my engagement in activities, have shaped what I can say in my research. The texts I chose to look at, the images I decided to present and analyze, the way I configure and represent the phenomenon of study, are products of my inner life and reflect my way of perceiving IBSE reality.

I bring my experience to my text because it is part of my research. It is part of my change in my subjectivity. I present others' ideas, re-interpret and re-describe them. I present ideas about assessment for learning within Inquiry Based Science Education through my own experience and meaning making. When re-interpreting and re-describing Krieger's words, by presenting other researchers' work and shared experiences in a school in Bogotá within the IBSE context, and expressing new possibilities for the research field in IBSE, I am talking about myself. My images of "them" are images of myself. My theories of how "they are", are, first of all, theories about myself: who I am, how I act, and what I am like. This is the way I am becoming a researcher.

Based on the fact that my subjectivity is involved in the construction of the thesis, I decided to bring my voice and subjectivity into the text. I consider that my experience in the IBSE network and assessment for learning impact what I research, how I research, and what I can say. My thesis does not present an object from a social reality "out there" that is clearly delimitated and that is independent of me as a knower. I am presenting "what is not there", but that can be given my construction of such a possibility.

This is reflected in the way I wrote and structured this document. I wrote chapters with different styles and using the first person as a way to make visible the involvement of myself in the research process and in the object of research. The document is structured to show the research process, the knowledge emerging from my inquiry, and the changes of my own subjectivity. Some times the "I" is used to express the involvement of the self and the relation with the object of research. It is used to make visible my own experience when it is needed. In other parts, the "I" disappears to indicate a distance of the researcher from the objects that are presented.

METHODOLOGICAL STYLE

A methodological chapter is identified as relevant to the development of a PhD dissertation. Different dimensions are subsumed within the methodology. What is generally expected is a discussion about the epistemology of the research, the rationality for the methodological approach, and a description and justification of methods of research, all this supported in literature (Monash-University, 2007).

These issues are referred in Chapter three as a movement of researcher subjectivity. This is supported by the fact that it was assumed a critical research paradigm. Since in this perspective it is relevant to understand subjective as well as societal changes (T. Popkewitz, 2004; Valero, 2004b), it became a necessity for me to identify my configuration of assumptions, based on my historical

experience within a networking of IBSE practitioners. My research methodology was constructed to move the initial possibilities of researcher's thoughts and actions within a cognitive IBSE cultural theoretical approach. Thus, it is important to make this movement explicit as it is part of the research process.

Assessment for learning within IBSE research activity produces knowledge that teacher educators and researchers use in their workshops with teachers. As mentioned before, the thesis started with my discomfort when looking at teachers' difficulties in adapting such research-based ideas. Scholars with a critical perspective recognize a need to carry out research in education within a different paradigm. This is because there is an acknowledged need to understand the gap between research results and practice (Atweh, 2004). For instance, it is identified a failure of research and curriculum to reach mathematics classroom praxis. Atweh (2004) argues that a new paradigm is needed in classroom research, which empower teachers to research their own questions and needs. This is recognized as a production of emancipating knowledge, that is, a research based knowledge producing changes in practice. Here I identify as a teacher educator and researcher following my questions and needs as a practitioner.

This research is based within a critical paradigm since it is the result of the need to understand my practice as teacher educator and researcher, and the difficulties I faced when teaching research knowledge. To understand critical paradigm is to acknowledge a need of emancipatory knowledge giving individuals possibilities to change their reality (Atweh, 2004). Atweh's (2004) quotation of Adler (1996) words help me to give an account of my expectations:

> [...] Students taught and assessed in traditional ways, learn to demonstrate that they have encoded the culturally approved knowledge and can reproduce it. Those who learn about teaching through reading about education research develop knowledge of a similar kind. In neither case is the knowledge necessarily a basis for further action or a changing personal view of reality. (p. 190)

Behind those words there is the idea of different kinds of knowledge, one knowledge that can be encoded and reproduced by students and teachers — culturally approved—, and knowledge that individuals need for action and to change views of reality. This could also be the case for teacher educators. There are also other kinds of knowledge that individuals may need for further action or changing views of reality. When as teacher educators we attempt to ensure that teachers will learn assessment for learning principles and use them in their teaching through inquiry, we do not consider the individuals' desires and needs for change, neither recognize their practical knowledge. In my experience, I learnt to use inquiry-based tools, to teach with them, to create experiences of

learning for teachers, and to change my view as educator. However, a new understanding was needed to identify innovative possibilities of action and change of subjectivity. What is needed is knowledge that brings light in understanding the individual process of subjective change. By doing this, the challenge faced by educational programs aiming to support new possibilities of teaching and learning based on research knowledge will be better understood.

The subjective changes of me as a researcher are used to communicate the epistemological perspective in the research, as well as the paradigms that were adopted. I recognize that my subjectivity movements are not possible to completely put into a rigidly organized frame. My claim is that a paradigmatic change in the individual subjectivity is a movement and not a state, as traditional ways of presenting seems to imply. As it will be argued, a subjunctive process of change is complex and is not clearly delimited. Changing subjectivity is always in movement.

The theory supporting the methodological choices, in accordance with the critical paradigm, is presented as a conceptual tool shaping the methodological activity. There is not a chapter including all the theoretical elements used to support the research. The principal theoretical elements are introduced in Chapter three, and will be used in different chapters to shape the research knowledge.

MOVING BETWEEN RESEARCH PARADIGMS

During the research process I noticed different ways of defining reality, connecting the researcher with the object of researching, planning and conducting a research study, and defining the research object. In this process of noticing diversity of cultural thinking and theoretical perspectives, I challenged myself to disturb my subjectivity. This meant changing my learned way of doing research and perceiving the researched object towards other possibilities. In that sense by changing my subjectivity I expected to be able to shape assessment for learning within IBSE including the role of culture and society in the conceptualization of learning.

I changed my perception of reality by becoming aware that others do not perceive the world in the same way I did. I noticed how the societal configurations in which I moved constrained my possibilities of being. I also modified my perception of the natural and social worlds. At the same time, I became aware of the strong connection between the self, knowledge and culture. I traveled from a positivist paradigm towards a critical paradigm, adopted to reflect my own vision of assessment for learning within IBSE, my assumptions, and moving towards new possibilities of thinking and being in this area. Finally, I advanced from my individualistic form of shaping assessment for learning within IBSE towards a socio-cultural form. I struggled with my view of learning

looking for changes in individual mind, towards a view perceiving learning as a movement happening in the activity made possible by the interaction of individuals.

USING THEORY

In Chapter three the theoretical concepts supporting the research process are presented. They are explained while I am using them to shape my research process. In that sense, there is not a section where all the theoretical elements are presented. There cannot be! As mentioned before, I thought of objects found in the culture, and I connected what I needed with what I was reading. I needed a theory to support the use of my experience and my subjectivity in the process of researching. I also needed a theory within a socio-cultural perspective with conceptual tools helping me to shape assessment for learning activity within inquiry-based classrooms. On the other hand, I also needed methodological tools within in critical paradigm. Additionally, I needed concepts that resonated with science and mathematics education.

I supported my research process adapting ideas from the theory of objectification and subjectification (Radford, 2002, 2008), activity theory (Leontyev, 2009; Roth & Radford, 2011), critical research (Skovsmose & Borba, 2004), and discourse (Fairclogh, 2001; Fairclough, 1992, 2001; Gee & Green, 1998; Rogers, 2004; Valero, 2007). I used objectification and subjectification theory to create five scenarios where my subjectivity was triggered, disturbed, and pushed towards new forms of knowing and understanding.

I looked at assessment for learning within IBSE research as a 'social activity' and its corresponding 'object/motive' (Leontyev, 2009) that can be shaped by concepts coming from cognitive learning approaches or socio-cultural ones. In each scenario, I identified 'actions' and 'operations' with specific goals (Leontyev, 2009) having in mind the object/motive. I used a critical point of view in each scenario to perceive assumptions and situations that could be different if we change those assumptions, and to create a hypothetical formulation of an activity of assessment for learning within IBSE classroom, using my new form of knowing and understanding —with socio-cultural assumptions in mind. At the same time, I used a view of language and the notion of discourse to shape the analysis carried out within each scenario.

Radford and Empey (2007) use the term *cultural sensibility* to express the way in which individuals, immersed in a culture, are capable of creating new forms of understanding and novel forms of subjectivity. By cultural sensibility they understand "the subtle progressive cognitive and epistemological change that leads the individuals of a culture to pay attention to themselves and to their world in a new way" (p. 38). In order to construct the process of my research, I interpret Radford and Empey's (2007) concept of cultural sensibility as the

"trigger" that sets in motion the constant interplay of objectification and subjectification. My research captures and promotes the cognitive and epistemological changes of myself as researcher, initially immersed in individualistic educational research culture, with its understandings of assessment for learning within IBSE, in order to open up the possibility of creating new forms of understanding and novel forms of subjectivity with socio-cultural theories in mind.

THE ANALYTICAL STRATEGY

The analytical strategy guiding the research inquiry is presented in five chapters (Chapters four, five, six, seven and eight). It is frequent to find in a dissertation statistical analysis of data or qualitative analysis of data (Monash-University, 2007). In this inquiry, some data was produced during the research process. Researchers' texts, curricula designers' texts, and other artifacts used in the IBSE network, where I was a practitioner, were collected and analyzed to identify the individualistic research perspective in the scholars' research activity. From my visit to a classroom, some dialogues between a teacher and myself, students' answers, mails with the supervisor were used to question my assumptions. The experience in the school, the reflections about the experience, and the analyses done in Chapter seven are communicated as events that made me aware of the complexity of the social activity in which I was involved. They became essential material for sensibilizing or triggering my process of objectification and subjectification. It is argued that only by looking from inside social praxis, in which the researcher is involved, it is possible to conceive a socio-cultural perspective for researching assessment for learning within IBSE. The intention was to move researchers' subjectivity. It was not intended to document such realities or produce categories illustrating some social phenomena out there.

My research process generated "sensibility spaces". Such spaces are particular actions (Leontyev, 2009) I undertook as researcher. My experience as 'learner' or a knower —being part of specific cultural activity, living at a historical time, immersed in a PhD study at Aalborg University— within the sensibility spaces transformed my capacity to change assessment for learning ideas in IBSE. This was possible by noticing and becoming aware of new cultural forms of understanding and being: using socio-cultural lenses. The generation of sensibility spaces as a rationality behind the actions of the researcher started with my adoption of some elements taken from a critical research paradigm. I followed Skovsmose and Borba's (2004) critical research perspective considering hypothetical changes in social activities when participants are involved in a critical process of reflection of their own activity.

From this perspective, it is essential to look at the activity in which the researcher is involved as the opportunity to analyze it differently, to look for other possibilities by taking into account what is actually happening in the situation. It is to assume the research object as inseparable from the knower and the activity in which the researcher is involved.

Chapter four, five, six, seven and eight are conceived as sensibility spaces for researcher subjective change. Each sensibility space provides an account of the actions carried out by the researcher, myself, to move from individualistic towards socio-cultural possibilities of thought. The ultimate goal was to appropriate socio-cultural concepts, assumptions and tools to use them in constructing a hypothetical situation of assessment for learning within an inquiry-based classroom. During the inquiry process I bring socio-cultural assumptions about learning, knowledge, the self and the culture into assessment for learning within IBSE research.

My analytical process during the inquiry was created to identify the reasoning of scholars following the assessment for learning within an IBSE perspective, and also the thinking of researchers from a socio-cultural view. The analysis is found in Chapters four and five, and the learning process of the researcher was called naturalization. I explored educational research texts informing me about the diversity of forms of understanding and knowing the process of learning and development (Chapter four). I also found out about which forms of understanding and knowing guided assessment for learning research that I used in IBSE network, and compared them with the existing ideas in the educational research field (Chapter five). By doing that, I recognized my own forms of understanding and knowing. In addition, I became aware of other possibilities.

But noticing was not enough to be able to change my way of looking at assessment for learning within IBSE. A learning process looking for the subjective change of the researcher was called de-naturalizing. In Chapter six, I questioned some terms and ideas structuring the assessment and IBSE educational proposals, and challenged them by adopting new form of understanding. In Chapter seven, I also explored socio-cultural assumptions by looking at my experience in one classroom of the IBSE network, while I tried to make sense, with a teacher, of all these new cultural objects that I encountered in my exploration. This learning process was called disturbing assumptions and ideas of the researcher. Finally, in Chapter eight, I produced two simulations of assessment activities. I challenged my imagination by describing two classroom situations and trying to experience what it was like to adopt one or another theoretical perspective, and the impact of that in the inquiry-based assessment classroom. Those analyses allowed me to postulate some elements that characterize assessment for learning research when a socio-cultural theoretical perspective is adopted.

RESULTS, CONTRIBUTION AND CONCLUSIONS

The results, contribution and conclusions of my research process are identified in several chapters. Indeed, each sensibility space is seen as producing results emerging from the analytical process. However, in Chapters nine and ten they are presented as objects emerging from the analytical process and my subjectification. Each chapter contains objects that can be identified with one of the three dimensions of my research problematique. In Chapter nine some categories of researcher subjective change are presented. In Chapter ten, two modes of researching assessment for learning are characterized: the individualistic and the socio-cultural perspectives. In Chapters nine and ten there are some reflections about the contributions to the field of assessment for learning and IBSE with the knowledge produced during the thesis.

My research shows a change in my own capacity to conceive and do research, as well as to recreate assessment for learning knowledge within IBSE using a new theoretical perspective. I felt that the individualistic learning perspective did not allow me to consider the diversity of cultural and societal configurations in the learning processes where individuals experienced the activity of assessing, teaching and learning. I chose to use the socio-cultural theory of learning to change the possibilities of thought within the individualistic perspective of assessment for learning within IBSE, and to built and imagine a *socio-cultural-based assessment for learning within the IBSE* perspective research. By adopting a new theoretical perspective, I put myself in "trouble" since my perception and theoretical approaches in my practice were all shaped by the individualistic perspective. I was confronted myself with the deep process of subjectivity change encompassing a new possibility of objectification.

Assessment for learning within IBSE is explained as a research field using results from psychology and developmental theories. In particular it can be identified as being dominated by an individualistic perspective. It is presented as been supported by a socio-constructivism paradigm. Learning is conceived as an individuals' brain process using environmental feedback (social and natural) to construct individual reasoning and ideas about natural phenomena. This line of thinking is identified as cultural sensibility —as the set of assumptions and rationality guiding researchers activity— identifying assessment for learning within IBSE research.

My thesis presents a new perspective for researching assessment for learning within IBSE with a socio-cultural line of reasoning. This cultural sensibility is described as well as the implication of scholars' reasoning in the construction of assessment for learning research within IBSE. Researchers' reasoning is differentiated from the individualistic perspective and the

assumptions are used to describe assessment for learning activity in an inquiry-based classroom.

The use of researcher's subjectivity for methodological purposes is also discussed in the thesis. Some examples of researchers' modes of communication are used to show different styles of giving an account of the researcher experience of learning and producing cultural knowledge. Some categories emerging are also described. The concept of Cultural Knowledge (Radford & Empey, 2007) is used to support the constitution of these categories.

Finally, the implications of my research are discussed by analyzing assessment for learning research activity results in the light of the problematique. The contribution of the research is explained in terms of the tools that the new perspective brings to a different understanding of assessment for learning research and IBSE as foreign educational cultures. The difficulties of change are analyzed by adopting a critical point of view.

2. SETTING THE SCENE OF THE THESIS

> The crucial point is rather to elicit how mathematics, as reflection of the world, was instrumental in the formation of new sensibilities. By sensibility we mean a subtle progressive cognitive and epistemological change that leads the individuals of a culture to pay attention to themselves and to their world in a new way. Here we are interested in sensibility in terms of capacities to create new forms of understanding and novel forms of subjectivity. (Radford & Empey, 2007, p. 8)

The research story and the narrative of this thesis can be described by interpreting Radford and Empey's words. I challenged myself to change my sensibility. I built a research strategy to allow myself to notice something about myself and to look at my own world in a new way. I was looking for new forms of understanding and novel forms of subjectivity. My intention was to explore possible changes in the educational culture where I was immersed by changing my view. As a teacher educator involved in teaching about assessment for learning within Inquiry Based Science Education —IBSE—, I noticed a certain resistance on the part of teachers to enter into the logic of the assessment research statements. In order to understand this resistance, I needed a change in my own subjectivity.

Radford and Empey's statements envision a movement in a culture. There is a collectivity changing a way of being in the world. In fact, they explored how mathematics was instrumental in the formation of new sensibilities, and how individuals of a culture carry out an epistemological change. By challenging myself, and changing my assumptions, I am challenging the collective sensibility of my educational culture. But this is only possible if I look at collective sensitivity from inside, from my own perception of assessment for learning research. My inquiry uses the fact that I was in charge of communicating and teaching assessment for learning within an IBSE network. My research opens a door towards new cultural forms to shape assessment for

learning within IBSE. At the same time it allows me to see the teachers and classroom activity with a new understanding and possibilities of actions.

I argue that there is a need to understand individuals' subjectivity change when confronted either to new forms of understanding and epistemological turns. I see assessment for learning and IBSE research based knowledge as expected to be used by individuals who share other educational cultures. Teachers, teacher educators and students from different cultures are nowadays challenged to pay attention to themselves and to their world in a new way — with assessment for learning and IBSE assumptions. I argue that this is a challenge that needs to be investigated. The thesis should bring light to such complex process.

This chapter presents the struggles that envision a global change of science educational systems by introducing assessment for learning and IBSE in a diversity of cultures. The difficulties can be expressed as a need for understanding how new cultural knowledge is instrumental in the formation of new sensibilities. It is argued that changes in educational cultures must be conceived by understanding the process of change of an individual. First, I present assessment for learning, IBSE and the political ambition for educational change with those pedagogical perspectives. Secondly, I bring from my point of view and that of some other researchers, the problems that are faced when measuring and looking for a quality in the educational system where those pedagogical tools are introduced. In a third part I make visible the perspective of individuals experiencing a change in their own culture when confronted with a foreign culture such as assessment for learning and IBSE. To conclude the chapter, I highlight the problematique guiding my decisions throughout the research process.

ARGUING FOR RESEARCHING ASSESSMENT FOR LEARNING AND IBSE

I will show that assessment for learning an IBSE are two relevant educational research fields, which have an impact on policies and practices. Although assessment for learning is a concept that is used to refer to forms of assessment helping children to learn in all subjects taught at school, there is a particular field of research which aims at understanding how assessment for learning principles work when teachers are teaching science based on inquiry pedagogical principles. This section describes assessment for learning concept, assessment for learning and Inquiry Based Science Education knowledge, and presents arguments supporting global educational change, and the need for researching in this area.

ASSESSMENT FOR LEARNING

Assessment for learning is a concept that has been developed mainly in the academic literature in English. The concept has been identified as close to the concept of *formative assessment* and differentiated from the concept of *assessment of learning* and *summative assessment*. In this section the concept is presented by following the view of Black and Wiliam (1998b) that is the most quoted by researchers working within this area. Across the different chapters a more developed idea of assessment for learning research will be presented.

Assessment for learning concept has emerged within a historical development of assessment research where some difficulties were observed in classroom assessment activities. In particular, some evidence has been provided to support that different current assessment practices can have positive or negative effects on students' learning processes, social life, and motivation to learn. For instance, some studies show the impact of the traditional 'tests' on students' identity and social life (Wiliam, Bartholomew, & Rey, 2004), students' ideas about knowledge, and their motivation to learn (Cowie, 2005). Particularly, there is documentation of the negative impact on the way that children with low self-esteem perceive their future and their capacities to learn (Harlen & Crick, 2002; Wiliam, et al., 2004).

Black and Wiliam (1998b) characterize as poor assessment practices those that rely on a memory based and superficial learning, do not share assessment questions and methods used to assess learning within teacher communities at school, and are not critically reviewed in the light of the what is assessed. They also explain that primary school teachers' tend to assess the quantity of work and presentation and less attention is paid to the quality of learning. Other approaches to assessment focus on which students are the best, and less attention is paid to the quality of learning. This is recognized as having an impact on learners' motivation to learn, and views about the learning capacities of each student. The feedback seems to act as social control rather than learning.

However, assessment for learning concept has emerged also as the identification of some characteristics of assessment practices that have positive effect on learners and their process of learning. Black and Wiliam (1998b) considered that a good assessment practice is to inquire about learning, to qualify learning and to motivate learning. For them, one of the purposes of the assessment practice should be to identify students' learning, to identify and differentiate students' learning needs, and to distinguish different achievements on students' learning. In order to qualify learning, Black and Wiliam (1998) proposed that the feedback process should be seen as improving learning quality, helping students to improve their learning and sharing with students the learning goals and doing what ever is necessary to help every body to reach learning

goals. They also recognize as important those assessment practices that encourage learners' motivation. This means promoting among students a positive view of their own capacity to learn and encouraging them to learn and believe in their own capacities to learn. They claimed that this kind of assessment practice helps students to meet educational standards.

According to Black and Wiliam (1998), different studies have shown that the way to qualify students' learning process, or assess them for learning is to provide them with frequent feedback, to share and construct educational goals with them, to facilitate self-assessment and peer assessment during day-to-day practice, and to promote students' motivation to learn. When one gets closer to this kind of assessment classroom practice, it is possible to identify some dimensions of the assessment activity that emerge in the daily work of teaching and learning. For example, students can be invited to assess other students' answers or solutions to a problem; the teacher and students assess their thinking through a dialogue; the teacher and students together develop criteria for assessing a particular task; or students participate in making assessment decisions together with the teacher. In other words, assessment can be continuous and focused on the process, as well as being collective and designed to grasp the significance of the social dimension of learning. This is part of what is covered by the label 'assessment for learning'.

Assessment for learning is the concept used to characterize the assessment classroom practice which teacher's aim is to identify learning processes, and at modifying teaching based on evidence of students' learning. Wiliam (2011) links this kind of assessment with the formative assessment by the fact that the evidence of students' learning is used to modify teaching. In that sense, assessment for learning is embedded in the teaching practice (Shepard, 2000). Assessment for learning has been conceived by researchers as part of everyday teaching activities in the classroom: informally taking place in conversation and actions, and formally adopting a more structured format as happens in current assessment practices. Both teaching and assessment are aimed at stimulating students' learning. However, assessment for learning can be distinguished from teaching in the fact that the objective is to produce valuational statements and judgments about student's learning, and that the statements are used to plan how to enhance learning and modify teaching — adjusting it to the learners needs.

The assessment for learning activity is often described as the activities that the teacher and students do to observe learning and to establish how students are doing in relation to some previously fixed goals, thus enabling the teacher to help them advance in their learning (Biggs, 2003; Black & Wiliam, 1998b; Ruiz-Primo, Li, Tsai, & Schneider, 2007). Research has shown that students learning with teachers that use this form of assessment have better learning processes and better results in summative tests (Ruiz-Primo & Furtak, 2006). Assessment for

learning is also aimed at shaping the process of learning. Valuational statements allow teacher and learners to improve the learning experience. The information produced by learners is used to measure how far students' learning experience has advanced in relation to the expected or intended learning goals. Assessment processes modify teaching as well as the learning process of each student.

Shavelson et al.'s (2008) have identified two types of activities that can be labeled under assessment for learning: *informal assessment*, which takes place in every class during interactions among students and with the teacher, and *formal assessment*, which involves precise moments in which students' individual learning process concerning crucial points of knowledge is assessed. In both cases, the purpose is to give students feedback, to point out their learning goals and negotiate, to decide on new paths for teaching, to understand one's students' learning process (Harlen, 2006a; Shavelson, et al., 2008).

Researchers on assessment for learning produce conceptual objects that shape actions and interactions in daily classroom life. Learning goals are established to drive the assessment activities. The purpose of assessment activity is to determine how far students are from learning goals. In order to produce the valuational statements and the judgments other objects are created and used: criteria, questions, assessment conversations, tasks or activities related to learning goals and criteria. All those objects are there to visualize the assessment for learning processes and to support interactions in the classroom. In particular, they are used to drive feedback to the learner, self-assessment and peer-assessment, as well as to establish and show learners the gap between what they have been doing and what is expected.

Which differentiates assessment *of* learning and assessment *for* learning is what the teacher does with evaluative statements. In the case of 'assessment of learning', the purpose is to represent in scores or valuational statements the 'outcome' of the learning process of each individual. When assessment is aimed at establishing a judgment about the results of a learning process, it is called *assessment of learning* or *summative assessment*. It seeks to identify and observe what students have achieved or learned, after doing different activities. This information about each learner allows the school system to promote the student from one year to another; to give each student a diploma that opens doors to continue in the educational or work system; or to classify students' performances. These results are communicated to parents, school staff and society in general. These assessments are recognized as having higher or lower impact, according to the consequences for an individual or an institution —i.e., the assessed person is not accepted in college or in a new school year, or an institution whose students show low levels of achievement does not obtain resources, etc. (Biggs, 2003; Black & Wiliam, 1998b; Harlen, 2006e, 2007; Ruiz-Primo, et al., 2007).

IBSE AND ASSESSMENT FOR LEARNING

Within the Science Education research community in the USA, the argument that students in school do not learn science in an adequate manner was used to press for the need to invent new ways of teaching. The National Academy of Science and the National Science Resource Center based their claim on evidence:

> According to the National Assessment of Educational Progress (NAEP), only 14 percent of fourth-graders knew that it is easier to stay afloat in salt water than in fresh water and could explain why. Only 10 percent of eighth-graders knew why eating potato salad made with mayonnaise that has been left out in the sun could cause food poisoning. Only 26 percent of twelfth-graders could figure out how to use a sieve, a magnet, water, and a filter to separate a mixture of steel pellets, copper pellets, iron filings, sand, and salt. (Center-For-Science-Mathematics-and-Engeneering, 1998, p. 3)

In this kind of rationality, it appears that learners do not learn what is expected. The majority of students, after their science lesson, are not able to use what they learn to predict what could happen in everyday life situations such as that it is easier to stay afloat in salt water, or some foods behaviors, nor to use some technical knowledge to produce changes in substances. Several films have been produced by the NSRC showing those facts, and interviewing students from prestigious universities[4].

Those kinds of evidence were used to critique the traditional way of teaching science at school. The traditional methodology is described as students reading aloud from science textbooks, memorizing long list of scientific terms, preparing to take tests that call for simple rote recall, doing laboratory experiences designed to confirm what they have been told, and few opportunities for students to think critically (Center-For-Science-Mathematics-and-Engeneering, 1998). In this approach, students are provided with a "set of science facts and with technical words to describe those facts" (Center-For-Science-Mathematics-and-Engeneering, 1998, p. 1 foreword)

Inquiry based learning emerged as an alternative to this traditional way of doing teaching in science lessons. Instead of teaching children to memorize

[4] One video was presented in the "Tercera Conferencia Internacional sobre la Ciencia en la Educación Básica", Monterrey, Nuevo León, México March 2004 by Sally Goetz Shuler Directora Ejecutiva de NSRC in her intervention "La Enseñanza de la Ciencia Basada en la Indagación y el Papel del Desarrollo Profesional de Profesores".

.

definitions and science concepts, and to repeat experiments already prepared, it is expected to stimulate children's critical thinking by engaging them in classroom activities that use their questions and ideas about what is observed in the natural world (Center-For-Science-Mathematics-and-Engeneering, 1998). According to the Inter Academic Panel Science Education Program (Inter Academic Panel, http://www.interacademies.net/Activities/Projects/12250.aspx) inquiry provides opportunities for students to see how well their ideas work in authentic situations rather than in abstract discussions. It is also said that "students build knowledge through testing ideas, discussing their understanding with teachers and peers, and through interacting with scientific phenomena" (Inter Academic Panel, http://www.interacademies.net/Activities/Projects/12250.aspx). The National Science Education Standards in the USA emphasize that "science education needs to give students, three kinds of scientific skills and understanding" (National-Academy-of-Sciences, 1995, p. 8). Students need to learn the principles and concepts of science, acquire the reasoning and procedural skills of scientists, and understand the nature of science (Inter Academic Panel, http://www.interacademies.net/Activities/Projects/12250.aspx) as a particular form of human endeavor.

Another evidence-based argument for inquiry is that those students taught in traditional way are losing interest in science as they advance in schooling. In this loss of interest, achievement declines (Center-For-Science-Mathematics-and-Engeneering, 1998). It is expected that learning through inquiry will increase students' interest in science and mathematics. Learning through Inquiry promises to improve student's participation and enjoyment in relation to scientific activities (IAP-working-Group, 2006). Inquiry Based Science Education appears as a solution to the students' lack of critical thinking, theoretical explanations, and motivation in relation to scientific matters.

Donovan and Bransford's (2005) categories for teaching can be used to describe the essential features of IBSE. Following their classification, IBSE can be identified as a teaching perspective that uses a "Learner-centered lens". According to these authors, it means that the teaching "encourages attention to preconceptions, and begins instruction with what students know" (p. 13). Secondly, IBSE uses a "knowledge-centered lens" focusing attention on "what is taught (learning goals), why it is taught, and what mastery looks like" (p. 13). Thirdly, IBSE also is constituted by "assessment-centered lens" emphasizing the need to provide frequent opportunities "*to make students' thinking and learning visible* as a guide for both the teacher and the student in learning and instruction" (p. 13). Finally, the "community-centered lens" could represent IBSE as encouraging a culture of "questioning, respect, and risk taking" (p. 13), as well as the interaction of learners and teacher as central to the learning process.

According to the American National Science Educational Standards (National-Research-Council-NRC, 1996), the term *inquiry* refers to the abilities

students should develop to be able to design and conduct scientific investigations and also to understand the nature of scientific inquiry (Center-For-Science-Mathematics-and-Engeneering, 2000). Worth and Grollman (2003) explain inquiry-based learning as what should be expected to happen in science classroom:

> You will read stories of children observing the development of an animal trough metamorphosis; documenting the seasonal changes of a tree; exploring the science of water, blocks, and shadows; and doing much more. All the while, they are asking questions, making predictions, and making new discoveries. (p. 9)

It is acknowledged that "children develop science knowledge as they observe and act on the world, asking questions, making predictions, and reflecting on their experiences" (p. 9). Learning is seen as happening while children "construct continually more sophisticated theories of how the world works" (p. 9).

For the Center for Science Mathematics and Engineering (2000) inquiry is in part a state of mind or as they termed it "inquisitiveness". They affirm that most young children are naturally curious, and often care enough to ask "why" and "how" questions, that are central in the process of learning through inquiry. According to these authors, "if adults dismiss their incessant questions as silly and uninteresting, students can lose this gift of curiosity" (p. xii). The use of children's curiosity has being seen as one of the most important aspects behind IBSE.

An essential part of learning through inquiry is to work in classroom with children's questions about the world. Teaching science through inquiry allows students to conceptualize a question and then seek possible explanations that respond that question (Worth & Grollman, 2003). The way to reach the answers and knowledge is by carrying out an investigation, communicating the results of the inquiry and discussing with teacher and peers.

Duschl (2003) talks about different ways of interpreting inquiry based learning. One possibility is to use inquiry methods to teach concepts. Another is to teach process skills. Yet another could be to associate inquiry with the completion of laboratory investigations. But for him, what is clear about learning through inquiry is the focus on scientific inquiry: "attainment of evidence and how it is used to generate and justify explanations" (p. 41). A perspective of assessment for learning within an IBSE context should be regarded as the activity driving inquiry-based teaching. Following teaching, based on students' conceptions, explanations and theories, as well as skills development.

Assessment research also involves inquiry about how the process of assessment should be carried out at school. Duschl (2003) identified three

domains on which assessment of scientific inquiry in educational context should focus. The first domain relates to "the conceptual structures and cognitive processes used when reasoning scientifically" (p. 42). A second one is "the epistemic frameworks used when developing and evaluating scientific knowledge" (p. 42). And the other is "the social processes and forums that shape how knowledge is communicated, represented, argued, and debated" (p. 42). He proposes that assessment activities and tasks in classroom should be opportunities to make visible a student's thinking in each of the three domains. Furthermore, the design of assessment practices should be done by including monitor of learning, and providing feedback on thinking and learning in each of three domains.

Additionally, Duschl (2003) considers it relevant that in the assessment practices, teachers learn to observe the inquiry. The kind of inquiry he expected to be observed is "that which occurs when students examine how scientists have come to know what they believe to be scientific knowledge and why they believe this knowledge over other competing knowledge claims." (p. 43). For him, students should develop and use analytical insights and criteria for assessing the thinking as well as the scientific inquiry being revealed. It is also important to create classroom conditions which allow students to report and share information and ideas.

For the Center for Science, Mathematics, and Engineering (2000) assessment in inquiry-based classrooms takes a broader perspective asking "what each student knows and understand, what is fuzzy or missing, and what students can do with that they know" (p. 75). In that sense, they argue that it is important to look at the concept of understanding presented in the National Standards:

> Understanding science requires that an individual integrate a complex structure of many types of knowledge, including the ideas of science, relationships between ideas, reasons for these relationships, ways to use the ideas to explain and predict other natural phenomena, and ways to apply them to many events. Understanding encompasses the ability to use knowledge, and it entails the ability to distinguish between what is and what is not a scientific idea. (National-Research-Council-NRC, 1996, p. 23)

As I have shown, assessment in IBSE is a particular pedagogy presented as a complex activity, examining and understanding learning science through inquiry, and requiring the assessment of different dimensions. It is recognized that it is not only a matter of assessing the capacity of children to repeat scientific concepts. Rather, it makes a case for the identification of several dimensions such the epistemological, procedural, relations between ideas and reasons, social communications and so on.

The combination of assessment for learning and IBSE define a field of research aiming at understanding how inquiry thinking, inquiry skills, epistemology of scientific knowledge and concepts are learned by students, and how the activity of assessment for learning helps to enhance learning. This research field can be thought as a research *activity* where scholars studying how assessment can be envisioned when teaching science trough inquiry. In that sense, researchers explore principles and goals of inquiry knowledge, as well as teaching strategies to support students' inquiry-based learning.

ASSESSMENT FOR LEARNING AND IBSE IN POLICIES

Assessment for learning and IBSE are research fields that have had connection with educational policies in different countries. For instance, science education curricula and evaluation policies from the Chilean Ministry of Education include assessment for learning and inquiry as strategies to teach school science. The Unit in charge of curriculum and assessment explains that since 2003 the Chilean Ministry of Education decided to introduce assessment for learning principles in schools in experimental fashion (Unidad-Curriculo-y-Evaluación-MEN, 2006, 2009). Their aim was to give clear signs to teachers on how to do assessment in relation to the learning objectives of new curricula. As a result, an implementation project to teach science using inquiry was developed by the Ministry and sent to schools around the country.

There are other policy documents, which refer to inquiry, in the Colombian Ministry of Education. Indeed, the theoretical foundation for science curricula and assessment (from a summative perspective) includes inquiry as one of the competences that all Colombian children and young people must achieve and, that, thus, needs to be evaluated (see Baquero, et al., 2007). Also the Educational Policies in England envisioned 10 principles which describe key elements of assessment for learning in a chart to be used by teachers (Assessment-Reform-Group, 2002). The aim of the Assessment Reform Group was to bring "the research evidence about assessment for learning to the attention to the educational community" and to improve practice. At the same time, the Unites States' natural science curricula and assessment principles in relation to inquiry see it as a way to teach and learn science (Atkin, Black, & Coffey, 2001; National-Academy-of-Sciences, 1995).

Another political connection to assessment for learning research is found in OECD documents and principles for educational policies around the world. The need for assessment for learning in classrooms is claimed. In the OECD (2009) report it is stated that "formative assessment is among the most effective classroom strategies for promoting high student performance" (p. 25). Furthermore, the relevance of assessment for learning in educational policy is acknowledged:

> OECD work on "formative assessment" (or "assessment for learning") —which is aimed at gearing teaching up to the needs and weaknesses of individuals in classrooms environments— suggests a number of broad policy principles, some of which have much broader application. (p. 26)

OECD statements show that formative assessment is a teaching tool serving the individual needs and weaknesses, as well as classroom strategies promoting individual high student performance. The OECD (2009) report establishes broad policy principles supporting educational policies.

Furthermore, there is some research evidence which claims that assessment for learning practices help students to reach educational standards (Black & Wiliam, 1998b). In that sense it is expected that learning goals, standards, and assessment should be aligned (Shavelson, et al., 2008). The policy principles expressed in the OECD (2009) pointed to the relevance of focusing on every day activities in classrooms, to ensure policies that align summative and formative assessment in the sense that they reinforce each other, as well as ensuring that the classroom, school, and system-level approaches to assessment are linked.

Besides, teaching science and mathematics through inquiry is stated as one of the educational possibilities, which may help to solve problems faced by science and mathematics education. It is often argued that students are not interested in mathematics and science. This is viewed as problematic because of the need for a qualified work force in the labor market. For instance, PRIMAS European Inquiry Based Learning project covering mathematics and sicence argues: "In Europe still too many students have interest in mathematics and science and thus do not choose to follow related careers" (see "Towards Europe 2020" Primas-Event, http://primas-event.ph-freiburg.de/). A possible solution to this problem might involve

> Implementing innovative ways of teaching such as inquiry based learning in science and mathematics education is a key lever in bringing about change in this situation by raising students' motivation and interest in these subjects. (http://primas-event.ph-freiburg.de/)

This European project envisions working with policy makers to make visible the relevance of this kind of approach to science and mathematics education in national and European policies (PRIMAS, 2011).

Additionally, the recognition of the relevance of science education in all levels of schooling is stated in the Inter Academic Panel —a body grouping several National Academies of Science in the world. They made explicit that learners should learn natural science through inquiry. They support projects

around the world to disseminate that approach as well as aiming to impact policies on education:

> Since the beginning of this century, IAP seeks to reform and develop science education on a global scale, especially in primary and secondary schools, with a pedagogy based on inquiry (Inquiry Based Science Education IBSE). (Inter Academic Panel http://www.interacademies.net/Activities/Projects/12250.aspx)

As stated, what is expected is to reform and develop science education on a global scale, specifically in schools. The pedagogy that is claimed to support the reform is inquiry based. The reform is thought at a global scale, which means that it is viewed as possible to use Inquiry Based Science Education in several countries, and continents with diverse educational systems and cultures.

RESEARCH NEEDS

I have argued that there is a political move expecting that teacher educators, and teachers in different educational systems, cultures and societies, will adapt pedagogical principles produced in those theoretical fields. My research object is framed within this landscape. I support my choice of researching assessment for learning within Inquiry Based Science Education with facts such as the case that in some countries there are curricula policies, supported by ministries of education, arguing for a reform in classroom towards Inquiry Based Science Education. Also, that there are projects aiming at supporting such changes, and organizations like OECD envisioning policies to drive reforms around the world on the use of assessment for learning principles and ideas. There are also civil organizations such IAP supporting reforms based on principles and ideas of inquiry based pedagogy.

I claim that there is a need to look at assessment for learning and IBSE pedagogical principles, and the epistemological assumptions supporting those educational fields. There is a need to inquiry about the role of culture and society in the learning process of individuals confronted with educational change. It is relevant to inquiry about individuals moving from one educational culture to another. Furthermore, it appears necessary to explore connections between assessment for learning and IBSE's epistemological assumptions, and teachers', teacher educators' and students' assumptions supporting every day teaching and learning activities. I see assessment for learning and IBSE as foreign cultures to the teachers and teacher educators in all those diversity of educational systems around the world. In that sense, it seems relevant to understand the tensions emerging when individuals are confronted to new forms of understanding classroom activity different from their own view on learning and teaching.

LOOKING AT ASSESSMENT FOR LEARNING INQUIRY-BASED ACTIVITIES AS FOREIGN CULTURES

Politicians, researchers and teacher educators are aware of the tensions arising when a change like this is envisioned in any educational system. This concern has been debated in different spaces. Documents based on research and developmental projects around the world present some principles and characteristics of such quality, as well as explain the possible pathways followed in the process of reaching that quality in the inquiry-based teaching activities. At the same time, each developmental project and reforms in a country are faced with a process of adaptation, implementation and issues of quality. Indeed, assessment for learning and IBSE principles and concepts were born in the USA and England, and as such, they are built within their own traditions of education. Considering this, bringing those pedagogical perspectives to other educational systems, languages and ways of communication introduces tensions when looking at classroom activities. However, it is also recognized that it is not easy to adapt this type of pedagogical perspective in USA and England. By looking my own experience, I show an example of implementation that makes evident the differences in the quality of inquiry-based classroom activities observed when compared to the ideal expectations based on the international principles of inquiry-based teaching and learning.

ATTAINING QUALITY IN IBSE

The case for quality in classrooms that use Inquiry Based principles is a concern for researchers, teacher educators, and politicians. The argument has been that until it is proved that a classroom is inquiry-based and students have had good learning experiences with this orientation, it is not worth measuring learning outcomes. For instance, IAP worked in that direction and carried out several workshops and meetings trying to understand large scale change. A similar situation was experienced for quality evaluation. Indeed, Harlen (2004) recognized that there are obstacles to the implementation of IBSE since changes in teaching involve changes in teachers practices and in school policies. In that sense, it is recommended that school principals support change, and that teachers take part in decisions about, and also feel ownership of the implementation process. At the same time, change implies a gradual modification of teachers' understanding of how children learn and of the nature of science. In addition, she explains how teachers' changes occur gradually from a first awareness of personal and management concerns towards a focus on the impact on students. Furthermore, it is recognized that change takes time, and quality should not be expected in the first year of any implementation. Finally, Harlen sees the need

for learning outcome measurements aimed at a process of evaluating immediate and long-term changes in student learning. The reason for that is "since some learning experiences take time to become internalized and applied by students in later learning" (p. 4).

Harlen (2004) presented the implications of these aspects as follow:

> To evaluate the effect of inquiry-based teaching on students' learning it is essential to ensure that the intended learning experiences are in place. The timescale or implementation needs to accommodate the fundamental shifts that are likely to be needed in teachers' thinking and beliefs about science and about education. Such changes cannot be made merely by placing new materials in teachers' hands or by providing two or three half-days of PD. Equally profound changes are required in students' thinking and ways of learning, which also will take time. Evaluation designers need to take account of the nature of these changes so that policy-makers and practitioners can have sound evidence on which to base decisions about the value of learning science through inquiry. (p. 4)

It seems that is difficult to find inquiry-based teaching. Such statement implies that there is there is no direct and fast implication of implementing principles of IBSE in order to achieve the expected changes in students' learning and attitudes towards science. It is strongly recognized that such change needs efforts in many directions involving teachers, principals, learners, policy-makers and more general practitioners in the places where those changes are envisioned. Most important, it is stated that a change in educational practices involves the participation of the individuals who will be responsible for bringing the change —teacher, students, principals and teacher educators. In order to ensure quality in the implementation of educational tools such as assessment for learning and IBSE it is important to examine processes of change, particularly individuals' changes immersed in specific educational cultures.

When teachers are involved in a process of change in their daily classroom practice, they can identify with some kind of teaching, which they can also differentiate from the new teaching perspective. For instance at the beginning of the Colombian IBSE project, Suárez et al. (2003), a group of teachers, documented a series of changes that they as individuals had experienced. One of the principles of Inquiry Based Science Education explain that children are expected to argue, reason, agree and discuss their ideas and results. For them, understanding this kind of position took time and involved organizing teaching differently from what they normally did before:

> Comenzamos nuestro trabajo como lo habíamos hecho siempre, explicando diferentes fenómenos en abstracto, de tal forma que

> la participación de los niños se veía limitada a la copia en el cuaderno de lo que nosotras dictábamos o escribíamos en el tablero.
>
> Preguntábamos a los niños acerca de que sucedería en un experimento que realizaríamos. Sin tener en cuenta las respuestas de los niños, procedíamos a explicar el tema. A la siguiente sesión se cambiaba de tema sin evaluar la comprensión de los niños sobre lo que se había tratado en clase. Al final de un largo periodo académico, evaluábamos la capacidad memorística de los niños. Iniciábamos las ciencias naturales sin dificultad, de la misma manera como estábamos acostumbradas a hacerlo.
>
> No aprovechábamos lo que ellos sabían como base para la construcción de nuevos conocimientos o hipótesis de trabajo, no lográbamos la participación de todos los niños durante la clase, ni que llegaran a conclusiones que surgieran de las observaciones realizadas y del trabajo desarrollado durante las sesiones. (p. 74)[5]

In their usual way of teaching science children did not use to participate in the same way as was expected in the IBSE statement. In addition, it was evident that there was a need for a change in teachers' classroom assessment practices. In particular, they had to evaluate understanding differently. Change in teaching occurs when children's ideas are recognized and used as a basis for the construction of teaching. That group of teacher also admitted how difficult it was to face such changes, especially in relation to the difficulty of using their senses. Particularly, they said that they realized that they did not know how to use their senses. For instance, they wrote

> [...] no fueron solo los niños los que aprendieron a percibir mejor el mundo con los cinco sentidos. Para nosotras, tener conciencia del uso del sentido del oído era una novedad. Se nos dificultaba

5 We started our work as we did always, explaining different phenomena in abstract, in a such way that the children participation was limited to writing in the notebook what we said or write in the blackboard. We asked to the children some questions about what they thought would happen in an experiment. With out taking into account the answers of them, we proceed to explain the subject. At the next session, we changed the subject with out assessing the understanding of the children about what we explained. At the end of a long academic period we assessed the capacity of memorizing. We started by doing in the way we used to do it." "We did not take into consideration what children already know to construct knowledge or work hypothesis, we did not arrived to make children to participate with their ideas, neither we arrived to make children to make conclusions that came up from their observations and the work during the teaching session"(p. 74)

> enormemente entender la clasificación de los sonidos que traía el modulo[6]. (Suárez, et al., 2003, p. 77)

They explain that this was reflected in the poor language that children used in their descriptions of their aural perceptions. This testimony shows that IBSE perspective implies changes not only regarding pedagogical practices and the meaning of what is scientific knowledge. It also involves the way teachers develop their perception with respect to the senses. For instance, the use of the sense such as hearing became a difficulty since this is not used in their current social activities. In Colombia aural ability is more developed in music teachers, who have other kinds of vocabulary to characterize different sound quality. Furthermore, considering that the vocabulary for characterizing what is perceived with the senses has an impact in children's possibilities to learn, then, it is important to acknowledge that to learn by inquiry implies that teachers must bring new language and develop sensibilities that are not part of the current practices of those teachers and children. Then, it is important to understand how individuals assume such a difficult change, when quality is measured in terms of learning outcomes.

Other efforts have being made in IBSE projects to create tools and documents based on what IBSE means. Documents and texts have been produced with descriptions of classroom settings, criteria to observe and evaluate teaching, what students should be doing in an inquiry based lesson, what a teacher is expected to be, how the curricula must change at school, and also how to evaluate learning outcomes. Examples of these can be found in Latin American countries as well as in the European countries —e.g. projects such as La main à la pâte, Pequeños Científicos, Fibonacci, IAP—.

I will not enter into the details of such material here. My point is that it is recognized that changes in classrooms in the direction of inquiry-based teaching is not an easy and direct process, and that it takes time to build meaning from it in the different places where the reform is undertaken. Also, that it is expected that such change could be better envisioned if teachers have school support, materials, and if they themselves have a positive attitude towards change. However, there it is not difficult to understand the difficulties faced by individuals such as the group of Colombian teachers, immersed in practices and social activities that differs from others teachers' experiences in different countries. I argue for the need of understanding change as a process of the

[6] There were not only the children that learned to perceive better the world with the five senses. For us, to be aware of the use of the sense of the ear was a new development. It became difficult to us to understand the classification of the sounds developed in the curricula unit.

individual facing different practices and activities with greater or lesser resources to do so.

LIVING WITH A FOREIGN EDUCATIONAL CULTURE

In Colombia, ten years ago, I started to work with Inquiry Based Science Education. Many people from different countries were working together in implementing IBSE in primary and secondary schools. During eight years I worked on a project, *Pequeños Científicos*, aiming at introducing IBSE in Colombian schools. The project was led and organized by researchers and teacher educators based at the Universidad de los Andes, where I worked as a lecturer. I had the opportunity of learning about IBSE, and of travelling and supporting IBSE projects in other Latin America countries. My experience gave me a particular perception of the activity. I made sense and gave meaning to IBSE through my participation in workshops with different teachers, exchanges with international researchers, and by working closely with six teachers in one public school in Bogotá (Suárez, et al., 2003). I specialized in the topic of classroom assessment and dedicated many working hours to conducting an evaluation of the Colombian project *Pequeños Científicos* (Carulla, Duque, Molano, & Hernández, 2006).

As an IBSE teacher educator, I was enthusiastic and convinced that IBSE proposals to teach science in primary schools was the way to do it. I learned to follow the logic, and to adapt my self to the view behind the IBSE approach. I assumed the IBSE principles. I liked the IBSE approach and the teaching sequences that supported school teachers' work. Two different aspects enlightened me: The teaching sequences designed by researchers and teacher educators in the United States gave Colombian school teachers the possibility of constructing a different practice in the classroom, and such a new practice could have an impact on students (Suárez, et al., 2003). In general, primary school teachers in Colombia have limited time to develop new ways of teaching school science. They also have limited scientific knowledge that enables them to be involved in a more experimental approach to science teaching. Very often teachers in primary schools teach science based on text books that privilege a teaching based on presenting concepts, followed by some application exercises (Suárez, et al., 2003). The working hypothesis of *Pequeños Científicos* was that teachers' involvement in adapting the teaching sequences based on IBSE and developed by educators in the USA, would allow them to change their traditional way to teach science. We —and particularly me— were convinced that science teaching needed to be replaced by a new form of teaching.

I liked to work in the project with teachers in public schools in what may be called "disadvantaged" areas in Bogotá. I was captivated by how students in these schools were experiencing a new way of learning science, in which they

had opportunities of expressing their ideas and of sharing activities with other students. I paid attention to students' voices and enthusiasm. In an official visit to the schools involved in the project, I was struck by an 11 year-old girl, who stood up in front of the Colombian Minister of Education, a scientist from the French IBSE project, and the press, and said: "What I learned in *Pequeños Cientificos* is that I can express myself. See, I can stand up in front of you, and I have no fear of speaking". In another context, a student said what he enjoyed most. Before his experience at *Pequeños Cientificos* the knowledge acquired in the science class was in the notebook. But now, with this new experience of learning, knowledge was in himself. He pointed to his head saying "here"[7]. I can still hear different voices of children resonating in me. Those voices gave me the strength to work enthusiastically with teachers, to convince them that IBSE was a correct perspective to work with.

In 2005, in Mexico, I had the opportunity of listening to Wynne Harlen, a well-known exponent of IBSE, talking about *formative assessment* and IBSE. Some of her ideas fascinated me. I wanted to work with assessment following her view: Helping students to learn rather than giving them a mark; raising awareness about the comments from the teacher to the students; taking care of the learning process of each student; and seeing students as people that have feelings and problems in the process of understanding and giving meanings (Harlen, http://innovec.org.mx/home/index.php/conferencias/3conferencia). I understood that assessment was a powerful tool in education, not because it measures a result, but because it can allow for caring for students in an IBSE context.

In Colombia, where many children in public schools live in extreme conditions of poverty and violence, I felt that my responsibility as an educator was to provide, in my own teaching and in schools, tools that focus on the human being as a whole, and not only on the cognitive aspects of learning. I dreamed about changing teachers' attitudes towards assessment. I started to see assessment as a way of helping each learner to "stand up" facing their life. Just like the 11 year-old girl did in front of the Minister. I wanted to focus on the *other*, and help allowing the other to 'fly' and to be.

In 2007, in Panamá, I had the opportunity of meeting María Ruiz-Primo, a researcher with several publications in assessment (Ruiz-Primo, 2007; Ruiz-Primo & Furtak, 2006; Ruiz-Primo, et al., 2007; Shavelson, et al., 2008). Her work moved my understanding of assessment even further. She taught me another dimension of formative assessment in IBSE. With her I saw the differences between assessment *for* learning or *formative assessment*, and

[7] From *Pequeños Científicos* video: Documental 2007, un recuento visual para Gas Natural.

assessment *of* learning or *summative assessment*. She made me aware of a more advanced understanding of inquiry and of scientific knowledge. I learned the relevance of understanding knowledge and ways to know in science in a deeper manner. At the same time I became conscious of the importance of being aware, during the assessment processes, of the different dimensions of inquiry in order to push students towards more developed ways of thinking.

With all those experiences in assessment for learning in IBSE, as well as my conviction and my awareness, I started to offer workshops and seminars for teachers in Panamá, Colombia, Bolivia, Chile, and Peru. Soon I was recognized as an expert in the area. In the success, however, something was bothering me. Why did teachers express difficulties in reading and interpreting those brilliant ideas of assessment? For me they were so clear and powerful. Why did teachers seem to struggle with them?

The goals of the pre-determined, IBSE teaching sequences were not clear for Colombian —or Latin American— teachers who operate in different contexts from the North American, where the ideas of IBSE and the materials had been developed. Although in those materials there are some explicit goals, in order to arrive at the level and complexity espoused by Maria Ruiz-Primo, there are other dimensions of knowing that were not present in the researchers' descriptions and theorizing. For the first time, I saw dimensions of knowing that I had not noticed before.

When I visited classrooms in Colombia, I was wondering about the learning process going on during group work, an important component of the IBSE approach. I did not feel a sense of 'strong' inquiry in the group work. I wondered how the ideas of assessment for learning could enhance this type of activity. It was not clear to me what kind of learning goals were possible to reach and work on from that assessment perspective. I did not have an idea about the way in which group work could be assessed to help groups learn better. Neither did the teachers. They gave instructions to the groups, but they seemed not to be so concerned about the quality of the underlying learning process taking place in the groups.

In my own workshops I began with the ideas of assessment for learning. I formulated and explained ideas in ways that teachers seemed not to understand. Teachers had obvious problems in making sense of the main principles of *assessment for learning*, in relation to their own assessment culture. In my workshops, some teachers commented that they found assessment for learning a very interesting idea, but impossible to implement in their classrooms. Others said that they found it complex and difficult to understand. Something was missing in my way of viewing the learning and teaching processes. I could not understand why it was so difficult to embrace my idea and the wonderful assessment models proposed. Why would people not simply appropriate them and work with them, and give them similar meanings to mine and to Harlen's?

My passion and my own understanding were not enough. I realized that, probably, both my way of viewing learning and my view of the role of culture in classroom activities needed a revision.

For example, in the different countries, cultures and places around the world where IBSE projects are being developed, teachers and students are confronted with many tensions when assessment takes place in the classroom. Some teachers reported their difficulties in implementing the assessment for learning model that goes with the IBSE curriculum materials, and that are discussed during assessment workshops and in-service courses[8]. In Colombia, for example, teachers associated *Pequeños Científicos* with the need to understand and adapt the assessment model that comes with the inquiry units — designed, implemented and tested in the Unites States. At the same time, they have to take into account the assessment policies issued the Colombian Ministry of Education, as well as the views of assessment held by the researchers, the teacher educators, the parents, the school administrators, the other teachers in the school, and the children themselves. Furthermore, the daily working conditions and possibilities for Colombian teachers (students' and teachers' background and future possibilities, teachers' responsibilities, teachers' and students' personal life, school culture, and atmosphere) have an impact on what and how they assess. I came to realize that the possibilities for taking on assessment for learning do not simply depend on each individual teacher's understanding of the idea and his/her capacity to put the idea into practice. Those possibilities are deeply dependent on the individual as well as on activities in which they are participating.

The proposals for conceptualizing assessment for learning have emerged mainly in English-speaking countries. The Assessment Reform Group in England introduced for the first time the term to distinguish it from the meanings giving to formative assessment (Wiliam, 2011). On the grounds of such research work in the USA, a group of researchers and teachers from three universities developed research in the context of Inquiry Based Science Education. Richard Shavelson, Donald B Young, Carlos Ayala, Paul Brandon, Erine M. Furtak, María Araceli Ruiz-Primo, Miki Tomita, and Yue Yin conducted a study looking at how to create tools for implement assessment for learning ideas in inquiry-based teaching sequences (Shavelson, et al., 2008). They produced several research documents and implemented assessment for learning principles with teachers, showing a diversity of results in their USA context. These proposals have been incorporated and re-contextualized within the practices of the IBSE Network.

[8] This statement is based on the information I received during my practice as formative assessment teacher trainer among the different Latin American countries.

What happens then when the statements and models of assessment for learning arrive at places with different educational cultures, languages, educational activities, etc.? Can those ideas and models be detached from their different social configuration? Can learning through inquiry happen for each student equally in all those different places on earth where IBSE is implemented? Can teachers from different social and cultural systems use assessment for learning models and ideas as they are originally conceived?

I started my thesis with all those ideas and feelings in mind, as well as with the seeds of sensibility towards aspects of the praxis of assessment for learning in IBSE that I had not considered before. How could assessment for learning address learning taking place during group work in IBSE environments? What is the role of place and cultural differences when teachers are trying to use and incorporate new ideas within their own praxis? These questions invited me to look at social processes and cultural dimensions that I had not been aware of before. My own subjectivity was immersed in an educational culture that conceptualizes learning without considering the milieu in which students and teachers are making sense of the world. After some months trying to give a meaning to 'see' and 'notice' the 'social' and the 'cultural' in relation to assessment for learning and IBSE, I produced the following image.

Graph N° 1. Illustrating diversity of cultures interacting

My collage brings different elements together. In the center, there are two groups of Colombian learners around a table, talking to each other, touching and observing some objects. At the bottom of those pictures, the label points to the fact that this activity is happening in a classroom that is based on teaching sequences that were designed in the United States, a cultural context different from Colombia, with the inquiry principles in mind. On the top of those pictures, a question expresses my concern at that time: What is the meaning of 'assessing

group practice'? At the background there are different pictures taken by me in Colombia. By means of those pictures, I wanted to highlight the idea that the learners, the teacher and myself, as a researcher, belong to different social classes. The learners have a particular way of interacting and being together based on their experiences in a social practices different from that of the teacher's and mine. The teaching and learning experiences of the teacher were different from my own teaching experiences and my experiences as a researcher. I felt that I needed to understand the role of those differences in my interpretation of the assessment activity, particularly when learners are working on joint activities.

ASSESSMENT FOR LEARNING ACTIVITY WITHIN INQUIRY-BASED CLASSROOMS

In this section I will provide arguments to support need to research assessment for learning activities in inquiry-based classrooms, particularly, considering that such activity is not the usual praxis of teachers, teacher educators and learners where it is performed. Indeed, in different projects around the world —e.g. Chile, Brazil, Colombia, France, Mexico, Denmark, China, Bolivia, and USA— teacher training projects are developed to support teachers in their adoption of the new teaching and learning activity.

My choice is supported by the researchers' recognition of difficulty in reproducing an inquiry-based teaching and learning activity. It is also influenced by acknowledging the efforts made by IBSE practitioners to construct tools supporting teachers in their transformation towards inquiry-based as well as bearing in mind Colombian teachers' tensions. Last of all, my choice is affected by my own difficulties of understanding teachers' transformations and teaching activities as a teacher educator and practitioner of IBSE.

My research journey gave meaning to the relation between culture, assessment activity in the classroom, and teacher and student interactions supporting individual learning. I will focus on the vision of assessment for learning activity. In such activity, I recognized that interactions among students and with the teacher were guided by their historical experiences at school and also by their individual experiences. In that sense, their relationships, their modes of interaction, their expectations are driven by the educational culture were they experienced every day activities at school. Additionally, inquiry-based and assessment for learning activities are guided by different modes of interaction, which constitute a foreign culture for individuals.

In order to understand assessment for learning activity in inquiry-based practice when looking at it as foreign culture, I turned my attention to socio-cultural learning theories. I found there some inspiration to give meaning to my

concerns. Those theories acknowledge that individual learning is inseparable from the activity in which the person is involved. The every day circumstances are considered essential to understanding learning. In that sense activity is analyzed as constituted by the educational culture, forms of cultural relationships, and cultural beliefs where learners and teacher experience schooling. This provides me with tools to understand the difficulties I observed and are documented by researchers.

Turning my attention to these types of theories is not a coincidence. As a doctoral student, the research group I was a part of, has an interest in researching science and mathematics education from perspectives that highlight the social, cultural and political constitution of school science and mathematics education practices. As a new member of the Science and Mathematics Research Group (SMERG)[9], I started being introduced to theoretical perspectives that offered a different reading of the 'world' of science and mathematics education.

INDIVIDUALS EXPERIENCING ASSESSMENT AND LEARNING

Up to now I have presented the first steps to set the scene for the thesis. The point I am making is that in this effort to produce a change in educational systems around the world, a change with quality, it became clear that individuals of any country faced the problem of changing their every activities in a way that is not the same as what they had experienced before. This is the case for all practitioners involved in projects in different parts the world. Now I turn my attention to individual experiences of assessment and learning within a culture. As I explained, I acknowledge that historical interactional experiences of individuals as well as personal experiences are essential to be able to understand the tensions faced by individuals in a process of change.

EXPERIENCING ASSESSMENT IN A CULTURE

I accepted that all my affection, personal characteristics, and ways of relating to knowledge and others, were relevant in the construction of the research process. Researching about assessment for learning was not something separate from myself. My personal way of feeling and perceiving when I am involved in an assessment situation as student and as teacher, or when I receive feedback from

[9] For details about this group and their position and academic views, see http://vbn.aau.dk/en/organisations/pp_a5b637de-22bb-4892-a047-4391eed69335.html

the outside world about my actions, affect myself and my possibilities of thinking, creating and being in social activities. I was seeking to create a model of assessment for learning that envisioned the individuals in the assessment activity as experiencing, perceiving, feeling, reacting and being touched in their possibilities of acting in their world, and not only a model envisioning the cognitive relations emerging in the learning and teaching activity.

The impact of assessment in the image of ourselves and of our capacities to be involved in social activities was studied by Wiliam, Bartholomew and Rey (2004). A dialogue with a girl, used by them to document the strong connection between assessment and identity, had a great impact on me and gave me reasons to look at assessment research from a new perspective:

> SHARON: I THINK I'LL GET A TWO, ONLY STUART WILL GET A SIX.
>
> I: SO IF STUART GETS A SIX WHAT WILL THAT SAY ABOUT HIM?
>
> SHARON: HE'S HEADING FOR A GOOD JOB AND A GOOD LIFE AND IT SHOWS HE'S NOT GONNA BE LIVING ON THE STREETS AND STUFF LIKE THAT.
>
> I: AND IF YOU GET A LEVEL TWO WHAT WILL THAT SAY ABOUT YOU?
>
> SHARON: UM, I MIGHT NOT HAVE A GOOD LIFE IN FRONT OF ME AND I MIGHT GROW UP AND DO SOMETHING NAUGHTY OR SOMETHING LIKE THAT. (P. 57)

This dialogue foregrounds that behind any activity of learning at school where assessment is experienced, there is a connection between the judgments produced in the assessment activities in classrooms, and the way the individuals construct an idea about themselves. However, not everybody has this kind of feelings about assessment situations. There are also feelings of pleasure when a positive judgment and social recognition of the accomplishment of any activity in which the individual is involved. This observation implies that there is also a diversity of individual and social constructions, as well as cultural ways of perceiving and experiencing assessment. Those social and cultural ways of experiencing assessment frame what is possible for any individual belonging to the culture to experience with his individual way of being. I highlight here that in any assessment activity, there is a relationship between individuals that are actually experiencing such a situation and that this type of relationship and that such relation can be different.

For instance, Harlen and Crick (2002), English researchers, also argue that the summative assessment impacts individuals forms of perceiving what counts as good learner and as learning. They present some results coming from research studies:

- Repeated practice tests reinforce the low self-image of the lower- achieving students.
- Tests can influence teachers' classroom assessment which may be interpreted by students as purely summative, regardless of the teacher's intentions, possibly as a result of teachers' over-concern with performance rather than process. [...]
- Students are aware of a performance ethos in the classroom and that the tests give only a narrow view of what they can do. [...]
- Students dislike high-stakes tests, show high levels of test anxiety (particularly girls) and prefer other forms of assessment. [...]
- Repeated practice tests reinforce the low self-image of the lower- achieving students. [...]
- An education system that puts great emphasis on evaluation produces students with strong extrinsic orientation towards grades and social status. (p. 4)

According to their review, assessment practices have an impact on what an individual in a society and culture constructs as an image of him/herself. Those statements reveal the strong connection between the individual's view of him/herself and the person's results in summative assessment. Testing practices also reinforce the low self-image of the learner who scores low/high results. It also shows the impact of the results in the relation to grades and social status.

However, in another culture, assessment examinations and researching assessment can be viewed differently. Taking the case of East Asian cultures, Leung (1998), who is a researcher from Hong Kong, argues that the East Asian Confucian culture is related to the successful results of East Asian countries in international comparative studies such as the TIMMS. He shows a diversity of characteristics of such culture: strong social orientation defined as "a tendency for a person to act in accordance with external expectations or social norms, rather than internal whishes or personal integrity, so that he would be able to protect his social self and function as an integral part of the social network" (Yang (1981, 161) quoted by Leung 1998). He points also to the relevance of the high expectations on students' achievements and effort, as well as specific attitudes towards study and assessment:

> Not only is examination an old tradition, but there has developed in the CHC culture a great emphasis an trust in competition and examination as a fair method of differentiating between the able and less able. Examination has acquired the position o something of value in itself and becomes an important incentive for

> studying. "Education was not meant for learning of practical skills or applications in real lives. It was meant for success in examinations." (Cheng, 1994) As result, CHC students are used to and excel in (paper and pencil) examinations. This explains partly their success in international comparative studies. (p. 30)

In Leung's view, another perspective of looking at assessment and the individual becomes evident. It is assumed that examinations are social mechanisms to distinguish more able students from less able students. The results of examinations do not predict individual competencies for future involvement in activities. They don't give information about the individual's skills or capacity to do something in real life. The purpose is not to take a picture of the individual's learning, nor to relate individual self-image to test results. What is important is to classify individuals according to the success in examinations. Individuals are confronted to examinations as part of the educational culture.

These examples of different ways of looking at assessment examinations in relation to individuals support the need of looking at assessment as an activity immersed in a culture and in the diversity of social experiences. Assessment research as an activity producing tools for practice needs to be thought of in relation to the particularities of the cultures in which the tools will operate. Therefore, assessment for learning and IBSE cannot continue to be conceived of as general, de-contextualized tools that can un-problematically be translated and introduced in many new countries and cultures.

EXPERIENCING LEARNING DIFFERENTLY

I wanted to construct a view of assessment that acknowledges that education and learning situations do not simply involve 'cognitive machines' that can learn to think and use scientific knowledge. Rather, I wanted a view that allows for conceptualizing education as a process that transforms individuals, their way to experience and their being while engaging in knowing. I also wanted to highlight that assessment is not a process of one individual, but a relationship between individuals.

Two things guided me in the construction of my research. One was my experience in a course with Wenger (1998) and his view of learning:

> Because learning transforms who we are and what we can do, it is an experience of identity. It is not just an accumulation of skills and information, but a process of becoming —to become a certain person or, conversely, to avoid becoming a certain person. Even the learning that we do entirely by ourselves contributes to making us into a specific kind of person. We

> accumulate skills and information, no in the abstract as end in them selves, but in a service of an identity. (p. 215)

Those words touched my soul. I started my research process by seeing it as a process of learning that would involve changing myself, and by doing so, constructing a new identity. But also it allowed me to dream of a new way of seeing assessment for learning research in IBSE as looking for ideas bringing this new notion in research practices and classrooms. This would involve assessment viewed as a process of relationships between individuals that are more that a cognitive entities.

I found it very difficult during my initiation as researcher to see the social and cultural dimensions involved in researching assessment and learning. Wiliam, Bartholomew and Rey (2004) put in words the complexity that my research process was trying to bring to my possibilities of thought, creation and innovation:

> Assessment, learning and identity are therefore inextricable related. Although they are often taken as unexceptionable, assessments come to define fields of enquiry, and yet apparently innocuous requirements for reliability and validity have profound consequences. Those who end up as 'winners' and 'losers' are in large measure the result of choices made in creating these assessments. To understand what these assessments do, to understand who can, and cannot be successful, and what that means for them, one needs to investigate the historical and social forces that have shaped those assessments. When 'researching the social', nothing can be taken for granted. (p. 60)

Assessment appears in those statements as having a great impact on social configurations of individuals' experiences and social possibilities. But another idea is there: the needs to investigate historical and social forces that shape assessment practices. In my way of perceiving research and assessment those words were empty, I did not understand what they meant. I invite the reader to think of my thesis as an attempt to make sense of all those dimensions that the socio-cultural perspective brings and make visible what was hidden to my senses. The thesis inquiry is a fight of my self with the different possibilities of thought that are present in the historical moment I am living.

FINAL REMARKS: THE PROBLEMATIQUE

Supported in documented arguments presented in this chapter, I developed the research problematique that will be unfolded as the writing advances. As pointed out in the previous chapter, I identified the need to research because assessment for learning within inquiry-based classroom is a pedagogical tool that is expected to be used in different educational systems; the need for a new research perspective because the conceptualization of assessment activity should recognize the complexity of a classroom activity in diversity of educational cultures; and the need for change in researcher's subjectivity because my possibilities of research were blind to the social and cultural dimensions in the everyday classroom activities.

THE NEED FOR THIS RESEARCH

In this chapter I documented the need to research assessment for learning within IBSE. I claimed that assessment for learning and IBSE are two research and developmental fields having an impact on diversity of countries, cultures and educational systems. On the other hand, researchers feel a need to measure the impact of such pedagogical perspectives on student's learning and classroom practices, and acknowledge that this kind of measurements can be done only when one can be sure that classroom activities are inquiry-based.

By recounting my experience in a Colombian IBSE teacher education project, I showed the difficulties faced by myself when trying to communicate to the teachers the ideas of those pedagogies. Based on my experience, I claimed a need to look at assessment, assessment for learning and IBSE as concepts established in a diversity of geographical areas where the traditional summative assessment shapes what most individuals share as being experienced as assessment. I state a need to look at individuals' experiences of change.

I also showed that assessment practices have an impact on the way individuals experience such activity. I claimed a need to consider research that takes into account that depending on the cultural traditions of assessment in the institutions or in a country, the individual learns to act according to a collective way of perceiving such activity. On the other hand, to acknowledge that the history of a child or person brings to the individual a possibility of interpretation that can differ from what the collectivity perceives as such. I saw a need to consider an assessment activity producing judgments and statements about different things related to the process experienced by individuals in a class.

THE NEED FOR A NEW RESEARCH PERSPECTIVE

Based on the documented arguments presented in this chapter, I claimed for research perspective that acknowledges the relation of collective an individual assessment experiences in the learning process in classroom activities. I also claimed that assessment for learning and IBSE are educational fields that use research knowledge about human learning and development in their conceptualization. I presupposed that assessment for learning and IBSE should share the same views about learning for the assessment purposes. I claimed that there is a need to look at assessment for learning and IBSE pedagogical principles, and the epistemological assumptions supporting those educational fields.

There is a need to inquiry about the role of culture and society in the learning process of individuals confronted with educational change. It is relevant to inquiry about individuals moving from one educational culture to another. Furthermore, it appears necessary to explore connections between assessment for learning and IBSE's epistemological assumptions, and teachers', teacher educators' and students' assumptions supporting every day teaching and learning activities. My claim for a need to research in this field is supported by the researchers' recognition of difficulty in reproducing an inquiry-based teaching and learning activity. I also acknowledged the efforts made by IBSE practitioners to construct tools supporting teachers in their transformation towards inquiry-based and the difficulties for interpret them in the expected way.

I showed that assessment for learning is considered an important part of inquiry teaching. It is needed for supporting the conceptual change of each learner during his/her interactional experiences in the classroom. The conceptualization of this kind of assessment research acknowledges that a subject learns by constructing knowledge based on interaction with others and experience in the world. I stated a need to understand the links between interaction of the child with the world —with natural phenomena and with peers— and the assessment for learning activity.

I identified a need to approach the research of assessment for learning within inquiry-based classrooms with a different theoretical landscape about learning, knowledge and human thinking, including social interaction within educational cultures. I identified a need for a change in the theoretical support for assessment for learning activity in an inquiry-based classroom, and the possible impact of such a different conceptualization in classroom activity.

To explore this dimension of the problematique, I recognized a need to give meaning to the relation between culture, assessment activity in the classroom, and teacher and student interactions supporting individual learning. I identified a need to focus on the vision of assessment for learning activity where interactions among students and with the teacher were guided by their historical

experiences at school and also by their individual experiences. In that sense, I identified that their relationships, their modes of interaction, their expectations are driven by the educational culture were they experienced everyday activities at school.

As explained, in order to understand assessment for learning activity in inquiry-based practice when looking at it as foreign culture for some teachers, I turned my attention to socio-cultural learning theories. I found there some inspiration to give support to the needs of this study. Indeed, those theories acknowledge that individual learning is inseparable from the activity in which the person is involved. The everyday circumstances are considered essential to understanding learning. In that sense activity is analyzed as constituted by the educational culture, forms of cultural relationships, and cultural beliefs where learners and teacher experience schooling. This provides me with tools to understand the difficulties I observed and are documented by researchers. I also acknowledge a need to investigate historical and social forces that shape assessment practices.

THE NEED FOR CHANGE IN RESEARCHER SUBJECTIVITY

However, the need for new theoretical perspective to conceptualize assessment for learning activity within inquiry-based classroom resulted in another need. In my way of perceiving research and assessment there was not room to understand the change that a socio-cultural perspective brings to the conceptualization of assessment classroom activities. Indeed, since the researcher's starting point was an understanding of assessment for learning activity in inquiry-based classrooms, which focus was the individual conceptual change, it was not possible to conceive of such activity with a new theoretical approach. I identified a need of change my subjectivity as researcher and teacher educator shaped by my experience with assessment for learning and IBSE conceptualizations.

For me, this research endeavor clearly became the search for reconfiguring the meaning of assessment for learning within IBSE when adopting theoretical assumptions about knowledge and learning from socio-cultural theories. The analytical strategy was constructed to move the researcher's subjectivity. It became clear that a re-thinking of the "object" of research could not be possible without a deep change in the researcher

The term *cultural sensibility* help me to present the reasoning for the need of individual researcher change and supported by existing collective forms of thinking. Paraphrasing Radford and Empey's (2007) words, by sensibility I mean a subtle progressive cognitive and epistemological change that leads researchers from a particular educational culture to pay attention to themselves and to their world in a new way. In this research I am interested in sensibility in terms of researchers' capacities to create new forms of understanding and novel

forms of subjectivity. Individuals confronted with the need to adopt another cultural sensibility face a challenge: to move from their cultural understanding of teaching and learning situations conceived within the assessment for learning and IBSE sensibility towards understand classroom activity with a socio-cultural sensibility. My research expects to throw some light on this exchange between those different educational cultures.

Using Radford' and Empey's (2007) words to shape my problematique, the crucial point of my research was to elicit how theories of learning, as reflection of the world, were instrumental in the formation of new sensibilities. Following Radford' and Empey's words (2007), by sensibility I also understand a subtle progressive cognitive and epistemological change that leads my subjectivity, constituted by assessment for learning and IBSE theoretical perspectives, to pay attention to myself and to my world in a new way. Thus, there are two elements involved in this reasoning. First of all, I started the inquiry immersed in a rationality of researching assessment for learning within IBSE shaped by an individualistic perspective, as will be documented in Chapter five. Secondly, I felt a need for a theoretical change for researching assessment for learning within IBSE. This fact implies a subjective change, a process of learning. Indeed, it was relevant for me to adopt a new cultural sensibility, the socio-cultural, to be able to think of assessment for learning activity within an inquiry-based classroom. This personal change is documented in Chapters four, five, six, seven and eight.

3. Using Theory and Defining a Methodological Style

> People need to be taught how to read. In traditional psychoanalytic papers, the authorities are quoted as though what they say is self-evidently true. A vignette is used to illustrate and validate a previously made theoretical problem. It isn't interpreted or redescribed, it's simply reiterated. It becomes like a Maoist training camp—you say it 500 times, and then you sort of believe it—rather than thinking that all these cultural objects are available for redescription. It would be very useful for people to be taught that reading and interpreting is a useful thing to do and that part of one's imagination is the redescription of already existing cultural objects. Those cultural objects could be human rights, or paintings, or poems, a whole range of things. The project is to transform the available materials, not submit to them. (Padania, 2010)

The words of Adam Phillips, in an interview made by Pandania (2010), describe what the reader can expect about my work. I do not reiterate what researchers in assessment for learning within IBSE state as ideal assessment activities for inquiry-based teaching, nor do I use existing methodologies to assert procedural correctness and the validity of my research. Rather, based on my experience in the IBSE network, I have used written thoughts and ideas of researchers, and conversations and shared experiences with a teacher to inspire my imagination, to redescribe and to interpret them. My methodology is conceived to challenge my subjectivity by using ideas in research texts from different theoretical approaches. My project transformed my truths, my beliefs, my relations with others ideas, my view of thought, knowledge and learning. The methodology allowed me to found new forms of understanding assessment activity within IBSE. The methodology challenges my subjectivity to transform the existing assessment for learning ideas by identifying, differentiating, questioning,

disturbing and producing new configurations of assessment classroom activities. I challenged my common sense interpreting the researchers' written formulations, the conversations with a teacher and my own experience by exploring other ways of conducting research in education. I used the fact that I myself was immersed in IBSE cultural sensibility, and started looking for new possibilities of being by participating in activities with a socio-cultural perspective.

My research journey started in Bogotá, Colombia, a big city surrounded by huge mountains, tall trees, different colors, vegetation and climates. There you can experience the pleasure of changing from one kind of natural environment and weather to another. In few hours, you can drive from the cold lands at the top of a mountain, to the warm lands at the bottom, and then to the hot lands on the river plains. You can perceive the differences with your senses: in the air —from drier to very humid—, in the scents —from soft dark soil smells to strong, green and fresh vegetation smells— and noises —from the silence of the highlands to the buzzing of insects in the lower lands. And that can be experienced every week of the year, all year round. Maybe you do not understand what I am talking about, but I am sure that someone from Colombia does. They have experienced something similar. Everyday experiences with the natural world are so different in other parts of the earth, that, for instance, people living all their lives in Denmark cannot give the same meaning to my words, unless they have been in a tropical area.

Similarly, when arriving in Denmark, it was difficult for me to learn to locate myself in the city. The streets in Bogotá are organized by numbers in such a way that I do not need a map in order to go to unknown places in the city. Indeed, when I get an address such as "Calle 80 Nº 35-26", I just follow the numbers and go there: You look for the 80th street (which is easy because we know that street numbers increase from West to East), then you find the 35th avenue (these road numbers increase from South to North), and then you look for the building numbers until you find the 26th (which means 26 steps from the previous street, to the west, since even numbers mean the location is to the north or the West of the road or street, respectively). I had difficulties on my first working day in Denmark. Someone gave me directions to get to the office at the University. I walked for 30 minutes, with the feeling that I was lost, and in fact I was. I found a map in the street, but I did not understand it: I was looking for a street called Fibigerstræde, and it was not a street! It was a group of buildings! I learned then that Aalborg University was organized in a different way from the way the city was organized. Indeed, Aalborg's street configuration is based on names. This is the reason why, without previous experience, a map, or a GPS, you cannot find the address where you want to go just by yourself.

After various experiences in a social world organized differently, I learned how to live in a new way; and that allowed me to enjoy my time in

Aalborg. Bogotá is a big city with 8 million people, a chaotic traffic, very noisy, with huge differences between socio-economic levels, and unsafe. In Denmark I have the pleasure of moving from one place to another without spending hours. At the same time, I feel safe and I do not need be alert all the time to prevent someone's aggression. Even though I do not speak and understand Danish, I love to discover the way people live here. I like to share moments with Danes in their homes. I like to discover all those differences that make it clear that I belong to another culture. At the same time, I enjoy becoming aware of the personal changes I have gone through while I have been interacting in this new social environment.

In this short story, there is one subject: *myself*. This self is expressing, telling and sharing her experiences in a *natural world* —different types of weather, flowers, animals, light etc. in different places of the earth such as Colombia and Aalborg. The person also experiences a *made world* —different physical objects, streets, buildings, etc. in Bogotá and Aalborg— and a *social world* —different ways to act and interact with other subjects, organization of space, activities, etc. in Colombia, in Denmark, in Latin America, in Europe. At the same time, in my story there are relationships between the subject and the natural, made and social worlds —myself expressing a way of perceiving the changes and differences in the everyday life when I moved to Aalborg, Denmark. Finally, there is another dimension, the relation between the subject and the cultures. It is the case of me experiencing life in Colombia, South America, and then in Denmark, Europe —those politically and socially organized places with subjects acting in many different ways.

In the story above, the self uses everyday language and shows awareness of different ways of acting and being in different social systems and cultures. During my journey, little by little I became aware of different ways scholars expressed their learning experiences, perceived the world, and constituted reality. From my initial perception of the self, detached from the social world, I travelled towards one considering the self attached to it: a social-self. I became able to see how different social systems push the self not to be a unique individual but also a social-self. An individual who uses what exists in the culture to act, think and change. This thesis is about understanding cultures, coexistence, and possibilities of merging them —coexistence and merging of the individualistic culture of assessment for learning within IBSE and a socio-cultural cultural approach to education—.

Similarly, as the research process advanced, I learned to distinguish my initial educational research perspective and culture —assessment for learning within IBSE— from a new one —a socio-cultural theoretical educational approach—. As in the previous story, I transformed myself and adapted to the new culture. At the end of the dissertation I clarify the idea of coexistence and

merging of those different educational perspectives when individual subjects learn them.

The methodology is constructed through analytical processes that gave me the means of changing how I could think of assessment for learning within IBSE. The theoretical tools support the use of my subjectivity and my experience in the research process, and the transformation of my subjectivity. At the same time, they are used at the end of the thesis to create a new conceptualization of assessment for learning activity in inquiry-based classrooms. Additionally, they contribute concepts, which clarify the difficulties faced when individuals from one culture move towards another.

I have organized this chapter in four sections. The first one illustrates and makes explicit my subjective changes, my view of reality, my research perspective and my forms of knowing and understanding assessment for learning within IBSE. The second part is constituted by the theoretical concepts that I borrowed to support and structure my research process. I present some theoretical tools of objectification and subjectification theory, activity theory, critical research and discourse. In the third part, I shape the research process by using five scenarios each one presenting analysis and actions informed by a critical perspective, as well as explaining the role of discourse in the constitution of my research methodology. Finally, I summarize the methodological elements, which make up my research.

DISTURBING MYSELF

I started with my passion for doing research that established relationships between the learner, the teacher, and mathematics, and scientific knowledge, as is usually done in the French school of mathematics education, where I qualified as a mathematics educator. In particular, I made a close study of the theory of Douady (1986) on the dialectical relations between mathematics as theory and as tool when imagining learners solving problems, and using different representations of concepts to learn (e.g., Dialectique outil-objet, and jeux des cadres). I also used to work with the concept of didactical enginery (ingénierie didactique) used by Artigue (1995), an analytical process to imagine a teaching situation by looking at the characteristics of mathematical content, hypothesizing about cognition, and designing problems based on didactical knowledge.

In those analytical approaches the focus was always on looking at the relation of mathematics, cognitive processes and teaching activities. This explains my choice of finding out about socio-cultural theories of learning by focusing my view on their impact on the relation to the teacher, the learner —the teaching activities by inquiry— and scientific and inquiry knowledge —the

characteristics of mathematics and cognition—. I also wanted to understand the relationship between scientific learning processes and society. These two concerns directed my attention towards a critical research perspective aiming at investigating changes in classroom interactions while understanding the classroom as part of a social configuration. I also used to understand concepts from the field of education by testing them myself, by using them in my own teaching or imagining the consequences of these concepts in practice. This influenced also my choices of the methodology.

I started my journey marked by a view of research that considered the "social" as the nature of mathematics and scientific knowledge that are "constructed in an interpersonal interaction between the teacher and students and also among students themselves" (Valero & Zevenbergen, 2004a, p. 1). Furthermore, using Valero and Zevenbergen's (2004) words, for me, the core of the social dimension was the exchange among the participants in a learning situation. My thinking and perception was shaped by ideas coming from research in the field of cognitive science. Indeed, I explored and learned about assessment for learning research within IBSE by studying research focusing on learning and cognition theories.

My hypothesis was that when we look at the classroom situation in another country, another educational system or another school another historical time, then, the relation between the learner, the teacher, and knowledge, changes. Studying assessment for learning within IBSE in everyday teaching and learning activities happening in different geographical places and historical times, was the focus of my research. A new trend in science and mathematics education looks at teaching and learning as part of social phenomena (e.g. Valero & Zevenbergen (2004a), Roth (2005a), Roth and Radford (2011; 2008)). This means that the object of study is part of social, cultural and political institutions where learners and teachers are experiencing teaching and learning science and mathematics. I traveled to this new "country", full of scholars with foreign languages.

My research connects this new perspective and the older one. In that sense, my research object is constituted by assessment for learning within IBSE viewed as an activity involving the learners, the teacher and the scientific knowledge, and at the same time, as an activity characterized by the educational culture and the society in which the activity is experienced by the learners, the teacher and the school curricula. I decided to research assessment for learning within IBSE from a cultural-historical perspective.

In the following sections, I will attempt to describe the process I experienced dealing with my common sense, my research and educational culture, and my ways of being. My poor English vocabulary and expressions are limited to express this disturbing process, however I bring some expressions aimed at communicating my change. In order to understand what I want to

communicate, try to imagine the experience of someone arriving in Denmark without speaking and understanding Danish, using her English with difficulty to communicate, and being confronted with another way of living and social configurations and relations. In the same way, I arrived at an educational land, the so called "socio-cultural perspective" and I did not speak the language of scholars living there, nor did I have the same experiences. At the same time I traveled from Spanish writing towards English traditions of writing, two different worlds and languages to express experiences and research.

MOVING MY VIEW OF THE WORLD AND REALITY

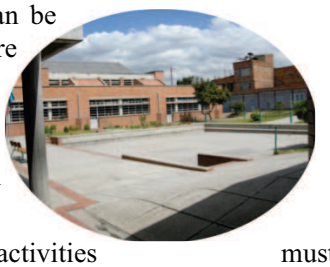
I used to believe in a world 'out there' that was the same for everyone. I used to call that *reality*. This view changed at two different levels: On the one hand, my view of reality connected to my object of study, assessment for learning within IBSE —a social phenomenon— was modified. On the other hand, my view of reality connected to the objects of study in the natural sciences —natural phenomena such as floating and sinking, plant growth, etc.— was also modified.

Since my research is located in the field of science education, both dimensions are relevant and need to be defined. It is important to make my assumptions about reality visible, and to define some concepts concerning these two levels: the educational phenomenon and the natural science phenomenon. In order to set the ground for constructing the story of my thesis, I distinguish between the notions of *world* and *reality*.

I followed the idea that the 'world' is constituted by all its entities independently of the subjects (Henriksen, Nørreklit, Jørgensen, & O'Donnell, 2004). I distinguished between different entities. Those belonging to the category of the *natural world,* also known as biological reality, comprised by mountains, rivers, sea, air, trees, animals, humans etc. Others belong to the category of *made world,* also described as human-made, material reality, comprised of buildings, tables, spoons, etc. In this category we find all kinds of entities fabricated by humans using their knowledge about the natural world. Natural and made worlds are the objects of study in the natural sciences. Researchers develop theories to explain what is observed in the natural and made worlds, to predict what could be done or what will happen in the future, and to build new objects.

Finally, I considered human activities and classified them within a category of *social world,* constituted by the interactions among human beings, and between them and the natural and the made worlds. These can be activities in companies, schools, houses, cities etc.

For instance, boys, girls, women and men go to buildings in particular places on Earth, every day. There are some activities that can be seen. In this



picture, some elements from the natural world can be perceived: trees, grass. From the made world there are windows, a big patio and a building. When I took the picture there were no people around, so elements of the social world cannot be seen here. I took the picture, so I know that this is a school, in the south of Bogotá.

In order to be a school, particular human activities must happen there. One of the typical activities, happening inside a room in the building, is teaching, an element of the social world. There are tables, chairs, paper, all elements of the made world, being used by boys and girls around the same age, and there is a person —normally older— that instructs those boys and girls and guides some activities for a particular time. The person standing in the picture is called a teacher, and the boys and girls, the students. In this social world, you have some facts, people writing, talking with each other, listening to the teacher, doing what the teacher says.

I followed the idea that subjects do not perceive the same about these worlds. At the same time, that *reality* is the way in which each subject perceives the world. Reality does not exist independently from subjects. I considered that each subject has his/her own way of acting and being in relation to the natural, made and social worlds. For instance, when I look at the pictures above, I know that I am not part of the activity going on. Therefore, my way of perceiving the situation is different from the way that a teacher and the students in that school and classroom perceive it. Each person lives a different reality, according to the meaning that each one gives to the situation.

Reality depends on our own experience. In that sense, I will suppose the existence of several realities:

> Reality is our awareness of, knowledge about, feelings for this world. Reality is that which works for us [...] is to live and to make things happen, so if anything is real in this sense, it is because we can do things with it, we can make things happen, we can change things [...] Realities are subjective in the sense that they are our private constructs. (Henriksen, et al., 2004, p. 17)

Reality can be shared. Each subject has different constructs or perceives the world differently, but people can share views and communicate about the world(s). When we communicate, we can focus on some aspects of the world and share our view.

I will borrow the term *psychic reality* to define the term reality. For Rousillon (2002) and Rojas-Urrego (2009b) psychic reality is used to denominate a specific reality, different from biological and material reality (external reality) but based on these two realities. This reality has specific properties: It is autonomous and unique, which makes it possible to distinguish from the others. According to Rojas-Urrego, this term is used in psychology and psychoanalysis. From the point of view of psychoanalysis, psychic reality is not only constructed at a conscious level by each individual, as psychologists suppose, but it also includes an unconscious level. Psychic reality is an objective complex reality, specific to each human being. For psychoanalysts, psychic reality refers to things, which in their psychic character have the value of reality for the subject. This reality is unique and individual.

Rojas-Urrego (2009), building on Rousillon, (2002) ideas, explains psychic reality as:

> Finally, it is a *unique and individual reality*. We make sense and give meaning to life and the world through it. It determines to a great extent the way we live life, relationships, our history, the shape we give to the psychic contents, to the representations we build ourselves and of the world. It provides the individual, specific and unique sense, for a specific person, of the things that happen and have happened to he or she; of what appears in front of each person and how he or she represents it; of the very personal way of this individual of grasping external reality and transforming it, often distorting it, and sometimes even replacing it. (p. 3)[10]

I use this notion to explain the term *experience*. Since our individual psychic reality is different and unique, our personal way of experiencing the world is unique as well. As argued by Rojas-Urrego, each one constructs his/her representations of themselves and the world. Each individual has his/her own way of grasping the world and of transforming it. Experience will be the way an individual makes sense of the world at every moment of his/her life. The result of that process is the construction of psychic reality. I will consider that psychic reality is constructed upon historical and cultural experiences, from the moment the individual is born.

This notion of reality allows me to introduce the complexity involved in an assessment activity in a class. I used to think that when a teacher was teaching, the students in the class were interpreting and experiencing the same, as if reality was static and there was only one possibility of perceiving that

[10] Translated from Spanish by Verónica Fornaguera.

should be common to all individuals. I also believed that the way the teacher perceived a classroom situation corresponded to the way each individual student was experiencing it. Since my new set of concepts does not allow me to presume the match of perceptions, then a new reconceptualization of an assessment situation has to emerge.

MOVING MY IDEAS ABOUT THE SELF IN RESEARCH

I used to think that doing a research study was a clear and straight process: You have a well-defined and delimited problem in relation to the state of the art of research concerning the problem. You choose a method to solve the problem, according to the questions and focus. You collect and analyze data in a way that allows you to answer your questions. Finally you present the results. Easy. That was my '*bon sense*', my '*sense commun*', or my common sense. Rather it was the view of research that had become natural for me. My research journey challenged my naïve perception of the research process. I move towards a methodology constructed around a problematique, where the object being investigated is approached by different angles, and by looking it as a complex social-phenomenon. The study approaches the complexity in a permanent dialogue with literature, theoretical models, and assumptions, and by considering the results as a knowledge produced and shape by researcher's subjectivity.

I thought that research was a matter of finding what others have not found yet. It was to delimitate the existing knowledge in the field relating to the object of study and then to find out something missing in that knowledge as if there was knowledge 'out there' and the task of research was to discover it. The knowledge produced by the research was a kind of addition to the existing knowledge. This knowledge was universal and could be understood and used out of context. The context was not a crucial issue.

I thought that the quality of a research study was measured by the accuracy of the methods and the fidelity of the interpretations that guaranteed that the knowledge produced was objective and free of personal beliefs, values and interpretations as if there was a reality out there that we could make visible by an objective methodology. As a researcher, I needed to detach myself from the object of research and use a method to be sure that different people would look at what my research had brought to light. During my journey, I learned that my natural way of seeing research was grounded in positivism (Denzin & Lincoln, 2003; Dezin & Lincoln, 2003; Krieger, 1991): Knowledge exists objectively out there, independently of the knower; truth and knowledge are objective existing without political contamination (Gipps, 1999).

I used to research without being aware of my own assumptions, and not knowing that there were more possibilities to do research in science and mathematics education than the "objective" way I had learned to carry out and

was used. I came from a positivist tradition where the self-researcher is detached from the knowledge that he/she is producing. I began to find interpretative traditions where the self-researcher is attached to the knowledge that is being produced. This last view had a great impact on me.

While I advanced in my research, I was able to perceive many objects —concepts, ways to do research, assumptions about the world— that I was not able to see before or, rather, that were not possible for me to be aware of due to the fact that the position I held had become my common sense. My PhD research process is the attempt to appropriate those new objects of knowledge that I encountered during my journey in myself. I used them to think and to re-interpret, re-describe, and re-create objects. I considered that learning is the way as the researcher produces the studied object.

Using Luis Radford's (Radford, 2008) dialectical process of objectification and subjectification —presented in chapter one—, I describe my learning process as a process of perceiving the objects of a research culture and little by little appropriating them in myself, that is, at the same times as I objectify them. Such objectification of knowledge is also a process of change in subjectivity. The process that triggers both objectification and subjectification is central to observing my changes in perception and understanding not only of my research object but also of myself as a researcher. I conceived the change of my subjectivity as a process of change my cultural sensibility. Cultural sensibility introduced in chapter one as the process of learning —objectification-subjectification— that changes my possibilities to conceive assessment activity in inquiry-based teaching and learning environments.

Different styles of research can be found in science and mathematics education research that vary from an outsider researcher, observing the reality of the classroom without participation, towards others including the researcher as participant of the inquiry (Roth, 2005b). The first kind of research produces knowledge about the mechanisms by which the process of learning operates in a classroom, generally looking at learning as an individual psychological process, mathematical knowledge characteristics, and how knowledge is constructed with others during the interactions (Valero & Zevenbergen, 2004a). In science education such research study 'science at school' as a specific scientific phenomena to be analyzed (Sherman, 2004) meaning that the social phenomena studied —science at school— can be delimited outside society and situated conditions of the actions and relations observed and analyzed during the inquiry.

The other perspective generates different possibilities of constructing the object of study. Valero and Zevenbergen (2004) explain this other view as looking at mathematics (or science) education as social and political praxis:

> This praxis is social because it is historically constituted in complex systems of action and meaning and in the intermesh of

> multiple contexts such as the classroom, the school, the community, the nation and even the globalised world. This practice is political because the exercise of power, both in it and through it, is one of its paramount features. (p. 2)

From constituting the objects of research as focalized in a classroom, isolated from a broad context, the second kind of research acknowledges that what is happening in the classroom is tied to the complex social system in which individuals interact every day. Also, that in such social complexity political dimensions such the exercise of power are involved.

Within the last possibility, the participants in the research process are involved in the research and the research is looking for changes in the researcher's practice —for instance, a teacher researching his practice (Atweh, 2004; Valero, 2004b). This research perspective opens up the possibility of using the research self in order to constitute the research process. This means considering the research object including the self as part of the research object (Roth, 2005b). I challenged myself to follow this new line of research.

Daston and Galison (2010) studied the development of the notion of scientific objectivity in history. In their analysis of the constitution of objectivity as a notion and an epistemological virtue of scientific research communities, they proposed to take objectivity and subjectivity as two inseparable entities. They see that one defines the other. They were interested in looking at how, in the mid-nineteenth century, the meaning of scientific objectivity emerged in relation to particular forms of scientific subjectivity. I live in another historical time, however my perception was shaped by a kind of training and views about research that existed around me. Myself researcher was shaped by collective ways of perceiving research, knowledge and objectivity. As Valero and Zevenbergen (2004) showed, the historical conditions within where and individual lives is seen as being part of the theoretical perspective that guides this type of research.

Daston and Galison (2010) recognized different meanings and terminologies for objectivity in history. For instance they used the term *mechanical objectivity* to name a particular set of practices in the mid-nineteenth century focalizing attention on the procedures used by researchers at that time to represent natural phenomena. To illustrate the relation between the objectivity and subjectivity, they exemplified how the emergence of scientific objectivity necessarily goes with the emergence of scientific subjectivity:

> Subjectivity was the enemy within, which the extraordinary measures of mechanical objectivity were invented and mobilized to combat. It is not accident that these measures often appealed to self-restraint, self-discipline, self-control: it was no longer variable nature or the wayward artist but the scientific self that

> posed the greatest perceived epistemological danger. This untrustworthy scientific self was a new as objectivity itself; indeed, it was its obverse, its photographic negative. "Why objectivity?" becomes "Why subjectivity?" –or, more specifically, "Who is the scientific subject?" (p. 197-198)

This statement helps to understand the movement of myself-researcher. As illustrated, there is a relation between the researcher and the constitution of the research object. The methods and the way research is done became part of the researcher's subjectivity: "self-restraint, self-discipline, self-control". A scientific self considered as being dangerous for the production of knowledge. The way the research is constituted, the methodological pathway, and the tools for representing the 'thing', are essential in order to understand the knowledge that research is supposed to produce.

Similarly to natural sciences, Krieger (1991) states that the social science disciplines in 1991 tended "to view the self of the social scientific observer as a contaminant". She argues that the self, the unique inner life of the observer, is regarded as separated and controlled. It disappears from the object of research; it is neutral. This means that it is possible to detach the observer from the social phenomena that is observed. Is like if the objectivity is guarantee by following an accepted methodology.

I used to follow the first type of research paradigm. For instance, I remember when I did my master's research on two teachers' representations of mathematical concepts in their teaching. For 8 weeks I went twice per week to their classes, recorded teachers' actions, registered all their representations on the blackboard, and noted children's activities. I stayed in the classrooms, trying to be invisible, without talking about my perceptions of the lessons with the teachers —self-restrained, self-disciplined, and self-controlled, using Daston and Galison words. I did not want to contamine their reality with my comments — a "scientific self that posed the greatest perceived epistemological danger" as Daston and Galison (2010) described. I wanted to capture 'the thing out there'. Then, in the comfort of my office, I analyzed the videos and wrote my report describing what teachers did, and how they represented the mathematical concepts. It is now evident to me that I configured the knowledge, which I had believed to be 'theirs'.

My question today is why I carried out research it in that way, and what knowledge resulted from my research approach. Nowadays, I do not like my position as a researcher back then. For instance, for me today it makes no sense to be 8 weeks at school collecting information and then leaving the school. This lack of attachment between the situation and myself bothers me. By doing what I did I feel that I invade their class intimacy. I exercised my power by correctly representing what they were doing, without taking them into consideration,

without giving them the opportunity to look at them selves and be critical about their life at school. If I went back in time, I would prefer to work with those teachers and learn from them, and also show them other possibilities. Today, I am more concerned about change. Now I see that changes in the classroom only take place if you get people involved in a process where change make sense in the context and becomes necessary for them.

I also learned during my journey that there are many possibilities of being a teacher, a researcher, and a teacher educator. I believe that there is not necessarily right or wrong in this matter. This idea makes me question my own view about the "good way" of teaching mathematics or science. Somehow I judged the teachers' work as if there was 'one way to do it'. I judged their use of representations based on my own expert ideal of representation uses. I ignored the context completely and the possibilities of teachers within a school where the complexity of the educational systems determines their activities. I used to think that teachers needed more education in order to become what they were ideally supposed to be. The socio-cultural context was external to their possibilities.

In my reflections about my subjective changes in perception, there is a recognition that to do research implies a change in the researcher's subjectivity, as well as the view about the knowledge emerging from the research process. Valero (2004b) explains how researchers in mathematics education constructed their field and objects through their activity. She recognized a diversity of ways of doing research. In this diversity, different methodologies and forms of constituting the research object emerged. What is important at the end, is that "as researchers, we create the 'objects' of our study while we engage in the practice of researching those objects" (Valero, 2004b, p. 6). In that sense, the researcher's choice, of a new methodological perspective to conduct research, implies the formulation of a particular kind of research object.

I moved towards the second research paradigm, adopting a view that the researcher inner life, or the observer inner life, is connected to the research object, and indeed 'contaminate' the research process, or in other words, is part of the researched object. To adopt this perspective implies an activity of self-reflection on inner thoughts in relation to the research, and also to recognize the role of the researcher in the constitution of knowledge.

Roth (2005b) argues that the use of the self in the research process is possible because society exists in and through the membership of individuals. What the individual writes about him or her self is also about society collectively. In other words, Roth is arguing that both the individual and the collective presuppose one another. I will use Roth's ideas particularly that "investigating the self, or rather, our actions, gives us access to the ways in which culture is concretely realized" (p. 19). For instance how the everyday life of a researcher is what finally constituted the knowledge to be shared. I

considered assessment for learning and Inquiry Based Science Education as an educational culture. I constituted my research object using the fact that I was and I am embedded in those educational cultures, as well in the Colombian educational culture. Those are conditions and constraints of my possibilities as researcher.

There are different ways of using the self in the research process. One is by following ethnographic methodologies of research. In this kind of research, the researcher use methods such as autobiographies, and notes about researcher's life, to constitute the phenomena under study. The researcher's career is recognized as a source for shaping the research, as is illustrated by Roth (2006a) with testimonies of this kind of research. Another possibility is to use everyday experience to research. It is to recognize the everyday movement of life, those instance that little by little constitute the reality of individuals. In that sense is to recognize that social phenomena is shaped by the everyday life of individuals. For Roth (2012), what is important in this perspective is to recognize how the researcher experiences the world, by analyzing the experience with his or her own senses. I did not produce my biography using ethnographical empirical material in a systematic way, or inquired about my everyday life to constitute the research. I used the fact that I had a history of interaction within a practice (IBSE and assessment for learning), and used that fact to look at the postulates that guided such practice. I looked at my practice in a systematic way.

My thesis reflects how I am becoming a science educator researcher: A self who is immersed in different cultural possibilities, and is not detached from those possibilities. In my writing, I am constructing a new research identity, and I am using concepts from the domain of science education as well as from other research fields such as psychology and anthropology. This new self is trying to re-interpret, re-describe and re-create new ideas based on existing ones. Roth (2006b, p. 71) expresses this idea in other words: "Today I understand that an individual career is a concrete realization of culture, and culture is produced by individual careers." He became a science education researcher in the constant interaction with different scholars and their thinking. Ideas from different thinkers in a variety of fields changed him. Those changes drove his thinking and possibilities to act as and to be a researcher. I see this as the expression of this social-self that we all are: Roth is a unique self-researcher, but at the same time he is an expression of a more complex cultural and social phenomenon.

The process was conceived as an opportunity to open new sensibilities in order to transform my subjectivity and thus, my possibilities of knowing. This transformation was planed to allow myself to experience assessment for learning research in IBSE differently. The various research activities help to move my capacity towards creation and innovation within assessment research using socio-cultural assumptions about learning. I was appropriating socio-cultural

concepts for imagining changes in a classroom situation when looking at classrooms from a cognitive perspective or from a socio-cultural perspective.

My claim was that only by changing my psychic reality was it possible to explore assessment for learning from a socio-cultural perspective. Using Valero and Zevenbergen (2004) words, it is to consider assessment praxis as social "because it is historically constituted in complex systems of action and meaning and in the intermesh of multiple contexts such as the classroom, the school, the community, the nation and even the globalised world" (p. 2). As mentioned in the thesis problematique in chapter one and two, I was interesting in understanding the arrival of a foreign culture in historically constituted reality. I was not aware that I also addressed the praxis of assessment as political "because the exercise of power, both in it and through it, is one of its paramount features by situating the learner, the learners, the teacher and the knowledge to be learnt in the activity lived by individuals in an educational culture, cultural ways of thinking and in the flow of the everyday changing life" (p. 2). This last 'non awareness' is reflected in the fact that in my analysis I did not clearly focus on the notion of power.

Roth (2005b) recognizes a possible danger by using the self in research processes. The individual is closer to him or her self, which raises the possibility that the individual does not find the distance required for critically interrogating his or her sense making. The use of the self in my research avoids this problem by looking at the self and using what is found in research literature. In that way, my research process will be always a critical look at myself, as well as my own educational culture. By looking at a new theoretical research perspectives in literature, I explored my own assumptions as well those of the educational culture where I worked. I tried to critically examine my theoretical perspective, my interpretations, and my difficulties in understanding.

I am assuming that to clearly present my object of study, I need to make visible the relation between myself, and the social practice I am looking at. I assume that myself is embedded in ways of making sense of IBSE ideas in a particular place, at a historical moment, and as part of an IBSE practice. During my years of work in *Pequeños Científicos*, the Colombian IBSE project, I shared an academic environment with teacher educators, material designers, teachers, and researchers from France, United States, Chile, Mexico, England, Brazil, Argentina, Bolivia, Panama, and Peru. The meanings and senses of the social phenomenon I developed in my journey are shaped by my interactions with those members of the network and with the products used in the IBSE network. Somehow, their voices are present in myself. They also constitute my social-self.

MOVING THE RESEARCH PERSPECTIVE

I noticed another culturally constituted research perspective in mathematics and science education, which fits more with my needs of understanding as researcher. My discomfort with my way of looking at research forced me to become aware of the critical research perspective. When I was looking for a research methodology, I found those involving the subjects as part of the research process. I wanted to involve subjects in my research, learn from their knowledge and respect their ideas; I wanted to recognize differences and to respect those differences. I liked research that involved the subjects in the research process. I also liked the idea of interacting, discussing, hearing their voices, and also making my presence visible in the research context. I decided then to do a qualitative study. I acknowledged that this field in social science has a variety of possibilities and had to face different challenges supported in epistemological, methodological, political, and ethical criticisms of experimental, quasi-experimental, correlational, and survey research strategies (Dezin & Lincoln, 2003; Schawandt, 2003). From these options, I chose to become a critical researcher. This implies the notion that it is not possible to be a disinterested observer, but rather that the observer is a social being who construes the world according to his values and perceptions, and his/her biography is central to what he/she sees and how he/she interprets it (Gipps, 1999).

I found that critical researchers adopt the position of resisting the positivist conception of scientific rationality. They attempt to deconstruct objective truth (Kincheloe & McLaren, 2005). While positivists look at an existing object out there, critical researchers look at transformations of the world. It is not a matter of looking at patterns of behavior or characteristics of a classroom, or representations used by a teacher. The aim of critical research is the criticism and transformation of social, political, cultural, economic, ethnic and gender structures (Skovsmose & Borba, 2004). In positivist research, researchers claim neutrality in their constitution of knowledge. For critical researchers it is relevant to announce "their partisanship in the struggle for a better world" (Kincheloe & McLaren, 2005, p. 305). In my case, as researcher and teacher educator, I was always attracted by the possibility of change: Transformations in mathematics and science classrooms, which provide tools that allow children to feel good in their lives. Likewise, I looked for the well being of teachers.

Transformation and change were essential for the constitution of my activity as researcher. The research methodology was constructed in order to understand social change in a quite punctual practice: how do assessment for learning and IBSE arrive as foreign cultures and are assimilated by people of other cultures? At the same time, a critical perspective allowed me to find a way to look at my own movement between types of researching in mathematics and

science education: How does the research self change her possibilities to research assessment for learning and IBSE moving from a traditional positivist perspective?

Transformation of society and individuals are central for the critical research paradigm. Kincheloe and McLaren (2005) express the following as a relevant point of critical research:

> Research in the critical tradition takes the form of self conscious criticism researchers try to become aware of the ideological imperatives and epistemological presuppositions that inform their researches as well as their own subjective, inter-subjective, and normative references claims. Critical researchers enter into an investigation with their assumptions on the table, so no one is confused concerning the epistemological and political baggage they bring with them to the research site. (p. 305-306).

Thus, I constructed my methodology to make my assumptions visible, as well as those culturally accepted around my practice. However, during the research process, my subjective changes did not allow me to identify all the dimensions referred to the words of Kincheloe and McLaren, particularly a special sensitivity to power that I have not been able to realize in my understanding. I started my investigation without consciousness of my assumptions, normative references, political and ideological concerns etc. I know that I still have work to do but I also recognize that now I am able to see more than before. However, as is shown in the presentation of the research process, the identification and differentiation of my own assumptions and those of others became the strategy to constitute the researched object, as well as the researcher's subjectivity.

The general assumption in the critical paradigm, expressing that individuals' view of themselves and the world are strongly influenced by social and historical forces (Kincheloe & McLaren, 2005) became important in the way I constructed my research process. Little by little I became aware that human thinking is mediated by contextual languages, objects, configurations of space and power relations that are social and historically constituted (Kincheloe & McLaren, 2005; Lemke, 2001; Radford, 2002; Roth, 2007; Skovsmose & Borba, 2004). This complex idea is central to understanding how changes in educational settings can take place. In order to understand the complex world of assessment for learning within IBSE, the configuration as foreign culture, and the possibilities of changes, I needed to consider this tight relationship between individuals and the social structures and cultural configurations where they live in the transformative flow of everyday human activities. This was considered at two levels, firstly by looking at the constitution of the object by the research process —the assessment for learning activity within an inquiry-based classroom—, and secondly, the constitution of the methodological strategy —

considerations about the self-researcher in relation to the construction of the researched object.

As much as this particular assumption became clear, I am fully aware that other assumptions that critical research assumes as relevant for the process are still blur for me. I recognize that for critical research it is relevant to understand that the facts can never be isolated from the domain of values or removed from some form of ideological inscription, and that research becomes a transformative endeavor unembarrassed by the label "political" and unafraid to consummate a relationship with emancipating consciousness. However, in my thesis I have not made an effort to take these claims on board. The reader must not expect to find this kind of reflection in my text. Still, I recognize that my thesis is aimed towards some kind of emancipating actions. I reveal contradictions of the world of appearances accepted by the dominant culture (Kincheloe & McLaren, 2005) as natural and inviolable both in assessment for learning within IBSE and in IBSE. I question their assumptions and develop other possibilities.

Another central aspect of the critical research paradigm is the consideration that language is a key to the construction of subjectivity (conscious and unconscious awareness) (Kincheloe & McLaren, 2005). I became aware of the relationship between the configuration of reality of individuals and the role of language. My methodology considers that language is necessary for individuals to constitute reality. Language changes their experiences in the world. In particular, different language configurations, reasoning, utterances, words, and meanings create a collective way of perceiving and constituting reality.

Critical researchers based their research methodologies on the relationship between language, culture and society. Different researchers have used the term *discourse* to refer in different ways to this relationship (Fairclough, 1992, 2001; Gee & Green, 1998; Rogers, 2004; Valero, 2007). Discourse is a word with different meanings and interpretations in research. Rogers (2004) specifically explores critical discourse analysis in educational research. For her, the scholars using critical analysis discourse "describe, interpret, and explain the relationships between language, and important educational issues" (p. 1). For instance, as a way of illustrating this kind of analysis, she postulates the possibility of analyzing the relationship established between the top down model of business (and classroom) leadership evolving towards the concept of community of practice, changing in that way the relationship among practitioners. What seems to be relevant in this kind of analysis is to recognize contradictions between policies and practices when looking at the differences between the policies and the practices, sometimes moving in different directions (Rogers, 2004).

I accept that language is part of a society and they are not two independent entities. I follow Fairclough's (2001) assumption that there is an

internal and dialectical relationship between language and society, and that linguistic phenomena are social phenomena. He argues that the ways in which people use language are socially determined by relationships in different social settings, and have social effects helping to maintain or change those relationships. However, I did not used Fairclough's methodological tools to look at language. As I will show later, I used the concept of discourse to represent the connection between the artifacts and text used in my practice, the texts and artifacts used by researchers, the activity of researching and the object of research, and finally, to understand the connections between top-down policies —such as assessment for learning and IBSE— arguing for a change and the needs and movements in practices —such as teachers practices within their own educational system.

To talk about assessment implies looking at theories of learning and their relationship with assessment. In the international field of science and mathematics education research, some people have challenged dominant research discourses which are based on the view of learning mathematics and science as an individual cognitive process. These people have moved towards a view of learning as a dialectic process between the individual and society —e.g. in science education (Leach & Scoth, 2003; Roth, 2006b, 2007; Schoultz, Säljö, & Wydhamn, 2001; Schoultz, Säljö, & Wyndhamn, 2001)(Leach & Scoth, 2003; Roth, 2006, 2007; Jann Schoultz, et al., 2001) and in math education (T. Popkewitz, 2004; Radford, 2008; Sfard, 2008; Skovsmose & Borba, 2004; Valero & Zevenbergen, 2004a).

Inspired by the argumentative style of Leach and Scott (2003), Shoultz, Säljö, and Wydhanm (2001), Säljö (1997), Roth (2007), and Lemke (2001) in science education, and Radford (2008), and Sfard (2008) in mathematics education, I use the contrast between one kind of perception of the world, research objects and learning and another possible conceptualization. The strategy of contrasting cognitive and socio-cultural views, almost two paradigms of learning, as Sfard (2008) would argue, allowed me to grasp how different concepts, theories and assumptions change the constitution of reality. It became indispensable for me to contrast, and to change my own assumptions about learning. Only by doing that, was it possible for me to address the impact of my analysis in the IBSE research context. Only by making sense of the differences and changing my sensibility was I able to imagine a new theoretical basis for assessment for learning within IBSE.

Before I began my doctoral studies, my paradigm was in line with the individualistic cognitive view. My research gaze was always focused on how each individual learns mathematics and science and which activities were carried out by teachers and researchers to help each individual develop his/her cognitive possibilities (e.g. Carulla, et al., 2006). I reduced the social dimension of any activity at school to a set of variables that affected the cognitive potential of each

individual (e.g., cognitive stimulation in families, opportunities to face cognitive challenges, nutrition, school infrastructure); and affected individual teachers' possibilities to do what was necessary (e.g., no support from administrators, lack of opportunities to face complex challenges during their own learning process, difficult social conditions of their students). Nonetheless, I recognized that the possibilities in the classroom activity were connected to different dimensions within the school and educational policies.

During my doctoral studies, the social and cultural dimensions started to become essential parts of the teaching and learning processes, just as the research methods and assumptions stated. Some of the difficulties I had faced in understanding the teachers' problems in implementing IBSE teaching methods and assessment for learning began to make sense. I saw those difficulties not as a problem of individual (mis)understanding, but as a complex phenomenon resulting from a relationship between the individual, the school culture in which the individual is immersed, and the general constitution of a society.

My sensibility shifted from a view of learning as something primarily happening in the individual's head, towards a view of learning as a process linking the society and the individual. This means "viewing science, science education, and research on science education as human social activities conducted within institutional and cultural frameworks" (Lemke, 2001, p. 296). To view learning far from a cognitive processes implies that the object of research is viewed as a social activity (Lemke, 2001; Valero, 2004). To research assessment for learning within IBSE with The new perspective on learning implies to pay particular attention to all kind of interaction and language in educational settings, which are viewed as relevant to the learning process (Lemke, 2001; Mercer, Dawes, & Wegerif, 2004; Rojas-Drummond & Mercer, 2003; Roth, 2006a; Schoultz, Säljö, & Wyndhamn, 2001). It is different from other traditions where interaction is viewed as a way of helping individuals in their own process of learning, because learning is viewed as, in essence, an individual matter. On the contrary, a socio-cultural research perspective constitutes the learning activity as essentially social. The 'others' are not merely ancillary (Lemke, 2001).

When the view about learning changes, the activity of researchers in mathematic and science education is configured differently. Lemke (2001) maintains that in the same way as teaching and learning is viewed as inseparable from the social organizations, the study of these disciplines is viewed differently:

> Similarly, it means seeing the scientific study of the world as itself inseparable from the social organization of scientists' activities, as is done in the work of Bruno Latour and many other contemporary sociologists and historians of science (e.g., Latour, 1987; Lynch & Woolgar, 1990, Shapin & Schaffer, 1985). But this

> is only the beginning. Interpersonal social interaction, whether collaboration in a laboratory or dialogue in a classroom, is only the smallest scale of the social. (p. 296)

Socio-cultural theory emphasizes that all human activity is possible because of a social organization. Each activity is influenced by all kind of social issues as for instance power interactions within organizations. In that sense, the individual activity makes sense only in relation to a social organization. The way each individual lives across different social communities and organizations provides him or her with cultural tools to interpret the world as is done in the culture. Languages and pictorial conventions as well as beliefs and values or specialized discourses are being formed within each community or organization (Lemke, 2001). Following this idea, when an individual is involved in one activity, she/he is making sense of the situations within a particular culture. *Culture* here is understood as a set of meanings that are shared by people involved in the same kind of social activity.

DISTURBING MY SENSIBILITY

By presenting the movements in paradigms above, I tried to support my research choices. However, what was essential for me was to communicate the disturbances of my self, my being, because without them a new type of objectification would not have been possible. I saw research as a process of learning and production of knowledge during such activity. I followed Wenger's (1998) words: "Because learning transforms who we are and what we can do, it is an experience of identity. It is not just an accumulation of skills and information, but a process of becoming" (p. 215). The exposed transformations are in fact a documentation of myself-becoming.

I continue nowadays to fight with all the contradictions that arise when part of myself is still within the positivist research perspective, and I am confronted with how to support my choices for the reader. While I still admire and somehow live the cognitive perspective on assessment for learning within IBSE, at the same time I see the potential of changing this type of such theoretical perspective. I see the great impact on my possibilities of thought, my life as a teacher and as a researcher by being critical and at the same time the difficulties involved in assuming such position in my soul and for the reader.

The research process was constructed to disturb my culturally learned possibilities to research assessment for learning within IBSE and move towards a new understanding. I kept above movements from the previous presentation of these changes. I retained the following points guiding my methodological choices and the constitution of my research object:

- I recognized different definitions of reality relevant for my inquiry. The natural world or biological reality that scientists explore to create theories and knowledge, and that learners and teacher, in any teaching, learning and assessment activity at school, are supposed to know, are not the same reality for all people perceiving it. At the same time, there is the made world that is constituted by the material world created by humans using knowledge about the natural world. In the definition of this made world, there is no a consideration about the artifacts with cultural meanings and diversity of uses. What is relevant is that those artifacts created by humans are based on knowledge about the natural world.
- I distinguished also a social world in which activities are the moments that define what an individual is doing and saying at particular moments of his or her life. This social world was presented in all its complexity by examining social praxis from a perspective that involved the interaction of human beings within different institutional configurations, and also political concerns. And finally, I defined psyche reality to make explicit this configuration of reality that each individual constructed in his personal experience in the interaction with others in the social activities in which the individual is acting.
- I acknowledge that my psyche reality is part of my research process and also that this psyche was formed by my relations with the cognitive perspective research activity used in the IBSE teaching activities in which I was involved. I made explicit the assumptions guiding my inquiry. I state the configuration of my research object depended on the use of my own experience. I used myself, my inner experience, my social-self, and my empathy with the ideas of researchers and teachers to re-create new possibilities of finding out about assessment for learning within IBSE research activity.
- In line with this idea, I adopted a critical research perspective. During the inquiry I aimed at examining my own assumptions and possibilities of experience in the research field from a cognitive perspective, and questioned those assumptions in the light of other exiting assumptions in the socio-cultural traditions of research. I disturbed my objective way of looking at social phenomena and accepted that I would bring a perspective acknowledging the presence of the self in the research.
- I realized that it was only possible to research assessment for learning within a socio-cultural theoretical perspective by changing from a view of learning espoused by socio-constructivism scholars towards a one that acknowledges that the individual is not a cognitive machine

> isolated from the possibilities that the activity in which he or she is immersed will provide and neither is he or she cut off from the social relational space which surrounds activities It means that when individuals interact this involves affective relationships, power relationships, material relationships, and social aims as well as personal ones.

SUPPORTING MY METHODOLOGICAL STYLE WITH THEORIES AND CONCEPTS

To support my inquiry and methodological style, I used Radford's (2008) theory of subjectification and objectification. I see my research as a process of learning and production brought about by such a learning process. Adapting Radford's words to my situation, by process of learning I mean, "endowing conceptual cultural objects with meaning" (p. 225). For instance, in my research process this means providing a qualitative meaning to the individualistic[11] and socio-cultural terms. Furthermore, it is characterized by my "open-mindedness" or "opening movement towards others and the objects of culture" (p. 225). For instance my decision to give meaning the individualistic and the socio-cultural terms used by others scholars, and at the same time to accept changes in my own subjectivity, by making sense of them. With my research process I went beyond "acquire something", or "possessing it, or mastering it, and went to the culture to find something in it in this encounter with the other and cultural objects" (p. 225). By doing that, I experienced a process of reformulation of myself, and as Radford said, to finally *find myself*. A new self that is able to follow a "creative process of finding or noticing something (a dynamic target)" (p. 225). This is to imagine, or to configure 'something' —'Assessment for learning within IBSE'— by 'noticing' a cultural-historical perspective to carry out the research activity. The process I have described is my interpretation of what Radford called a process of *objectification* (Radford, 2002)and the way I am adapting it to my own research.

However, according to Radford (2008), objectification is tied to a parallel movement, subjectification. Indeed, he argued:

> [...] objectification thus is more than the connection of the two classical epistemological poles, subject and object: it is in fact a transformative and creative process between these two poles, where, in the course of learning, the subject objectifies cultural

[11] I use the term individualistic to denominate the cognitive perspective earlier described.

> knowledge and, in so doing, finds itself objectified in a reflective move that can be termed *subjectification*. (p. 225)

I made visible to the reader how this research process transformed myself, a self-unique in the sense that what I produced and lived is only possible by my unique history or trajectory within research, academia and life. As Radford explains the process of objectification is merged with a process of subjectification:

> The making of the subject, the creation of a particular (and unique) subjectivity is thus a process of subjectification that is made possible by the activity in which objectification takes place, and by the *re-flective* nature of thinking and the possibilities that e.g. language and other cultural instruments of thought offer to distinguish between an "I" and its surroundings (I/non-I; I/you; I/it; we/them, the impersonal discourse of science, etc.). (p. 225)

I decided to bring to my writing this process of objectification and subjectification. In order to produce a new language and possibilities of thought —using a cultural-historical activity theory— in assessment for learning within the IBSE field, I needed a movement of my subjectivity. However this desire arrived with a major challenge, since it is not usual in the researchers' writings to find this type of process described or used as part of the research process. It became difficult to make a distinction between "I" and my "surroundings". I needed then to prepare the reader for my own methodological style, and transform my text in such way that I, the writer, and we, the readers, could found a methodological support and those processes clearly enunciated.

To support it, I used cultural–historical activity theory following the developmental historical line of Vygotsky and Leontyev, and continued nowadays by Roth and Radford (see Roth & Radford, 2011). I acknowledge that there are other interpretations and uses of such theory, like the famous and recognized triangle representation explicated by Engeström, Miettinen, & Punamäki (1999) in educational research, and that both developmental lines are based on the Marxist tradition of thought. But, since Roth and Radford's research is in science and mathematics education, I found reflected my thought and my interests. I then faced the challenge of presenting my methodological style and my possibilities of thought and creation as an object that could be part of cultural knowledge, and useful for others, and not only for my own process of subjectification.

TRANSFORMING THE SELF: SENSIBILITY

In her book 'Thinking as Communicating', Sfard (2008) starts by saying: "This book is a result of years-long attempts to change my own thinking about thinking, a task seemingly as improbable as breaking a hammer by hitting it with

itself" (p. xiii). She maintains that to produce knowledge and theoretical changes it is necessary to transform the self. She realized that in order to understand mathematical thinking it was important to look at human thinking at large. In particular, she ended up "wondering with Vygotsky about how the unique human abilities "have been formed in the course of human history" and about "the way they develop over and individual's lifetime." Vygotsky (1978, p. 1)" (p. xiv).

Sfard's words and expressions help me to introduce the term "sensibility" used by Radford and Empey (2007), which has already been mentioned in Chapter 2. They used the concept to analyze changes in mathematical thinking throughout history. To me it is relevant to consider that thinking and cultural ways of being today, my today, are shaped by the historical development of that thinking and cultural ways of being, and also by my individual lifetime, as Sfard mentioned.

Radford and Empey (2007) defined sensibility as a "subtle progressive cognitive and epistemological change that leads the individuals of a culture to pay attention to themselves and to their world in new ways" as well as "capacities to create new forms of understanding and novel forms of subjectivity" (p. 238). I interpreted those words by considering IBSE and assessment as a body of knowledge that creates forms of understanding and of subjectivity. This body of research is shaped by theories about how people learn, think, know and develop through time.

As a teacher educator I was interested in understanding how teachers working in different places and times can adopt new forms of understanding and subjectivity. How it is that teachers and practitioners in different countries and continents, embedded in different social configurations and praxis, as well as within different educational cultures, can adopt educational theoretical perspectives —IBSE and assessment for learning models and principles— to work with in their own classroom.

I adopted assessment for learning and IBSE forms of thinking and reflection shaped by assumptions about learning, thinking and knowledge. The individual embedded in this kind of culture uses these assumptions to re-create and re-interpret concepts and ideas within their own practice, in everyday life. The theoretical perspective that I am using considers how assumptions about learning, knowledge and thinking shape possibilities for subjectivities. Radford and Empey (2007) analyzed how mathematical thinking became instrumental in the formation of new sensibilities. I transformed their postulate and argue that in my case, in any educational praxis, assumptions became instrumental in the formation of new sensibilities.

Adapting Radford and Empey's words and ideas, I realized that individuals from any assessment educational culture reach understanding and

new forms of subjectivity when they accept for themselves assumptions about knowledge, learning and thinking. Teacher educators, researchers, teachers and learners of the IBSE network are involved in activities that allow them to change their subjectivities and develop an assessment and IBSE sensibility. This is envisioned by introducing principles and ideal activities in different educational and cultural practices in order to teach and learn science.

Questions about the nature of science and IBSE educational objects, their mode of existence, the forms of science and IBSE educational discourse, etc, in terms of Radford and Empey (2007), find their justification in the supra-symbolic system of beliefs. In their view, supra-symbolic systems of beliefs are bearers of historical traditions, far from static entities, and kept in motion (and modified) by actual tensions in the always-moving space of praxis.

For researchers such as Roth and Radford what is relevant when a socio-cultural historical perspective is adopted in research, is to analyze what we are studying, praxis, as it occurs in real life. Roth and Radford (2011) said:

> This life can be comprehended only concretely, in the form of what is rather than what ought to be. The world that makes this life unitary, unique, and experienced concretely: 'it is a world that is seen, heard, touched, and thought, a world permeated in its entirety with the emotional volitional tones of the affirmed validity of values' (Bakhtin, 1993, 56). (p. 10)

In my methodology, I chose to show my activity of researching about assessment for learning within IBSE, and not how it ought to be. I attempt to show the piece of world I am looking at as unitary, unique, and experienced concretely. I used my life in the IBSE network and my experience in a Colombian school to move my understanding. I adopted that only by looking at the everyday activity it was possible to understand the challenges faced by assessment for learning within IBSE research, when as a foreign culture ought to be used by teachers and students. Only by looking the problem of such transformation is that I can understand teachers' resistance to adapt such foreign cultural knowledge. Only by looking my own difficulties adopting a foreign culture, I can imagine theirs.

LIVING CULTURAL-HISTORICAL RESEARCH ACTIVITY

As it will be shown later, there are two forms of subjectivity and understanding within educational research: the individualistic perspective and the socio-cultural one. Both are constructed with a set of assumptions, creating subjectivities, that in their everyday life as researchers, are able to see the process of learning in different ways, offering to individuals new forms of action and ways to understand assessment activities in educational settings. I distinguished a

research activity based on individualistic assumption from a research activity following socio-cultural ones.

Radford and Empey (2007, p. 235) defined cultural knowledge as emerging from a social praxis that is structured by:

> *Semiotic Systems of Cultural Significations*: the set of beliefs about conceptual objects, conceptions about truth, methods of inquiry and legitimate ways of knowledge representation.
> *Forms of Social Relations*: division of labor and social institutions
> *Forms of Production*: artifacts, signs, objects, etc
> *Cultural Knowledge*

The subject researching is a producer and user of cultural knowledge that is at the core of those concepts. In that sense, when the researcher is inquiring with individualistic perspective the Semiotic System of Cultural Signification, Forms of Social Relations, Cultural Knowledge and Forms of Production are boundaries for his own possibilities of creation and innovation. In the same way, the possibilities for a researcher within the socio-cultural perspective are restricted. The methodological problem I faced was that my initial possibilities to produce cultural knowledge were shaped by my individualistic subjectivity. How then a subject with a particular way of perceiving cultural knowledge moves towards another subjectivity. Indeed, in order to use socio-cultural assumptions, the beliefs about conceptual objects, the conceptions about truth, the methods of inquiry and legitimate ways of knowledge, my research self needed a process of transformation with other possibilities of production of cultural knowledge, social relations and also other artifacts, signs and objects.

My methodological style tried to capture this movement. For that, I constructed *sensibility spaces*. Each space is a scenario where I experienced a process of disturbance in order to move from one set of assumptions towards another. I tried to capture the internal reconfiguration of my sensibility as the process of visualizing my own assumptions and ideas, to identify them with cultural forms of researching, and then to look for other possibilities. The configuration of my new sensibility became the process of changing such assumptions for new ones in order to innovate. I make explicit this sensibility emerging in my intention to become a socio-cultural researcher. Each space captures this everyday life, in which an individual who is researching is moving towards a new subjectivity in a process of objectification-subjectification.

To give a sense to my research activity, I chose to use cultural-historical activity theory since it allow me to convey this constant movement of the self in the engagement of social praxis. Leontyev (2009) established a relation between activity and consciousness. His concern was “the significance of the category of activity in any interpretation of how human consciousness is determined” (p. 1).

He is against a view that studies human cognition separated from everyday situations, assuming a relation between the subject and object: The subject adapting him or her self to the surroundings. For him this perspective is problematic since "it assumed, on the one hand, things and objects and, on the other, a passive subject influenced by them" (p. 1). In his words, "this approach ignores the significant element of the actual relations of the subject with the objective world; it ignores his activity" (p. 1). Based on this idea, I moved from looking individual's learning and knowing as independent from the activity towards individual's learning and knowing as dependent on the activity in which is involve.

What is central to the Leontev's activity theory perspective is that development is considered to happen "through relation with others in the pursuit of collectively motivated activity" (Roth & Radford, 2011, p. 2). In that sense, the individual psyche is considered as a culturally historically evolving form of reflection. Two dimensions in the constitution of all individual psyche are identified by Roth and Radford: an 'I' and an 'Ego'. It is as if every subject has in his psyche the 'I' representing the subject, and the 'Ego' constituted by the outside world (Roth & Radford, 2011) —for instance symbols and objects with their meanings in the culture where the individual experience every day. A psychic reflection occurs while a material living subject, which is highly organized, interacts with the material reality close to him. Any study using this theory must study the individual within the activity. For Roth and Radford this means that mind, abstract knowledge, psychic reflection, or consciousness cannot exist or arise without subject activity. In order to set up the problem of my thesis, I use Roth and Radford's (2011) definition of activity. They see activity as "a process in a system of relations that realizes the societal nature of human beings" (p. 5). They also state that activity "is a unit that cannot be reduced to inner (cognitive) or outer (material) processes" (p. 5).

In the case of my research process, I considered that there is a research activity in which scholars are involved, that appears in written documents where the psychic reflection, the mind, the consciousness and abstract knowledge appear as materializations of the activity. Those ideas produced in the interaction of the scholars with the materiality around them are what constitute, in my research, the collectively produced ideas that I assume as part of my own subjectivity —my Ego. At the same time, the document I am producing while researching assessment for learning within IBSE, is also 'my' activity. I play during the research process with this duality of the psyche reflections, my historical experience —my 'I'— and my contact with research ideas —my 'Ego'. My focus is the connection of the subject —the I— with the activity, and the cultural knowledge produced in the process. In another dimension, I identify the subjects' activity —learners and teacher— experiencing assessment for learning within an IBSE classroom constituting the object of study for scholars.

This activity is what I try to understand and to capture in my research with socio-cultural lenses.

I see myself as a subject researching assessment for learning within IBSE with the possibilities offered by a materialized world around myself. I started the research process with my subjectivity and cultural possibilities of psyche reflections. At the beginning of my research, the sensibility was dominantly shaped by looking at learning as an interaction of the subject's inner mind and the outside world. I had had no contact with research ideas coming from a socio-cultural perspective. Then my possibilities of thoughts were given by my sensibility formed in the interaction with assessment for learning research scholars, which research was mediated by the individualistic perspective. This means that the assessment activity in the classroom in which learners and teachers were involved was conceived as a process involving cognitive individuals, the natural world and the symbolic system of scientific knowledge.

From Leontyev's theoretical perspective, we can not think of activity without looking at it as concrete and specific activity, "each of which satisfies a definite need of the subject, is oriented towards the object of this need, disappears as a result of its satisfaction and is reproduced perhaps in different conditions and in relation to a changed object" (Leontyev, 2009, p. 6). For him, what distinguishes one activity from another are their objects. Furthermore, Leontyev defines objects as motives, that "may be both material and ideal; it may be given in perception or it may exist only in imagination, in the mind" (p. 6). Activity without a motive does not exist. For him an activity that appears to be without a motive is an "activity with a subjectively and objectively hidden motive". I consider researching assessment for learning within IBSE as an activity experienced by bodily subjects and producing knowledge. Using the activity as the unity of analysis implies seeing the complex societal phenomena of assessment research as produced by those subjects involved in the activity and the possibilities of reflection psyche that is provided by the symbolic and material reality around them.

The object of the activity is what finally is materialized as a product of the activity, and the motive is what guides the individuals during the activity: the object is the materialization, and the motive is the ideal of such object. I will represent this relationship as object/motive. I identify as the object/motive of the assessment research activity 'to produce Cultural Knowledge about assessment for learning in IBSE classrooms'. In my research, I do that by traveling myself from considering learning as a process happening in the relation of the individual mind and the surroundings —mind in relation with others' minds and material world—, towards a perspective that uses subject-activity as the unit to conceptualize assessment for learning.

Moreover, following activity theory also means understanding the social world in the flow of everyday life, it is to perceive the continual process of

change. In that sense the motive of any human activity is also shaped by specific circumstances that 'move' people in everyday life. I identify my research process immersed in particular social and contextual circumstances. As a person working at the Andes University in Bogotá, I was 'forced' to follow a PhD to secure my post. I decided to become a student because of my personal desire to have a socially certified title and to enjoy a learning process. So my research is not an abstract activity happening in my head independent of all my feelings, personal and institutional goals, and constraints. It is constituted also by my needs of doctoral education, my social position as 'PhD student', the characteristics that such position 'impose' on my writing, the possibilities offered by being at Aalborg University, at the Department of Learning and Philosophy, within the SMERG research group, and having a Paola Valero as a supervisor.

For Roth and Radford (2011), what makes Leontyev's conceptualization of other development of the theory different is the recognition of change present when one looks at the everyday activities in life. Roth and Radford consider change as another unit of the model. It is recognized that, for instance, a model representing activity theory such as Engeström et al.'s (1999) classical triangle representation, attempts to dismiss the specificity of any human activity. Instead, Roth and Radford invite us to think that it is only possible to approach and construct the activity in the flow of actions, in the instant operations and actions which are lived and experienced by individuals. This is a challenge for any research process, since it is necessary to capture this continuing changing activity.

Leontyev (2009) states that human activities are delimited by the actions that realize them. He defines actions as "the process that corresponds to the notion of the result which must be achieved, that is, the process which obeys a conscious goal" (p. 6). Operations are the concrete basic constituents that make it possible to carry out the actions. Assessment for learning within IBSE research as an activity is accomplished by some actions that typically characterize this kind of social activity. It is to set up research questions within some problematic issues identified in the field —a body of knowledge socially accepted—, to use socially accepted methodologies to find answers to the questions, and to constitute a set of results after an analytical process. As PhD student, I must support my research in the body of knowledge socially and culturally available. My thinking is constrained by these essential actions that constitute any research activity. The operations are all those processes that I carried out to accomplish the goals of each action and to finally reach the object of this social activity in which I am involved.

Sensibility spaces are conceived as actions with a conscious goal and operations intended to achieve the goal. Each action was thought to found a reconfiguration of my initial possibilities of researching, within a cultural

sensibility, and to configure a new one, within another cultural sensibility. The final motive was to be able with a new subjectivity to imagine and create new forms of psyche reflection in the assessment field within Inquiry Based Science Education. This is some how contradictory since IBSE is conceived within an individualistic perspective. The transformation is faced at the end of this document.

USING LANGUAGE TO CONSTRUCT SUBJECTIVITY

For Roth and Radford (2011), when cultural-historical activity theory is used, the subjects of any activity are considered "subjects of *collective* activity" (p. 10). Furthermore,

> in the course of participating in cultural-historically formed relations with others, individuals become cultural-historical beings through unending process of *subjectification* (Radford 2008a), that is to say, processes of becoming through cognitive, emotional, ethical, political reflexive and critical differentiations, and identifications. (p. 10).

I create in my writing the five sensibility spaces that are justified by using Roth and Radford's arguments. These spaces are the product of my process of becoming a cultural-historical self, touched by other researchers using socio-cultural theories of learning as well as socio-constructivist ones. I consider that I am part of a collective activity —researching about assessment for learning within IBSE. In each sensibility space I carried out a cognitive process, I lived emotional moments, I confronted myself with ethical and political reflexive and critical differentiations, and identifications.

Researchers in education as well as scholars and designers in assessment for learning within IBSE research activity produced artifacts such as concepts, texts, graphs, etc. Their activity became materialized in those artifacts and words that are used by others to be subjectified. My research is built around those artifacts. I used them to critically inquire about my own assumptions, the assumptions of others and also to look at different interpretations. Each sensibility space is created as a dialogue of myself with ideas of other researchers, as a disturbance of my subjectivity and as processes of moving my perception of the world. I pushed my psyche to a process of identification and differentiation from the ideas of other researchers, as well as a process to take distance from my initial self.

Language is relevant to the construction of sensibility spaces. Indeed, my process of subjectification-objectification was made possible through my contact with written texts of researchers, conversations with colleagues, my supervisor and other researchers, and also by my talk with a teacher at school. I found

myself immersed in a world of cultural-historical signification that characterized my subjectivity making. Roth and Radford (2011) explain this process:

> Of paramount importance in the making of the subject —in the formation of this unique in-flux subject that is continuously becoming— are those cultural-historical significations it engages in and in which it finds itself immersed. Cultural-historical significations are those generalized forms in which the individual appropriates the generalized and reflected/refracted human experience. (p. 10)

In this quotation, I highlight the term 'cultural-historical significations' used by these authors to designate those generalized forms in which the individual —myself— appropriates generalized and reflected/refracted human experience. For instance, I appropriated individualistic researcher' view on assessment for learning within IBSE generalized and reflected bodily experience. I also did the same with the generalized researchers' socio-cultural view of learning, knowing and thinking.

According to Roth and Radford (2011), significations are "crystallized and fixed in the sensuous semiotic vehicles used as part of communication" (p. 11). Communication involves subjects' relations and interactions. I considered in the constitution of my research process that meaning emerges from the interaction of myself and texts issue from the researchers experiences. As Roth and Radford point out, signification is not in the words or in the subjects' minds, it emerges in interaction: the subject reading the text produced by the writer. The same can be said for the conversations.

My analysis followed each sensibility space exploring researchers' and designers' languages, as well dialogues, aiming to follow some ideas that constitute what is termed an individualistic perspective in research and also ideas that shape socio-cultural perspectives. I used the term 'discourse' to capture the analytical process and to designate the social complexity in which I immersed myself.

In concordance with this perspective, I followed the idea that researchers' texts reveal the particular structure of the cultural knowledge they are involved in their praxis. In that sense, I identified different traditions in educational research and followed the ideas through different texts. It was essential to my changing process to delimitate individualistic as well socio-cultural research cultural knowledge. They were part of the structure of my analysis in each sensibility space.

I consider assessment for learning and Inquiry Based Science Education as historically constructed discourses in a process of social interactions. Discourses are not only the formulations and sentences that, written or spoken,

enunciate ideas. As mentioned above, they also refer to the associated set of practices and values that go together with the actions where the formulations are produced. Assessment for learning within IBSE is also a discourse constructed on the basis of the dynamics of both discourses on assessment for learning and IBSE. Different people with different roles in society are implicated in producing those discourses. Researchers in science education use those discourses to interact, to decide which research to do, and to give a set of formulations, norms and reasons that determine a set of activities in school and particularly in a class. Educational designers use these ideas to plan future activities for both learners and teachers. They translate them into activities, norms and reasons. Teacher educators and teachers use these formulations and products to regulate what they do in their classrooms. I consider that assessment for learning, IBSE, and assessment for learning within IBSE are discourses influenced by other discourses about how learning happens and should happen in a teaching situation. Assessment as part of teaching activities is influenced by discourses that regulate how to teach.

CONSTRUCTING SENSIBILITY SPACES FOR SUBJECTIVITY CHANGE

As a researcher, I am looking at the discourses embedded in a diversity of socio-cultural environments. The focus is Assessment for learning in IBSE environments. Assessment for learning viewed as a research activity producing an ideal discourse about how assessment should be carried out in inquiry-based classrooms. I say 'ideal' discourse to emphasize that my focus is not assessment for learning produced in an existing classroom.

I consider assessment for learning discourses that were introduced in some practices in the *IBSE Network*. I see the network as a social activity driven by a series of related projects in more than 30 countries located in different continents. I acknowledge that assessment for learning is a discourse embedded in teaching and learning discourses. In this sense, it is not possible to separate it from discourses used in the IBSE network. I focus on IBSE network discourses that shape the activities of teacher training workshops, conferences and seminars, so as to define ideal IBSE classroom practices at primary school. This is relevant since my individualistic perspective of assessment for learning within IBSE was born and developed within these network activities.

To build my inquiry process, I found inspiration from the critical research perspective of Skovsmose and Borba (2004). For them, doing critical research means

> [...] not only to consider what is taking place but also to consider what could have taken place and what could be imagined as possible alternatives to what is taking place [...] also means *what is not* there and *what is not actual*. To research also what is not there and what is not actual means to investigate what could be. Critical research pays special attention to hypothetical situations, although still considering what is actual. (p. 211)

This characteristic became central in my journey. Using their view, I decided to drive my research activity with the *object/motive* in Leontyev's sense. The motive guiding my actions and operations was to build a hypothetical situation, an ideal; something that is not there and is not in the world. This means, researching assessment for learning within IBSE from a socio-cultural perspective by changing my individualistic subjectivity. It is not an existing practice or a current state of affairs, since assessment for learning research in the IBSE territory is supported by the individualistic viewpoint. I acknowledge that there is assessment for learning research activity from a socio-cultural perspective but this is not used in the IBSE world where I grew up. In this sense, the final object of my research is a conceptualization of assessment for learning activity within inquiry-based classroom using my subjective change and adopting a socio-cultural perspective.

At the same time, I consider 'what is actual' —research activity within an individualistic perspective— and what is taking place as a point of departure. This is, how the researchers who work in an individualistic tradition build their artifacts and the kind of ideas, which support them, in the same way as socio-cultural researchers built their objects and artifacts. I do not just intend to imagine a situation, out of the blue. I intend to imagine a new possibility in the light of what is happening somewhere. This is relevant because in this sense the hypothetical becomes possible. It is not far from what could be. It is a re-arrangement of elements that imagines another configuration of the world. Furthermore, I myself tried to use socio-cultural assumptions in a classroom where I experienced a process of thinking with a teacher. My experience there also provided me with the basis to create this hypothetical situation.

I configured five sensibility spaces to move my individualistic perspective. They do not follow a linear sequence. I did not do one first and then another. In my daily PhD life, I traveled among them during the process of my research. Each one of them is conceived as a dialogue with available cultural knowledge in the researchers' texts as well in concrete dialogues with a teacher at school. I support my methodological choice by assuming that individual sense "is a concrete realization of collective significations, which, as a general (universal), exists only in and through all concrete realizations and the possibilities that this enable." (Roth & Radford, 2011, p. 11).

In terms of cultural-historical activity theory, the object/motive of my research activity was to produce a study using Radford and Empey's (2007) Cultural Knowledge definition from a socio-cultural perspective (*Semiotic Systems of Cultural Significations*: the set of beliefs about conceptual objects, conceptions about truth, methods of inquiry and legitimate ways of knowledge representation. *Forms of Social Relations*: division of labor and social institutions. And, *Forms of Production*: artifacts, signs, objects, etc). As mentioned before, I had no idea what such things meant. I had no signification. My initial perspective on this matter was that I was looking to introduce the socio-cultural *context* where individuals in the assessment activity live, which varies from one country to another, to question my knowledge as well as researchers' knowledge. Furthermore, each of the analyses in the sensibility spaces has a goal. I considered each space as the materialization of my *actions* and *operations* following Leontyev's ideas. In next sections I present the actions and goals behind each sensibility space.

Sensibility space one is the movement I experienced by tracking ideas and assumption in educational, developmental and psychological research fields. My goal was to recognize individualistic and socio-cultural assumptions, and see how they became operational in the research texts. In that sense I learnt to see my own, and to seek the new ones, as well as to see how scholars used them. The process allowed me to identify assumptions similar to those embedded in assessment for learning and IBSE discourses.

With the actions in *sensibility space two*, I recognized the alignment of the IBSE network with some ideas and expressions from the individualistic line of thinking. I traveled to my IBSE world with new cultural knowledge —the recognition of socio-cultural assumptions as different from the individualistic— and focused on my individualistic subjectivity. I saw ideas that I had not noticed before and that stimulated me to search and to analyze my practice.

Sensibility space three was conceived to examine such ideas with my incipient new socio-cultural subjectivity. I questioned my postulates about the child and forms of knowing the natural and made worlds. In sensibility space four, I also questioned my postulates by traveling to a classroom to plan and implement assessment strategies. I needed to be in contact with everyday activity and ask myself, in the company of a teacher, how to use the socio-cultural ideas in the assessment processes. It was to travel from the ideal classroom envisioned by individualistic research towards the activity happening there.

Finally, *in sensibility space five*, I created two scenarios reproducing assessment activities that used one or other set of assumptions. I proved my sensibility, and I challenged my imagination. The process experienced in those spaces gave me the opportunity to reflect on assessment for learning within

IBSE research activity and the consequences for the activity when one or other set of assumptions is adopted.

SENSIBILITY SPACE ONE: IDENTIFYING AND DIFERENTIATING

In this sensibility space actions —in Leontyev's sense— are constituted by reading researchers' texts looking for evidence that showed the existence of an individualistic perspective in educational research, and particularly in the field of assessment. In that sense, I followed my individual sense as the concrete realization of collective significations using Roth and Radford's (2011) arguments. I lived a process of *Identification*. For that I took into account sentences, utterances, ideas that were familiar to myself.

At the same time I myself could *Differentiate* with another existing world of research, the socio-cultural one. It was by looking at what was different from the individualistic perspective, that little by little I noticed new ways of doing, thinking and constructing research.

The first problem faced by my process of obejctification-subjectification was to capture the existence of different subjectivities in educational research. This was to identify forms of understanding and to communicate ideas about the relationship between the learner and the world —natural, made and social. I needed an epistemological turn, as well as an ontological one. I looked at ideas in texts produced by researchers. One of the firm ideas I had was that, IBSE and assessment for learning defined learning science as a process to change an individual's conceptions about the natural and made worlds. I needed to understand how individualistic and socio-cultural researchers faced such issues. This is one of the arguments that guided my thinking.

The other concern was to notice how culture and society were used in their conceptualisations. One of the more difficult ideas to move my subjectivity was that some scholars considered interactions of students in IBSE classrooms as the presence of culture and society. But this was not in every conceptualisation from a socio-cultural perspective. I was looking for different conceptualisations of learning, knowledge and thinking that could fit with IBSE and assessment for learning research, as well as how they made visible subjects immersed in specific socio-cultural spaces and historical time. Finally, I wanted to see how those findings were reflected in the assessment conceptualisations. My question was how those learning theorisations changed the assessment research postulates.

Using Radford and Empey's (2007) conceptualisation of cultural knowledge, I was interested in legitimate ways of knowledge representation (dimension of Semiotic Systems of Cultural Significations), artefacts, signs, ideas and objects (dimension Forms of Production), and social institutions or

schools and educational systems (dimension Forms of Social Relations). The goal of the actions here was to notice my own individual sense and cultural signification by *Identification* and to notice other subjectivity sense, the socio-cultural one, by *Differentiation*.

SENSIBILITY SPACE TWO: NATURALIZING

In this sensibility space, actions and operations were different in nature from the above sensibility space. Indeed although I was looking at texts, and individualistic and socio-cultural ideas guided my analysis, my *goal* was different. I needed to show that my individual sense was, as Roth and Radford conceptualized it, a concrete realization of collective signification. My goal here was to bring to the reader these collective significations present in my individual sense. Significations emerging from my reading of those texts were supported by my individualistic sense. However, I was trying to look for ideas that were different when a socio-cultural perspective was used.

I used the term dominant discourse to designate the logic of IBSE network social praxis. Using Foucault's (In Fairclough, 1992) perspective on discourse, it is to make available for the reader the way of structuring this particular area of knowledge and social practice: assessment for learning and IBSE configuration. According to Gee and Green (1998), one of the concerns in discourse analysis is to determine "how discourse processes and practices shape what counts as knowing, doing, and being within and across events in classrooms and other educational settings" (Gee & Green, 1998, p. 120). My analysis intended to present an IBSE discourse that shapes what counts as knowing, doing, and being within and across events in the network activities. This guides my analysis of the network texts and language. In order to do this, I considered texts that are used to promote IBSE discourse in different network activities. I observed texts used to give a meaning to inquiry-based teaching, in different countries and national projects belonging to the IBSE Network, I decided to look at assessment for learning and IBSE texts and how these became a discourse, shaping an ideal of an inquiry based classroom practice. In that sense, 'what is the case' became for my research 'what is the IBSE and assessment for learning discourse'.

Another concern of discourse analysis is understanding "how educational processes and practices are constructed across time by members of a social setting" (Gee & Green, 1998, p. 119). I show some typical practices in the IBSE Network where language is used and where different members of the network gave meaning to inquiry-based teaching and learning principles. I constitute the boundaries of the IBSE Network practice and constitute the discourse.

Another question is "how what is learned at one point in time becomes a socio-cultural resource for future learning for both the group and the

individuals" (Gee & Green, 1998, p. 119). I consider the IBSE Network to be a social setting. I will not elaborate on the issue of how historically it became a social practice. I will just mention how it started and has been growing, and I focus on the way the network operates nowadays and sustains a specific discourse about teaching and learning science in the primary school. I make the assumption that the historically constituted discourse of Inquiry Based teaching and learning became a socio-cultural resource guiding learning of groups (IBSE projects) and individuals (teacher educators, researchers and teachers).

My analysis positions assessment for learning as part of the dominant discourse in an IBSE context. I consider assessment as part of teaching strategies, clearly connected with learning processes. In that sense, it seems relevant to analyze the IBSE language and discursive practice of the members. It supports what is done in assessment for learning activities. However, it is also necessary to analyze the assessment for learning languages circulating in the practice. The constitution of dominant discourses in assessment for learning and IBSE is made up by:

1. Enunciation of the network boundaries. This means to show where the practice is taking place and how it is organized.
2. Description of current activities in the network where language circulates and takes meaning in each place.
3. Identification and description of tendencies, models, most used languages, and mechanisms by which the languages constitute a practice in school.

The *actions* that I carried out did to constitute this sensibility space had the *goal* of taking *distance* and of my own subjectivity and *Naturalize* my IBSE way of looking at the educational world. First, I needed to show to the reader the existence of an activity where I had experiences with assessment and IBSE. I made visible my individual sense as part of a collective social praxis. Secondly, I had to see by myself whether I reflected the individualistic perspective in my subjectivity. In that sense, I also wanted to show to myself that it was not just my intuition that worked in such way, but my sense making because I learned in the social praxes I was involved in. Third, my positivist way of looking at research encourages me to find evidence of the existence of such praxis and the individualistic perspective dominating the texts circulating in such praxis. I called the analytical process to Naturalize which means to be able to see what was natural for me within the collective set of significations, and also taking distance to see it from a socio-cultural perspective.

SENSIBILITY SPACE THREE: DE-NATURALIZING

The actions and operations in this space were guided by the goal of changing my IBSE common sense by using some socio-cultural views. I found some ideas and words that recurrently appear in IBSE discourse. For the analysis in this sensibility space, I took from a critical perspective on discourse "the constructive effects discourse has upon […] systems of knowledge and belief, neither of which is normally apparent to discourse participants" (Fairclough, 1992, p. 12). In this part of my analysis, I was looking at some ideas, which made up part of the system of knowledge and beliefs shaping Inquiry Based Science Education, which, I as practitioner, was not aware of, and tried to make sense of this within a socio-cultural perspective. By questioning ideas with different possible meanings that appear in some texts, I was able to make them explicit, as well as starting a change in my own subjectivity. I did what I called a process of de-naturalization.

SENSIBILITY SPACE FOUR: DISTURBING IDEALS

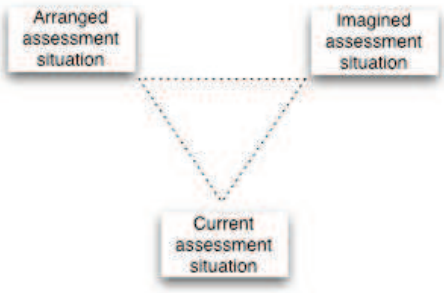
This space was conceived to perceive the flow of life in any human activity. As Roth and Radford (2011) have noted, cultural-historical activity theory uses the changing character in human activities as a unit of the theoretical perspective. These are not static entities. I needed to conceive a research process allowing myself to be in a classroom, with children and teacher, thinking of assessment within a socio-cultural perspective. Since I adopted a critical perspective in my research, I did not intend to carry out an empirical study. I just wanted to make sense of the social and cultural dimensions involved in the assessment for learning within IBSE activity research.

I chose to be in a classroom that was one of several that used the IBSE ideal to organize their science curricula. I acknowledge that it is just one case and it is not my intention to generalize. What I wanted was to explore the connections of assessment for learning languages, socio-cultural learning theories, IBSE language and languages of the classroom I visited. I used this experience as a source of inspiration to construct my hypothetical situation and develop a socio-cultural sense of a classroom practice.

I studied a current IBSE assessment practice in a classroom in Bogotá, Colombia, and established the aim of researching with a teacher the assessment possibilities to improve group work and to assess learning with socio-cultural assumptions in mind. With the teacher, we imagined different assessment possibilities that took into account the learning process during group activities. The process of field visits sought to construct possible meanings of assessment for learning for group work with the teacher and her students. My concern was to answer the following questions: what assessment for learning processes is the

teacher actually carrying out in order to promote scientific practice among the groups? What kind of assessment activities and assessment changes can actually be implemented, taking the context into account? Which can be improved and generalized, and which will emerge in the process of giving meaning to the group assessment issue? What transformations will this construction of meaning generate in the teacher, the students and myself?

I adapted Skovsmose and Borba's (2004) critical research model in order to develop activities with the teacher at school. *Graph Nº 1* shows three different dimensions of the field visit activity. I named the situation in the particular classroom and school as *Current assessment situation*. It was what a particular teacher normally does in order to assess the students' learning process during his or her IBSE lesson. I wanted to imagine together with a teacher different possibilities to assess group work having socio-cultural theories of learning in mind. This was to determine an *Imagined assessment situation*. The goal was to make those ideas possible in practice. It was to produce an *Arranged assessment situation*.



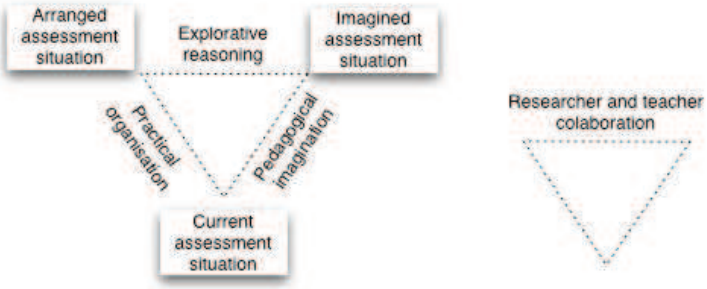
Graph Nº 1. Three elements guiding my activity research with a teacher

During a four-month period, I interacted with the teacher in order to identify critical points and change the *Current assessment situation*. The students' inquiry group process was at the core of our conversations. We met twice a week at school in a dialogical process to carry out the *Pedagogical imagination* research process. This process was mediated by the teacher's experience, interpretations of IBSE and assessment, as well as by my experience, interpretations of IBSE, views of assessment and socio-cultural learning discourses. The result of this interaction produced what I called an *Imagined assessment situation*.

At the same time, these assessment and classroom situations imagined during our discussions were adapted to the current classroom activities. The

results of this implementation and the students' reactions were taken into account in our weekly conversations. What happened in the classroom when our imagined situations were implemented was the *Arranged assessment situation*. Our conversations were the *Practical Organization* process of Skovsmose and Borba's (2004) methodology, which took into account the contextual possibilities. During the *Explorative reasoning* we explored changes and possibilities for the Imagined situation in the light of what happened.

I call all this complex process 'Researcher and teacher collaboration'. As shown in Graph Nº 2, it includes the processes and the situations. I represent it as a simple triangle to simplify it and I will use it later to explain my essential analytical research processes.



Graph Nº 2. Representation of field visit process

The analysis is not concerned to describe or produce categories, nor to make explicit the *Explorative reasoning* and the result of it. I decided to use information from the process as an inspiration to generate the hypothetical situation. I took information from the research process between the teacher and myself —the researcher and teacher collaboration. I recorded our conversations in audio and classroom activities on video. I also wrote e-mails to my supervisor explaining my concerns during my visits to the school, produced texts and activities and took notes. I selected some information coming from those sources and produced events to illustrate critical aspects of the experience. I consider them critical because they allowed me to notice the social and cultural dimensions involved in teaching and learning happening in a specific classroom. That critical information became a source of inspiration.

My research was conducted in one particular Colombian school, where science is supposed to be taught and learned according to inquiry principles; particularly, where group work is present in everyday activities. One teacher and her students have been selected because the group gave their consent to participate in a research process and to contribute with their own ideas to the

inquiry process. The children, the teacher and the researcher belong to different social classes; this is ideal, for it allows a diversity of points of view and because it is the typical situation in the Colombian project: the children belong to levels 1, 2 and 3 of Colombia's social classification system; teachers are normally in level 4; and researchers and teacher trainers come mainly from levels 5 and 6 (sometimes 4). At the same time, the cultural and academic backgrounds of students, teachers and researchers are different. Another important criterion for selecting this school was that teachers and administrators have chosen IBSE as the basis of their science curriculum, and based it on the Insights modules. The teacher has been selected because she has freely manifested her desire to participate, and because she has been assigned to work with 6th grade children during my visit to their classroom. There are children in her classroom who have been taught with IBSE strategies for 5 years. The main idea was that those students could contribute to the research project through their previous assessment and group work experience.

The sensibility space was constructed as a way to listen to my disturbances by arriving at 'the real world' and not by being in 'the ideal world' as it happened with my teacher educator and researcher perspective. My visit to the school and the material that was produced, as evidence of that materialized existing lived moment by a teacher, 42 children and myself at school in Bogotá Colombia, moved my individualistic perspective. From the theoretical perspective that appears in the researchers' texts, I put my effort into making sense of the socio-cultural perspective, but at the same time with my individualistic unchanged body.

Actions, in this sensibility space, had the *goal* awakening me from my way of seeing the context, as something static living in the place where schools work. The analytical process triggered my theoretical imagination. I visited a classroom with the goal of using and re-interpreting socio-cultural learning statements and seeing how these could be used in a specific practice. In this situation, I was looking at possibilities for assessment for learning considering socio-cultural assumptions. I experienced another culture, foreign to me, the culture of the teacher and students of that school. That culture was neither the individualistic, IBSE, or socio-cultural cultures. It was something else. The experience at school disturbed my ideal of inquiry-based classroom, tools meaning, and context.

SENSIBILITY SPACE FIVE: PRODUCING WITH ASSUMPTIONS

While I was trying to identify, differentiate, naturalize, de-naturalize and disturb my subjectivity, I needed to produce a classroom simulation. This is supported by the fact that theoretical constructions take on meaning when they are used in particular situation. In this case, I chose to illustrate how the theoretical

construction in the individualistic perspective shaped an ideal model of my individual perception about the inquiry-based classroom reality and the assumptions I identified as guiding such research. I used researchers' interpretations of learning within IBSE and theoretical tools of assessment for learning. A second move was to change assumption for those differentiated in the analysis of socio-cultural theories. It was to analyze the classroom inquiry-based simulation and make changes in the assessment activity where the new assumptions modified the shape of the activity.

Then, the analysis in this space was to see how assessment for learning within IBSE 'could be' materialized in an ideal classroom activity using one or other set of assumptions. Using the concept of sensibility, it was to see the transformation of my subjectivity by making sense of the assumptions in an imagined situation. For that, I used my knowledge as teacher educator, and also my systematic analysis of the research texts. I needed to produce the example to make sense of what I was learning.

Since the object/motive of my research was to propose a new theoretical support for assessment for learning within IBSE, it was important to determine where and when in classroom activities, the theoretical turn about learning had an impact on the way assessment activities were conducted. In terms of the process of subjectification-objectification, it was to objectify my new subjectivity by producing one hypothetical situation, evidencing to myself, and to the reader, the differences between the individualistic and socio-cultural approach.

FINAL REMARKS: RETHINKING THE PROBLEMATIQUE

The problematique was delimited by the needs to research within the field of assessment for learning and IBSE, to understand the complexity shaping classroom activities across diversity of socio-cultural conditions, and to explore my subjective changes when adopting socio-cultural theories of learning. I expected that socio-cultural theories of learning would have tools to consider socio-cultural everyday conditions of the teacher and the students, when including in their current school practice assessment and inquiry-based teaching and learning principles. With the theoretical tools introduced in this chapter, I configured my research objects. The first object becomes to explore the researchers' ways of using assumptions and reasoning with theories of learning, and the impact in the constitution of their research objects. The second one was transformed on understanding and following the researcher's transformation while participating in research activity. I explored the processes of learning producing subjectivity changes, when the researcher decided to transform forms

of researching assessment with an individualistic perspective towards forms of researching with socio-cultural assumptions and forms of reasoning. The third object, and the focus of the thesis, becomes to produce a proposal that, from a cultural-historical activity theoretical stance, views assessment classroom activities, recognizing teachers and students everyday modes of life, situated in a set of socio-cultural conditions.

ASSESSMENT FOR LEARNING RESEARCH AS SOCIAL PRAXIS

During the study I will explore assessment for learning research as a social activity, where researchers are engaged in understanding assessment for learning classrooms activities. I became interested on the possibilities of researching and the difference of research objects when one or another theoretical perspective on learning is adopted. I will inquiry the researchers' assumptions by analyzing their texts and describing collective forms of constructing ideas.

Radford and Empey (2007) approach to Cultural Knowledge allowed me to make a link between the researcher —*Myself*— with the Cultural Knowledge —educational research knowledge. I identified several possible ways of researching assessment for learning within IBSE, one in resonance with an individualistic perspective on human cognition, and the other from a socio-cultural perspective. In my interpretation of Radford and Empey's model, I see that by adopting one or other research perspective the researcher adheres to a particular set of beliefs about conceptual objects, conceptions about truth, methods of inquiry and legitimate ways of knowledge representation —Semiotic Systems of Cultural Significations—. Because I am a PhD student —not an institutionally recognized researcher—, I have a supervisor to support my learning process, and a group of researchers that will evaluate the production of knowledge and the quality of the research process. In that sense, my research methodology, my process of researching, and the knowledge produced is constrained by the division of labor and social institutions —Forms of Social Relations. Because a researcher is supposed to produce artifacts, signs, objects —Forms of Production— with the possibilities provided by the existing ones, the researcher must argue for the validity of those concepts and ideas produced during the research process by fitting in all these constraints.

In that sense, as someone learning to do research, it becomes relevant to understand research as an activity, modes of socially validated inquiry, assumptions, truths and beliefs supporting the constitution of research objects. Using a cultural-historical activity theory following Leontyev and Roth and Radford's approaches, I framed the subjective change —myself— in the process of conducting a social activity: researching. The object/motive helps me to visualize the focus of my research, and the actions and operation with their goals to make explicit the sense of each analysis in the thesis. I conceived the

sensibility spaces in order to delimitate various processes needed for a change of subjectivity. However, what is relevant is that the choices and forms of doing the analysis were possible because of the understanding and interpretation of collective forms of researching.

I bring to my writing some ideas about the notion of discourse. Although there are several interpretations and methodologies attached to this term, I used it in a more humble way. I just used it to connect language, texts, and dialogues with social praxis. I did not pretend to follow one ore other kind of research methodologies and designed analytical tools. I developed my own subjective forms of analysis, always bearing in mind the object/motive of my research activity and the goals of each action. Particularly, to critically review the research praxis in which I was immersed.

THE RESEARCHER'S SUBJECTIVE CHANGE

The adopted methodology and the analytical strategies had the purpose of supporting my processes of learning as researcher. The learning process was conceived as a process of subjectification and obejctification following Radford's view. As researcher, I searched out new forms of understanding participating in a critical perspective. Thus, I questioned my beliefs, truths, forms of inquiry, forms of constituting the research object, and assumptions. I experienced a subtle progressive cognitive and epistemological change. I opened a new research perspective for assessment for learning within IBSE.

As teacher educator, I was able to use the theoretical approach with the set of significations that circulate in a network of IBSE. Facing problems when I experienced teaching in different places and educational cultures where assessment and IBSE are introduced, I decided to explore those difficulties by engaging my self in new forms of conceiving educational research. I moved towards different possibilities to conceptualize assessment for learning within IBSE using a socio-cultural theory of learning. The research is that process whereby the researcher identifies her own assumptions and beliefs, differentiating them from others and by adopting a new way of thought, in resonance with another collectivity, by adopting socio-cultural theories of learning.

By assuming a critical perspective I decided to critically inquire about myself and the meanings of artifacts shared by the collectivity in which I lived as teacher educator. This approach is what allowed me to create an inquiry process based on a transformation of subjectivity by identification, differentiation, naturalization, de-naturalization, disturbance and production, as was described in the sensibility spaces.

CLASSROOM ACTIVITY

The object/motive of this research was to found new forms of understanding assessment for learning activities in inquiry-based classrooms. I explored the implications of a change of theoretical assumptions in the constitution of assessment activities. The adoption of Skovsmose' and Borba' (2004) critical research perspective was used to think new possibilities for conceiving assessment for learning activities within inquiry-based classrooms. I gave a particular sense to the notion of being critical. Using an activity theory perspective, researchers such as Roth and Radford are interested in what happens at the moment where events are lived and experienced by individuals in classrooms. However, my research was not conceived to document the everyday activity of teachers and students when engage in their interpretation of inquiry teaching and learning activities. I expected to theoretically explore assessment for learning activities within inquiry-based teaching and learning when considering teachers and students everyday socio-cultural conditions of life. The methodology strategy was to explore my self the everyday activities in a school to get inspiration from the experience.

The following five chapters materialize the analytical strategy adopted in each sensibility space. In the first part of each chapter I explained my actions and goals supporting the analysis. In chapter four I have differentiated two cultural sensibilities within the research activity: the individualistic and the socio-cultural. In chapter five I have identified assessment for learning and IBSE ideas with the individualistic cultural sensibility. In chapter six I have questioned individualistic ideas of IBSE and assessment for learning by adopting a socio-cultural sensibility. In chapter seven, I disturbed my individualistic ideas by looking my experience at one school in Bogotá. In chapter eight I produced a simulation of assessment activity in and inquiry-based classroom activity differentiating the simulation with the individualistic cultural sensibility from the simulation with socio-cultural cultural sensibility.

4. Sensibility Space One: Identifying and Differentiating

> Seulement les influences du milieu acquièrent une importance de plus en plus grande à partir de la naissance, du point de vue organique d'ailleurs aussi bien que mental. La psychologie de l'enfant ne saurait donc se borner à recourir à des facteurs de maturation biologique, puisque les facteurs à considérer relevant également de l'exercice ou de l'expérience acquise, ainsi que de la vie sociale en général.[12] (Piaget & Inhelder, 1966, p. 5)

A newborn baby faces a complex world with objects, people and events. He/she develops a process that allows him/her to create a relation with the world. How this external world is constituted and connected to the internal development is the center of many studies in developmental and cognitive psychology, as well as in other fields such as education and anthropology. In Piaget and Inhelder's words, one can identify the relevance for psychology studies to establish connections between the newborn child, the environment (milieu), and the child's development. In order to bring light to some assumptions behind assessment for learning within IBSE, and to consider other possibilities, I investigated the complexity that takes place when cognition, learning and development are viewed in the light of the relation between the growing child and the environment —social and physical. By doing this, I explore the implications of this issue in education, and, in particular, science education and assessment.

[12] The influence of the environment acquires an increasingly large importance from birth onwards, from an organic and mental perspective. The psychology of the child could not be restricted to factors of biological growth. Indeed, the influential factors that need to be considered also come from exercise or acquired experience, as well as social life as a whole.

As a practitioner of Inquiry Based Science Education, I learned that this kind of education was important in changing learners' misconceptions about natural phenomena. I also learned that interactions, group work and teachers' questions to the learners were relevant for learning. Thus, I needed to understand how socio-cultural theories of learning envisioned those issues, and if there were differences with the theoretical constructions used in the IBSE perspective. The inquiry became complex, since I found differences that I was unable to understand. For instance, that human cognition was situated, and that human interactions were understood as connected with culture and society. This subjective space materializes my actions, operations and goals in order to understand the differences between individualistic and socio-cultural sensibilities. My intention here is to highlight assumptions behind individualistic and socio-cultural sensibilities that impact assessment activity.

In the first part, I discuss the actions, goals, and elements that resulted from my analysis of the IBSE texts. This is important since they influenced my selection of texts and the questioning of the scholars' texts. Then, in the second part, I look at learning theories and the way they are used in theories about teaching and learning. I highlight the differences between theories by making some of their assumptions visible. Those assumptions guide my later analysis in other chapters. In the third part, I look at some assessment discourses and question them in the light of the mentioned assumptions. Finally, I address my learning process by doing the analysis.

ACTIONS AND GOALS

In my researching everyday life I did two actions —in terms of Leontyev (2009)— that are materialized in this chapter. The first was to identify those moments of the assessment for learning activity that triggered individuals' assumptions about learning. The second was to follow the assumptions in scholars' conceptualizations of learning that were similar to my IBSE sensibility, and at the same time, to differentiate them from the socio-cultural assumptions. As a result of these actions, I identified two *cultural sensibilities* —I am using the term cultural sensibility here to refer to a group of assumptions used by scholars in their theoretical constructions—: the individualistic and the socio-cultural.

As explained before, for Leontyev (2009) actions are important for the activity. They are a set of operations directed towards the object/motive. In terms of my research activity, I intended to identify the assumptions to move my IBSE individualistic sensibility. Indeed, since my object/motive was to create an assessment for learning activity within an inquiry-based classroom based on a

socio-cultural theoretical perspective, it became necessary to move my forms of understanding towards new socio-cultural forms —for me— of understanding.

ACTION 1: CONECTING ASSUMPTIONS, LEARNING AND ASSESSMENT ACTIVITY

I carried out an analysis to determine the elements that were essential in understanding the role of assumptions about learning in the constitution of assessment activity. For this, I identified moments of the assessment for learning activity in an inquiry-based classroom, in which different assumptions about learning changed the constitution of such activity. Thus, the goal of this analytical process —the action— became to establish a relationship between assumptions, learning theories and assessment activity. Since my research is situated within a critical perspective, this was essential to envision a change in the conceptualization of assessment giving an account of the different social configurations, and cultures, where IBSE has been implemented.

Assessment activity is seen as supporting and enhancing learning. Then, the assessment activity experienced in an inquiry-based classroom involves interpretations about what is learning, and what is good learning. I identified processes of individuals' interpretation during assessment activities in which different assumptions of learning, cognition and development have an impact on the process. First of all, a teacher observes students' activities and actions, and interprets them as signs of the students' learning and acquisition of knowledge, matching the teacher's expectations or requirements. It is important to highlight here, that assessment is essentially an interpretation of a performance in relation to an expected or ideal performance. Second, the children also interpret the teacher's instructions and assessment activities in their own way, based on previous activities and experiences.

Finally, the researcher, who writes articles and texts about assessment for learning in IBSE, observes and interprets both the teacher's and the students' activities. The researcher's interpretations are related to how children learn science. But the researcher's interpretations are always guided by a set of more or less explicit theoretical assumptions about what those activities —students' learning, teacher's teaching and teacher's assessment— should be. These assumptions concern some core elements: the child, the natural world, and knowledge. The researchers' framework used to interpret is based on theoretical positions on cognition, development and learning. In that sense, it also depends on particular views and assumptions about reality and scientific knowledge.

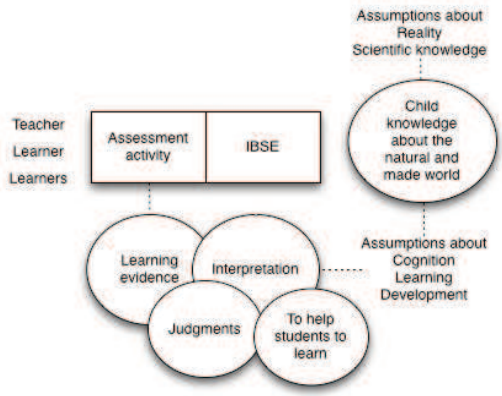
Although I am aware of the many possibilities of participants' —the teacher, the learner, and the researcher— interpretation during an assessment activity, in my analysis I considered the interpretation of researchers with their

theoretical approaches. Indeed, the research process was created to study assessment for learning within IBSE research activity and their conceptualizations of learning, knowledge and thinking.

I focused on the processes of assessment that directly involve assumptions about cognition, development and learning. Scholars writing about assessment for learning within IBSE identify certain actions of the assessment activity. First, there is a set of operations aimed at constructing **evidence of learning** —teacher designs an assessment task, children do the task, and teacher transforms the information from the children's task into evidence of learning. Second, the teacher **interprets** this evidence those evidences in order to make a link between the intended learning goals and the evidence Then, the teacher **judges** if a child is learning what was intended, gives feedback and modifies teaching —in order to help **students to learn**. Then, I identified four elements of the assessment activity as being affected by the change of assumptions: learning evidence, interpretation, judgment, and helping students to learn.

The assessment activity involves relations between the teacher and the learner, as well as the learner with other learners and teacher and learners. Since inquiry-based teaching is about the child learning about natural and made worlds, I identified assumptions about cognition, learning and development becoming instrumental in the construction of researchers' interpretations about evidence of learning. At the same time, I also saw that assumptions about scientific knowledge were important to the interpretations about good learning in inquiry-based researchers' conceptualizations.

Graph Nº 1 represents those elements that guided the reading of scholars' texts. The central action in this sensibility space became to find in educational research texts assumptions about cognition, learning and development guiding interpretations in the assessment activity in inquiry-based classrooms from the researchers' perspective.



Graph Nº 1. Dimensions involved in my analysis

As stated before, my hypothesis is that IBSE and assessment for learning are based on an individualistic perspective on learning, development and cognition. With the choice of the term individualistic I want to highlight the fact that learning, cognition and the development of individuals are considered be looking at the mind and the psychological process of conceptualizing learning, as is referred to in the literature (Leach & Scoth, 2003; Radford, 2008). With this idea in mind, the IBSE conceptualizations such as interaction among individuals supports the individual process of learning should be regarded as following an individualistic perspective. As a result of this action, I identified the need to understand which set of assumptions supporting a theory of learning and development are instrumental for researchers in their conceptualization about evidence of learning, interpretations, judgments, and activities to help learners to learn. Also, I needed to see which assumptions operate when analyzing the role of interaction for learning.

ACTION 2: LOOKING AT ASSUMPTIONS IN RESEARCHERS' TEXTS

Since I started my inquiry I was not aware of my own assumptions of learning, nor those supporting conceptualizations of IBSE and assessment for learning, I faced the challenge of finding this type of theory and assumptions. At the same time, I had no idea about the existence of other theoretical perspectives involving conceptualization about learning. It was necessary to identify socio-cultural in contrast to individualistic assumptions. The action and the set of operations here were aimed at differentiating one theoretical perspective from another by looking at the assumptions. At the same time my goal was to identify the assumptions that resonated with my knowledge about IBSE. Then, I looked at scholars' texts bearing in mind the characteristics of IBSE.

In my analysis, my interest was on the assessment for learning activity of children up to 11 years old, in school settings. I consider that these children are learning and at the same time developing. They are constructing a view about the world in permanent interaction and through their experiences. Indeed, IBSE curricula consider that children must start to learn science in the first years of school and continue until they finish primary school, only using the child's natural curiosity for the natural and made worlds. During this time, it is expected that they will have experiences, which allow for the construction of new theories and explanations about the natural and made worlds, based on evidence collected during their science lessons. In order to achieve that, Inquiry-based teaching uses pedagogical techniques to bring into the classroom children's own ideas about the natural and made worlds. It is assumed that children have built their 'own ideas' during their experiences outside school. Inquiry-based teaching considers that children's interactions with the natural, the made and also the social worlds are sources of learning. The teaching situations are planned in such

a way that children have opportunities to manipulate and experiment with materials and objects from the natural and made worlds, and also to interact with other children and the teacher. An important part of the pedagogical strategies of IBSE is the organization of children in groups for carrying out inquiry. In the groups and also in the interaction with the teacher, they will express and communicate their own ideas and review them in the light of interactions.

In this theorization of IBSE about learning and teaching science in primary school, there are three clear elements: First, the *child* and a view of him/her as a learner of school science; second, the *external world* that the child comes to know and learn about; and third, the *relationship between the learning child and the external world*, which, in this case, is the relationship of learning and teaching in which learners and teachers get involved while practicing IBSE as a pedagogical model for primary school science education.

I needed then to understand how those elements were addressed by theories of learning. I considered that a theory of learning, cognition or/and development was different from others where the basic assumptions about the relation between internal human development and the outside world changed. I believed that holding one or another perspective implied having to have a different way of perceiving interaction between the human and the world and the human and other human beings. It was to constitute reality in a different way. Indeed, I saw theory as a set of ideas that explained what we perceive about the human process of learning, cognition and development. I carried out the analysis convinced that when someone adopts this theory, he or she is able to transform his/her reality following those ideas. I also believed that a theory feeds our actions as educators in schools, our actions in life, our beliefs and our possibilities of action and change. In particular, assumptions behind theories determine the actions, operations and goals of assessment for learning activity in inquiry-based classrooms. In terms of my problematique, I was convinced that by identifying the assumptions behind the theories it would be possible to identify my own assumptions and, at the same time, to appropriate new ones and change my perception of reality. This was my adoption of researching with a critical perspective.

With those elements in mind, I navigated in scholars' texts collecting assumptions, differentiating one set of assumptions from another, and also, making links between the ideas presented in some texts with others. I addressed these elements by contrasting two main views that have been present in psychological, educational and science education theories. Indeed, the work of Jean Piaget and Lev Vygotsky has been widely discussed in educational research as central sources of thinking about the child, his/her relation with the world, and the process of learning and teaching in education. Their work in the field of psychology has been re-contextualized in education to build teaching and learning theories, even in fields such as science education.

.

CONFIGURATION OF CULTURAL SENSIBILITIES

The actions, and operations that I carried out in this part of the research process gave me the opportunity of configuring individualistic and socio-cultural cultural sensibilities. Radford and Empey (2007) used the term sensibility in another context, but it seems to me that it can be re-interpreted for the purposes of my thesis. The term emerges from the analysis about social praxis in terms of Leontyev. Radford and Empey were interested in eliciting how mathematics, as a form of reflection on the world, was instrumental in the formation of new sensibilities. They pay attention to certain social praxis where mathematics were used in the everyday life of individuals involved in praxis. They are showing a movement in the culture, by looking at how particular kind of mathematics became part of individuals' everyday life. Thus, how mathematics created new forms of thinking in everyday life of individuals. In their historical analysis, they were interested in capturing this movement in a culture that changes the way the individuals see their world. In that sense, how, by a subtle progressive cognitive and epistemological change, individuals in a particular culture, see themselves in new ways by using new mathematical ideas.

Furthermore, Radford and Empey used the term cultural sensibility to identify individuals' uses of mathematics, that were apparently different but from their perspective, these different mathematical expressions were part of the same cultural sensibility. I interpret this as the possibility of individuals in a culture to produce ideas, which, on closer inspection, are part of the same type of cultural forms of thinking. According to Radford and Empey, the term cultural sensibility has developed over time in the following manner:

> Progressively, during the late Middle Ages and Renaissance, mathematics penetrated the various spheres of everyday life and offered individuals new modes of action and ways of understanding the world. Of course, not everybody became a professional merchant or a mathematician —far from it. The point is rather that mathematical knowledge came to mediate the relationship between individuals and their culture in more than one respect. The art critic Michael Baxandall (1972) has suggested that there is a commonality between the cognitive skills brought both to partnership or exchange problems and to the making and seeing of pictures. The proportionality of the former and the perspective-based design of the latter are expressions of a same cultural sensibility, the difference being that one addresses commercial and numeric matters while the second addresses visual experience.

I used their idea by examining two different ways of constructing educational theories and conceptualizations. As I could see by reading articles written by different researchers is that there are two clearly different theoretical perspectives to conceive how people learn and know. Radford and Empey talked about mathematics and how they penetrate the everyday life of individuals. I identify one set of assumptions about human cognition that have an impact in their everyday life. This is the idea that individual cognition can be studied separately from society. In other words, that psychological process can be theorized as by using the individual's mind as the unity for conceptualizations.

As will be demonstrated in the analysis, there are many scholars in educational field that use such idea. I used to believe that it was the only way to look at human cognition. I constructed the analysis by following two different cultural sensibilities. This is, my text tries to capture the way researchers constituted their theoretical approaches to human cognition in two distinct ways: an individualistic cultural sensibility, and a socio-cultural cultural sensibility. Using Radford and Empey's idea that there are different uses of mathematics that are rooted in the same cultural sensibility, I was able to recognize that the positions of different researchers were rooted in the same cultural sensibility.

I start my analysis by looking at theories of learning and development. In particular, I analyzed the positions of Piaget and Vygotsky. My goal was to see the differences between them based on my hypothesis that these positions represented two different cultural sensibilities. After that, I continue by looking at scholars' theorizing about cognition that can be identified as being influenced by different cultural sensibilities. Then, I focus the analysis on researchers' studies that resonate with my IBSE knowledge. It is why I inquired within the field of misconceptions and naïve theories because I identified this field as impacting interpretations and conceptualizations of researchers in assessment for learning and IBSE. Finally, I explored texts communicating ideas about assessment that could be identified as reflecting different cultural sensibilities. My aim is to give a sense of how individuals from different cultural sensibilities constituted their objects.

REVIEWING LEARNING AND DEVELOPMENT

Piaget and Vygotsky have had an impact on educational settings. Their work on child development has been used to build theories about how human beings know, or, when re-contextualized within education, on how learning should be considered in order to design a teaching situation in formal educational settings. The debates about the differences and/or similarities between their writings have been extensive in educational research. More than going into the literature

presenting these debates, I went to the original sources with the intention of found the sources of ideas that circulated in the Inquiry Based Science Education that I linked with their ideas.

Piaget's and Vygotsky's thoughts are part of a historical process of conceptualization. By this I mean that their ideas are the result of their contact with a particular way of thinking which schools present in their historical moment and cultural context. It also means that theories of teaching and learning that build on their ideas emerged as particular interpretations of their original theories. Although I present Piaget and Vygotsky's basic ideas, I do not intend to say that those are the schools of thought that determined the theories of teaching and learning that developed later. Moreover, although I say that they influenced theories, this does not mean that their ideas are understood and used with the same original meaning. However, they are dominant and synthesize historical lines of thinking and educational use.

I considered Piaget and Vygotsky's developmental theories, which have been influential in many teaching and learning discourses. Indeed, concepts and ideas are de-contextualized from the initial purpose and brought to provide a theoretical grounding for the creation of teaching and learning situations. I also introduce some theoretical considerations found in educational settings, connected with the views of these scholars, which consider the relations between the learner and the world. These ideas are interpreted in the light of contextual assumptions and possible understandings in the historical and cultural moment where they are used. It is the case of IBSE discourses that apparently take ideas from both theories but do not consider the differences in the assumptions that may generate differences in the way possible practices may be established.

Ideas about the relationship between the child and the world are sources of differences between Piaget's genetic epistemological theory and Vygotsky's theory of development and learning. The debate between these opposing theories is related establishing which human functions are innate or genetically determined, and which are acquired or socially and culturally determined (Bursztejn, 2008; Engeström, et al., 1999). In synthesis, the question is what developmental characteristics depend on learning, that is, on the process of interaction between people and the world, which lead to changes produced in the body as a result of the interaction, and which are self developed or genetically driven, depending on the individual internal development. The issue at stake is how the development of intelligence takes place, and to what extent it is genetically or socially determined. In general, the differences between development theories relate to positions about whether human development is driven by external conditions or by internal conditions of the individual (Bursztejn, 2008; Engeström, et al., 1999).

Piaget was highly influenced by biology, conceiving learning as having to do with the adaptability of species, and therefore he focused on internal human

mechanisms. In contrast, Vygotsky was influenced by Marxist ideas in which social configurations are central to the way human beings act in the world. In this sense, one can say that development is driven not from the 'inside' of the individual —as Piaget supposes— but from the relationship between the person and his/her 'outside'.

Vygotsky (1997) identified three different relations between development and learning theories. First, he identified a set of developmental theories which consider that learning is independent from development. According to Vygotsky, to assume that learning is independent from the development of intelligence is to assume that different intelligence functions are developed independently from social influences:

> In experimental investigations of the development of thinking in school children, it has been assumed that processes such as deduction and understanding, evolution of notions about the world, interpretation of physical causality, and mastery of logical forms of thought and abstract logic all occur by themselves, without any influences from school learning. An example of such a theory is Piaget's extremely complex and interesting theoretical principles, which also shape the experimental methodology he employs. (p. 30)

In Vygotsky's view, from this particular perspective on development, the learning processes happening in school do not influence some functions of the intelligence in relation to the way a child knows the natural and made worlds. It seems that there is a particular notion of the individual's relationship with the world that is internally determined by a line of development. The evolution of notions and ideas about the way the outside world functions, explanations and so on, are part of a 'natural' predetermined internal evolution. This could explain why a child in a science classroom is able to deduce and understand, to modify his or her ideas about the world, to interpret physical causality and master logical forms of thought and abstract logic in an autonomous manner, without influence from learning. Vygotsky presents Piaget's theory of development as an example of this detachment between individual internal development and the learning processes. He also identifies other psychology theorists that assume that development is a prerequisite for learning, mentioning Binet's view (Binet, 1857).

Following Vygotsky (1997), a second group of diverse theories assumes that learning is development. Vygotsky identifies theories that view development as the mastery of conditioned reflexes: "that is, the process of learning is completely and inseparably blended with the process of development" (p. 30). He identifies James's (W. James, 1907) work as following this view. He found a common position with Piaget's approach, which is that

"development is conceived as the elaboration and substitution of innate responses". However, they differ in the fact that the first assumes that development came before learning and the second states that they are simultaneous.

Vygotsky presents a third set of theories, as a balance between the other two. It is assumed that development includes a process of maturation involving the development of the nervous system and learning, which is also a process of development.

Vygotsky (1997) rejects these three theoretical points of view. He proposes another possible relationship between learning and development. He assumes that "learning and development are interrelated from the child's very first life" (p. 32). He makes clear that learning is not a process happening only at school. Rather, he thinks that it starts at the beginning of life. When a child is assimilating a word, she/he is learning. The assimilation of language is a process of learning. When a child arrives at school, she/he is already an experienced learner with a previous history.

> Learning is not development; however, properly organized learning results in mental developmental processes that would be impossible apart from learning. Thus, learning is a necessary and universal aspect of the process of developing culturally organized, specifically human, psychological functions. (p. 35)

Intelligence cannot develop without learning, but they are different. Further more, the author connects learning with the development of a culture. One can interpret Vygotsky's words as though the psychological functions somehow depend on the culture and vice versa. A central tenet of Vygotsky's theory is that the interaction between the child and other human beings is essential to development. Thus, it is in interaction and imitation that internal development takes place. This is possible when what the child is imitating is close to his/her development potential:

> To summarize, the most essential feature of our hypothesis is the notion that developmental processes do not coincide with learning processes. Rather, the developmental process lags behind the learning process; this sequence then results in the zone of proximal development. (p. 35).

From this view, we can imagine that if there is no interaction with human beings, the developmental process will be completely different. Somehow, development depends on learning processes and therefore on interaction.

Looking more closely at Piaget's (2001) genetic epistemological theory on human intelligence, it is possible to examine how he uses knowledge from

biology, and also how he sees the development process. He defines intelligence in terms of an adaptive process in an organism. Piaget (2001) uses the following text by Claparède to illustrate the point:

> Every response, whether it be an act directed towards the outside world or an act internalized as thought, takes the form of an adaptation or, better, of a re-adaptation. The individual acts only if he experiences a need, i.e., if the equilibrium between the environment and the organism is momentarily upset, and action tends to re-establish the equilibrium, i.e., to re-adapt the organism. (p. 4)

Piaget considers the individual's internal and external acts as forms of adaptation and re-adaptation of the organism. This adaptation can only happen if the individual feels a need. This need is expressed as a possible 'momentarily upset' between the individual and the environment, as if the individual experienced a disequilibrium that needs to be equilibrated. The process of re-establishing the equilibrium or re-adapting the organism is what regulates the responses of the individual. In terms of the applicability in schools, one can imagine an act of a child in a learning situation as a potential source of change and adaptation. But this can only happen if the situation matches the developmental line.

Piaget (2001) uses the term *assimilation* to describe the fact that an individual is able to act on surrounding objects in such way that he uses previous behaviors involving the same kind of object as if there was a kind of behavior patterns that stimulates the activity of the individual in new situations with similar conditions. Piaget calls this a 'mental assimilation'. It is the process of incorporating objects within patterns of behavior. He defines patterns as "the whole gamut of actions capable of active repetition" (p. 9). Somehow, if this can be used in school, it is relevant to consider that it is only when a child can repeat the same act in different situations that assimilation can be observed.

However, for Piaget, the environment also acts on the individual when he/she is acting in his/her surroundings. Thus, the individual will accommodate. Piaget describes this implicit psychological process not as a passive act of receiving environmental stimuli but as an active process. The individual acts in response to the environmental pressures, he calls this *accommodation*.

Adaptation occurs in this dialectic process of the individual acting on objects from the outside world and the objects acting on the individual. He defines adaptation as "an equilibrium between assimilation and accommodation, which amounts to the same as an equilibrium of interaction between subject and object" (p. 9). This, for Piaget, intelligence is the state of equilibrium achieved by the successive process of adaptation "of a sensori-motor and cognitive nature, as well as all assimilatory and accommodatory interactions between the organism and the environment" (p. 12).

Social dimension and interaction

Piaget (2001) distinguishes the interaction of the individual with the physical world from the interaction of the individual with the social world. He assumes that the social environment affects the individual as much as the physical. He considers social environment produces a bigger change: "society, even more, in a sense, than the physical environment, changes the very structure of the individual" (p. 171). He thinks that social life affects intelligence. He identifies three mechanisms that make this happen: "Language (signs), the content of interaction (intellectual values), and rules imposed on thought (collective logical or pre-logical norms)" (p. 171):

> From birth to adult life, the human being is subject, as nobody denies, to social pressures, but these pressures are of extremely varied types and are subject to a certain order of development. Just as the physical environment is not imposed on developing intelligence all at once or as single entity, but in such a way that acquisitions can be followed step by step as a function of experience, and especially as a function of the kinds of assimilation or accommodation –varying greatly according to mental level- that govern these acquisitions, so the social environment gives rise to interactions between the developing individual and his fellow, interactions that differ greatly from one another and succeed one another according to definite laws. (p. 172)

Piaget identifies pressures from the social world on the individual in the development process. He assumes that these pressures are subject to a certain order of development followed by intelligence. He also identifies a function of experience in the development of intelligence. He called acquisitions the process by which the intelligence is developing. Experience linked to the functions of assimilation and accommodation according to the subject's mental level. The mental level and specific laws of development determine how interactions with the social environment will end in a process of assimilation and accommodation. The external environment, both physical and social, does not define the development of individual intelligence. There are interactions that trigger development and innate laws that determine development. Psychology, according to Piaget, must establish these natural laws.

The natural developmental line of individual intelligence, and the laws which logically follow form this, determine differences with other theoretical perspectives. For instance, Vygotsky (1986) criticizes Piaget, because for him the applicability of Piaget's work was restricted. He felt that for Piaget the child was not permeable to experience. To illustrate this, he presents an example given by Piaget. Piaget believed that the primitive human beings only learned by

experience in limited cases of practical activity such as agriculture, hunting and the manufacture of objects. Piaget, quoted by Vygotsky (1986), said: "But even this momentary and partial contact with facts does not react in any way upon orientation of (primitive man's) thought. This applies even more strongly to the child." (p. 55).

For Vygotsky (1986), it is also relevant to consider the social milieu where children's intelligence development occurs. He thinks that the results observed by Piaget about children's thinking need to be seen as relative to the social environment where the children under study live. The question is whether the child's thought is or is not independent of experience. What Vygotsky criticizes in Piaget's approach is that he postulated universal ways of thinking as if a child's thinking is independent from his/her historical, cultural and geographical environment. He said that Piaget's "experiments led him to believe that the child was impervious to experiences" (p. 55). For Vygotsky, studying children in different social spheres could give more validity to the laws that he was postulating. He expressed this difference as follows:

> The developmental uniformities established by Piaget apply to the given milieu, under the conditions of Piaget's study. They are not laws of nature, but are historically and socially determined. (p. 55)

For Vygotsky (1986), this uniformity established by the Piagetian stages of intelligence development are only possible under the conditions of his study. He affirms that they are not natural laws but they are historically, cultural and socially determined. According to Vygotsky (1986), Stern also criticizes Piaget's assumption by saying that he did not consider in sufficient depth the relevance of the social situation and physical environment in the development of intelligence.

On the one hand, there is the idea that a child follows inner rules of development that allow for the process of adaptation to the world, and, therefore, learning is seen as independent from development. On the other hand, there is the idea that the child learns from the outside world and that learning pushes the development in a certain direction. Development follows learning.

For Piaget (2001), social interaction is important in the development of thinking. For instance, in relation to operational development, he asked himself about the role of co-operation:

> Does operational development within the individual enable him to co-operate with others, or does external co-operation, later internalized in the individual, compel him to group his actions in operational systems? (p. 179).

Behind this question is the point of the role of the interaction between individuals and the effect of this on development. It is what he calls 'co-operate

with others'. This implies that in order to succeed in the interchange with others, certain development of thinking must be achieved. He proposes the following answer:

> To such a question there must of course be two distinct and complementary answers. One is that without interchange of thought and co-operation with others the individual would never come to group his operations into a coherent whole: in this sense, therefore, operational grouping presupposes social life. But, on the other hand, actual exchanges of thought obey a law of equilibrium which again could only be an operational grouping, since to co-operate is also to co-ordinate operations. The grouping is therefore a form of equilibrium of inter-individual actions as well as of individual actions, and it thus regains its autonomy at the very core of social life. (p. 180)

Piaget recognized the relevance of interaction with others for development. The interchange of thought and the co-operation with others allows for operational grouping. Without a social life, it will not be possible to achieve this. But, at the same time, to be able to interact with others, it is necessary to have reached a particular level of development: the exchange of thoughts corresponds to an internal law of equilibrium. It is only if this equilibrium is present that the individual will be capable of interacting and co-operating with other. Social life is therefore viewed as the possibility of interaction between individuals, from one inner life to another.

Vygotsky (1986) criticizes Piaget's view in relation to the child and his/her activities:

> Piaget argues that "things do not shape a child's mind." But we have seen that in real situations when the egocentric speech of a child is connected with his practical activity, things do shape his mind. Here, by "things" we mean reality, neither as passively reflected in the child's perception nor as abstractly contemplated, but reality that a child encounters in his practical activity. (p. 40)

Vygotsky suggests that Piaget's ideas mean that interactions of the child with reality, where objects are present, do not change thinking. It is not only the interaction with the other, as expressed before, but also the interaction with objects that do not change thinking. From Vygotsky's point of view, the child encounters reality during his/her practical activity. For him, activity plays a role in the configuration of thinking; it is not independent.

Language

When the child is considered in connection with the social world, the question of the role of language in development and learning processes becomes an issue. A child's language can be seen as the way the child communicates his/her thoughts, and also the way he/she thinks internally. In this sense, Piaget (2004) poses the hypothesis that there is a mental activity, thinking, going on, in a child's interior. He explains that there is a mental activity, a kind of logic, connected with words: "The child from 6 or 7, has images connected to the words" (p. 79). According to him, all this "mental activity can take place only on the verbal plane, and in this sense they will always differ from those bearing upon toys and instruments, etc., which imply manual work or at least manipulation" (p. 79). He says:

> [...] this verbal activity is not social; each child carries it on by himself. Each child has his own world of hypotheses and solutions which he has never communicated to anyone, either because of his ego-centrism, or for lack of the means of expression –which comes to the same thing, if [...] language is moulded on habits of thought. (p. 79)

Piaget distinguishes a language that is social from one that is related to the individual's inner life. The first is used to communicate, to exchange ideas; the second only concerns individual thinking. Through experiments in the laboratory, he shows that during the development of intelligence, the social language is available for children seven years and older. Until that age, children only master the other kind of language, a language that corresponds to what he calls egocentrism. It is as if the child is born with a genetically determined way of thinking and logic. A child comes full of hypothesis and solutions that he/she has never communicated to anyone.

Vygotsky (1986) criticized these Piagetian theories as well. What became relevant for him is that the characteristics of the child's conversations depend not only on their age but also on their conditions. For him, language is always socially determined: there is no such egocentric language.

> We consider that the total development runs as follows: The primary function of speech, in both children and adults, is communication, social contact. The earliest speech of the child is therefore essentially social...Egocentric speech emerges when the child transfers social, collaborative forms of behavior to the sphere of inner-personal psychic functions. Egocentric speech emerges when the child transfers social, collaborative forms of behavior to the sphere of inner-personal psychic functions. (p. 35)

In opposition to Piaget's ideas, Vygotsky considers that the function of speech is communication and social contact. He assumes that language emerges when the child transfers social behaviors to the personal sphere. In that sense, language comes from and is bounded by social practice. Through language used in social settings, the child transfers social aspects and forms of behavior to the inner-personal psychic functions.

Referring to Piaget's work, he mentions how in children's conversations there is an effect coming from the surroundings that supports the beginning of logical reflection. For him, it is the same when a child talks to him or herself as when he talks with others. Egocentric language, emerging from social language, has then become internal talk. Vygotsky also distinguishes different functions for language: global and multifunctional. He explains that although they are different, they are essentially social. For Vygotsky, the language that Piaget calls social language is a language that has a communicative function.

Following those two lines of thinking, one can say that, on the one hand, there is the idea that human beings are born with an already made reasoning about the natural, made and social worlds. On the other hand, there is the assumption that children acquire particular kinds of reasoning in interaction with others. In other words, a child can manage on his or her own a reasoning about the world, or the child takes from other people a culturally and socially determined way of thinking.

Experience

In Piaget's view, it seems that the internal laws of child development drive the child's experience. It is somehow the view of many studies in psychology and education that focus on the way the mind functions, isolating the individual from society, as if the activities and the local cultural meanings did not affect the way the child experiences the world. These theories give an account of the universal functioning of the individual mind. In this scenario, some studies assume that the child is not a passive learner, and he/she makes sense of his/her experiences by an intuitive type of knowledge called 'children science'. Those ideas are supported by assumptions connecting the child and the world in a particular way: a child has his/her own knowledge and beliefs about the natural phenomena and concepts used to interpret nature (Duit & Treagust, 2003). The consequence of this assumption is the creation of the idea that there is a child "who 'naturally' acts in a scientific, rational, mindful manner" (Radford, 2008, p. 216), an autonomous scientist constructing a Kantian epistemology from direct experience (Lemke, 2001). This idea of the innate rational child is an idea that socio-cultural theorists such as Radford and Lemke criticize and oppose.

On the contrary, following general ideas of the school of psychology and anthropology that are based on Vygotsky's theories, different assumptions are

made about the way individuals experience the world. It is assumed that individual experience is driven by the linguistic and social practices in which the individual is involved on a daily basis. Thinking is mediated by culture. Therefore, language, culture and human experience are inextricably intertwined (Säljö, 1997). Säljö (1997) argues that

> [...] culture in its material and discursive components, must be regarded as genetically prior to individual experience. But, even more fundamentally, [...] communication—i.e., talk (and other means of symbolic communication)—has primacy over experience in some central respects: for the individual it is the tool through which we learn to "experience" and to characterize and communicate our experiences. (p. 177)

The idea behind this view is that individual experiences in the world are shaped by a collective way of experiencing. A culture, which contains material (made world), and discursive (social world) components that the individual learns to use and experience. Language plays a central role in this view. It is the tool by which the individual communicates his or her experiences and experiences the world. At the same time, it is the tool that brings with it many of the institutionalized meanings of a culture. It is in these central assumptions where Piagetian and Vygotskian views differ and mark two distinct paradigms for learning.

Development and education

Vygotsky's notion the *zone of proximal development* is one of the most used in educational settings and has received many different interpretations. A clear difference from Piaget's individualistic view of development can be seen in this notion. In Piaget's theory there is an individual developmental process following an internal predetermined process of development. At the other extreme, Vygotsky's ideas suggest that the developmental process is possible due to the interaction with the social world:

> We propose that an essential feature of learning is that it creates the zone of proximal development; that is, learning awakens a variety of internal developmental processes that are able to operate only when the child is interacting with people in his environment and in cooperation with peers. Once these processes are internalized, they become part of the child's independent developmental achievement. (Vygotsky, 1978, p. 35)
>
> The zone of proximal development […] is the distance between the actual developmental level as determined by independent problem solving and the level of potential development as

> determined through problem solving under adult guidance or in collaboration with more capable peers. (Vygotsky, 1978, p. 86)

For Vygotsky, there are a variety of internal developmental processes that depend on the interaction with people. Only in this cooperation with peers and with others can the child do and imitate something that later on will be internalized. Development is achieved when it is internalized. This postulation of the zone of proximal development came after a discussion in which he explains how there was an assumption in developmental psychology that when a child was able to do a test on his/her own, without the guidance of an adult or a peer, he would demonstrate his/her developmental level. He criticized this by saying that this proves that the child may have reached a certain level, but when he or she can do something with the help of another the real developmental stage can be observed. In other words, if the child can solve the problem with someone else, it means that he or she is close to reaching the expected level of development.

One possible interpretation of the concept of zone of proximal development, commonly used in education, is to say that children in school must have the opportunity of interacting with the teacher and also with their peers. Of course it also used to say that the learning of individuals should happen in an interactional environment. Classroom activities must be designed by a teacher, who is more experienced than the child, interacting with the children, helping them to do things, and the children interacting with other peers with more, equally or less developed knowledge and capacities. For Roth and Radford (Roth & Radford, 2010) this is a simplified interpretation of the concept, it is "to be thought of in terms of the opposition of individuals" (p. 299). This means "they engage in an "inter-mental" or "inter-psychological" form where the learner constructs knowledge for him-or herself on an "intra-mental" or "intra-psychological" plane" (p. 299). Roth and Radford (2010) criticize this view by suggesting a different way to make a link between individual and collective consciousness. For them, this interpretation disconnects the individual from the collective consciousness:

> Their interaction is thematized through the dubious prism of the differences of what happens within the individual consciousness and what happens in collective consciousness –as if they exist separately. (p. 299)

They suggest another possibility: to see individual consciousness not as two separated entities as supposed by this position, but as two inseparable entities characterized by a "co-constitutive nature of subjective consciousness and collective consciousness" (p. 299). To see this relation in that way implies a

change in the way thinking happens. Assuming the first common interpretation implies that:

> Speaking is reduced to the individual, subjective intention of the speaker, who, in speaking, is considered to externalize ideas that have previously formed on the inside. (p. 299)

In Roth and Radford's interpretation, human thinking is more complex than an individual externalizing his or her already formed thoughts:

> More so, such approaches convey notions of verbal expressions system to emerge, and individually, each child produces a proper grouping that is constitutive of the collectively achieved system (pp. 299-300).

Somehow, individual thinking is possible within a collective framework where a particular way of thinking is available for this. Roth and Radford also criticize this simplistic view:

> The approach is substantialist in that it takes some prior situation, including the institutional positions of the participants in an interaction (i.e., teacher, student), and uses it to make casual attribution about the events that ensue. (p. 299)

In the first view, it is assumed that individual thinking can be independent of the institutional role adopted by a teacher or a learner. In their critique, they are looking for another perspective. That is, the role we assume in a particular situation also matters when thinking about what is happening in a classroom.

CONFIGURATION OF INDIVIDUALISTIC AND SOCIO-CULTURAL CULTURAL SENSIBILITIES

Cognition phenomena involve the subject that is using his/her body to know and act in the world, and the context where the individual is acquiring knowledge. Theories of cognition establish, implicitly or explicitly, a relationship between the subject knowing, thinking, and learning with the 'context' within which this subject acts and lives every day. On the one hand, there is a tendency to study cognition of the individual as happening in the individual's mind and adapting it to the environment. What matters is how the cognitive apparatus in the mind evolves and functions while it is solving problems or thinking and reasoning. This cognitive activity occurs while the individual mind is interacting with other human beings, and does not depend on the collectivity of other individuals that

are interacting with the individual. This tendency is known as an *individualistic* view of cognition (Leach & Scoth, 2003; Radford, 2008; Barbara Rogoff, 1999; Wertsch, Minick, & Arns, 1999). On the other hand, there is a tendency in which cognition is not conceptualized as an individual issue. It is a dialectical relation between the subject and the collectivity. Individual cognition is recognized as dependent on the social and physical context in which the individual is embedded. The individual way of thinking, knowing and reasoning is dialectically constituted in collectively, culturally and historically constructed forms of reasoning, thinking and knowing. This collectivity, that has norms, rules, and relationships, drives individual cognition. This is what is referred to as the *socio-cultural* view of cognition (Leach & Scoth, 2003; Radford, 2008; Barbara Rogoff, 1999; Wertsch, et al., 1999).

INDIVIDUALISTIC CULTURAL SENSIBILITY

Wertsch, Minick, and Arns (1999) characterize the individualistic perspective as a kind of theory explaining ontogenesis as starting in the individual:

> By adopting for an "individualistic" perspective, a theory views human experience and environmental forces strictly from the position of how they influence the individual's psychological development. (p. 151)

The individualistic view can be associated with Piaget's line of thinking. This trend of cognitive research focuses on the individual internal functioning of the mind in such way that the social and physical context is not considered as part of individual thinking. In Lave's (1996) words, traditional cognitive theory "is "distanced from experience" and divides the learning mind from the world" (p. 7). The context is somehow ignored, or just taken as providing opportunities for the individual to use a kind of universal cognitive capacity. The social dimensions of knowing are reduced to an external environment to which the cognitive activity of the individual has to adapt (Radford, 2008). Following this idea, researchers studied learning as if it were a process contained in the mind of the learner, and consequently as if individual cognition did not happen in a lived-world (Lave, 1996). Rogoff (1999) presents a clear picture of the relationship between individual cognition and context in this type of research:

> Cognitive developmental work has been overly concerned with describing mental changes which are assumed to occur within the individual independent of contextual influences. The predominant focus has been on establishing stages of development or transformations in capabilities associated with development. Most depictions of stages (e.g. the concrete operational stage of Piaget) or capacities (e.g. spatial skills, metamemorial ability) assume that the stage or capacity

> characterizes the person's thinking across a large number of task situations (Piaget, 1970; Feldman, 1980; Fischer, 1980). (Rogoff, 1999, p. 1)

In this view, the development of individual cognition represented in skills, capabilities or capacities is seen as individual internal mental changes that do not depend on contextual influences. Piaget and other's work is recognized in that sense. What is important to recognize is that for a large number of task situations a detached universal individual thinking can be activated by each of them. In this view, a dichotomy of mind and body can be identified (Lave, 1996). A theory that adopts an 'individualistic' perspective assumes "human experience and environmental forces strictly from the position of how they influence the individual psychological development" (Wertsch, et al., 1999, p. 151).

In this view, it seems that social and physical contexts are seen as static entities. In other words, it assumes these contexts as a 'delimited container' where interactions of individuals are happening with physical and intellectual objects: Interactions that are driven by each individual mind full of thoughts, skills, abilities and knowledge. Lave (1996) refers to a particular conception in this line of cognitive research. There is a conception of context as a "static, residual, surrounding "container" for social interaction" (p. 22). In this view, contexts are conceived as "containers of behavior, never touched by human actions" (Engeström, 1996, p. 66). In the individualistic view, problem solving, thinking and learning occurs in a particular context: a problem to be faced by the individual and knowledge domains. The individual's mental models and cognitive structure determine the context and the engagement of the individual in the context-task (Engeström, 1996). In consequence, the task in which the knowing subject is cognitively engaged, and the interaction with other subjects, provide a kind of "ethically neutral environmental feedback" (Radford, 2008).

For this line of thinking a particular view about knowledge appears. It is assumed that knowledge is a matter of individual construction. It is also a kind of knowledge that does not take into account cultural considerations. The individualistic view is "leading to a-historical and a-cultural accounts of knowledge" (Radford, 2008, p. 216). Knowledge is constructed by the individual as a set of conceptions that he/she adapts to his/her own existing conceptions (Duit, 1996). In that sense, knowledge can be understood as the already formed conceptions of the individual while he/she is developing in an adaptive way. It is also assumed that individual knowledge is a tentative construction and must be viable. Duit (1996) defines these characteristics as follows:

> *Tentative construction*. All knowledge or ideas constructed by the individual about traits of the world outside or about ideas another may have is tentative in nature. It is hypothetical and

> may need minor or major changes when other evidences become available. (p. 44)
>
> *Viability*. Knowledge and ideas that have been constructed need to be viable, i.e., useful for the individual (or a group of individuals respectively […] Only constructs that stand the test of being viable survive so to speak. (p. 44)

This idea can be connected with Piaget's view about the way the individual adapts to the world. All knowledge that an individual produces or constructs has an adaptive function. That is 'hypothetical' in the sense that it is useful while it serves and is not in contradiction with the environmental responses. If a new situation provides new opportunities of knowledge construction for the individual, and the feedback is negative when the individual uses his/her own knowledge, then the individual feels a need to re-adapt. The evidence appearing to the individual's eye can be this kind of feedback needed to trigger the internal des-equilibrium and also to re-structure what needs to be changed. Somehow, the innate hypotheses (Piaget, 2004) that the child brings with him/her to the world are modified in an adaptive way by the contact with the physical and social worlds.

In this perspective, thinking is an individual matter that can be characterized and has a kind of continuity, as if in everyday situations some kind of rationalities is used by individuals across different tasks. Thinking is looked at as detached from the social context and situations where it is produced. Research in this area provides categories of thinking with particular distinctions and levels. For instance, Bloom's taxonomy (Bloom, Hastings, & madaus, 1971) that provides a ranking of ways of thinking according to the cognitive difficulties which need to be overcome. This implies a kind of thinking that is naturally present for all individuals, and used by them across different tasks. These kinds of classifications do not give account of the social or cultural dimensions in which these categories of thinking are used or from where they emerged.

Finally, learning is conceived as an individual matter, detached from the context and social situation where cognition and learning is occurring. Learning is a personal issue happening while the subject is constructing his/her own structures of viable knowledge. At the same time, it allows individual thinking to evolve and to adapt to different environmental forces. Learning is assumed as a process of individual adaptation.

SOCIO-CULTURAL CULTURAL SENSIBILITY

The socio-cultural view capitalizes on another set of assumptions on cognition that focus on the relation between the individual and society. It assumes that it is not possible to separate individual cognition from the individual's life in a social

world —including interactions of the individual with the physical world and other individuals. In this theoretical perspective, it makes no sense to see the individual's mind in relation to an expected stage of development. The individual's actions are seen as driven by a social world, invisible to the eye, but managing all his/her possibilities of action. This is to assume that the "explanation of the individual's ontogenesis must begin with an examination of social phenomena" (Wertsch, et al., 1999, p. 152). To understand this strong connection between the individual's society and activity, it is important to see the assumptions behind this line of cognitive research. On one hand, it is assumed "that social phenomena are governed by a unique set of explanatory principles" (p. 152), which means that "social phenomena cannot be reduced to the sum of individual psychological phenomena" (p. 152), as individualistic perspectives seems to assume. On the other hand, it is assumed that "at least certain aspects of the individual's psychological functioning are determined by these social phenomena" (p. 152).

This type of cognitive research establishes a different relation between the individual, cognition and context. Vygostsky's developmental theory is normally associated with this line of thinking. By doing studies in different contexts and everyday activities, this line of research established that the tasks in which the individual is cognitively involved change the cognitive possibilities of the subject. People who seemed to have difficulties with a particular task involving a particular skill in a laboratory, did not have the same difficulty in their everyday activities (Barbara Rogoff, 1999). This shows how children's capacity appears to be different in their familiar environment in comparison with the laboratory activities.

Furthermore, in this perspective it is not enough to identify the situated characteristic of cognition. Indeed, in order to postulate a cognitive theory that considers this relation, it is necessary to have a theoretical conception of the social world. Lave (1996) sees that the theoretical problem

> [...] lies in treating relations among a person, an activity, and a situation, as they are given in a social practice, viewed as a single encompassing theoretical entity... Theories of situated activity do not separate action, thought, feeling, and value and their collective, cultural-historical forms of located, interested, conflictual, meaningful activity. (p. 7)

The social world is seen as a complex structure where activities take place. These activities that are socially constituted and take place within a particular culture and at a particular historical moment, determine somehow the possibilities of actions and being of individuals. In this sense, a social practice is not a single encompassing theoretical entity. Social practice is embedded in that complex structure that drives possibilities for individual cognition.

Different theoretical assumptions about context within socio-cultural theories can be recognized. Engeström (1996) presents two kinds of uses of context:

> Various phenomenological and ethnomethodological analyses focus on dyadic interaction, attempting to define contexts as social situations, as spaces of interactive experiences, or as fields of discourse. Although contexts are here seen as interpersonal constructions, they are commonly treated as purely linguistic, symbolic, and experiential entities. This makes contexts look like something that can be created at will by two or more persons in interaction, as independently of the deep-seated material practices and socioeconomic structures of the given culture. (p. 66)

One idea is to see context as an interpersonal construction. In that sense, it is viewed as a social situation, as spaces of interactive experiences, or as fields of discourse. This perspective on context does not take into account the structure where the interactional activity is happening. It is as if individual could create a situation and context independently of the socio-cultural moment. The material cultural-tools and language available, the socio-economic and political structures of the particular society must be considered as a fundamental part of the context. They constitute and make possible the interaction created by individuals.

The notion of *mediation* is central to the understanding of socio-cultural theories. It encloses the idea that subjects embedded in this context determined by available structures, signs and meanings and cultural-material tools, use their cognition restricted by these constraints.

> Mediation by tools and signs is not merely a psychological idea. It is an idea that breaks down the Cartesian walls that isolate the individual mind from the culture and society. (Engeström & Mienttinen, 1999, p. 29)

Mediation can be seen as the way by which cultural resources stimulate the individual's mind and his or her cognitive possibilities available in the moment of action and interaction. Following this, it is not possible to isolate the individual's mind from culture and society, nor from historical moments.

In a socio-cultural view, *knowledge* also depends on the context, and cultural historical constitution of society. Knowledge is produced and acquired in a dialectical process between the individual and the specific human activity in which the individual is involved. In this sense, knowledge is tied to the situation where the individual is operating. Individual appropriates cultural ways of acting, being and feeling in particular situations. Human cognition behaves differently across situations (Lave, 1988; Barbara Rogoff, 1999). In this

theoretical perspective, the transferability of knowledge is questioned. Somehow, the situation in which the individual is involved generates and allows for the appropriation of those meanings and cultural senses influenced by the historical moment. These cultural tools may not function in another cultural environment and socially determined activity. Human cognition allows the individual to change and adapt to the different activities in which he/she is involved.

For socio-cultural learning theories, "thinking is conducted through actions that alter the situation and the situation changes thinking; the two constantly interact. The notion that learning is a mediated activity in which the cultural artifacts have a crucial role" (M. James, 2006, p. 57) is especially important. In this sense, symbols, concepts, cultural ways of talking, historical experiences of the subject and of the society, the historicity and framing of a situation, and the artifacts available at a particular moment guide our perception and the sense that we are able to make of the different elements involved in a situation. Radford (2008), proposes a conceptualization of thinking and the relation with society:

> Thinking is a re-flection, that is, a dialectical movement between a historically and culturally constituted reality and an individual who refracts it (as well as modifies it) according to his/her own subjective interpretations, actions and feelings. (p. 219)

In this view, it is not a matter of individuals interacting and using their internal tools of thinking. Thinking is constituted by the possibilities of a particular way of constituting reality allowed by the historical moment and the culture in which the individual is living. At the same time, the individual's subjectivity is taken into account as the way he/she expresses those elements of the socially constituted reality in his or her own way of interpreting, acting and feeling.

This perspective moves away from the individualistic assumption that the learning process happens in the head of the individuals concerned. Instead, it is assumed that learning happens in the inter-subjective, social spaces in which subjects participate in social activities, where cultural products are available to them in a complex social, cultural and historical setting. According to socio-cultural theories, learning occurs while the subject, a fundamentally social being, participates in socially structured practices (M. James, 2006; Leach & Scoth, 2003; Radford, 2008). In other words, "learning is by definition a social and collaborative activity in which people develop their thinking together" (M. James, 2006, p. 57).

IDENTIFYING CULTURAL SENSIBILITIES IN SCIENCE EDUCATION RESEARCH

When children arrive at school, they are growing and developing their cognitive dimension as well as other dimensions. They have a history of experiences in the world. These experiences, together with their biological development, have given these children a sense and knowledge about the natural and made worlds as well as the social world. Different researchers have studied the way children's thinking relates to the natural and made worlds. This relationship is central for science education. One line of cognitive laboratory research focuses on the thinking of the child, what kind of explanations and connections the child establishes in relation to something that he/she observes in the natural and made worlds. Another kind of research considers social and cultural aspects in the configuration of the child's ideas about the natural and made worlds. The relation between the child, thinking and the world has been the subject of several studies in psychology in the work of researchers such as Piaget (Piaget, 2001; Piaget & Inhelder, 1966), Vygotsky (Vygotsky, Hanfmann, & Vakar, 1962), Wallon (Wallon, 1947), and Claparède (Claparède, 1926). All of them were looking for ways in which ideas about the world evolve independently of school (e.g., Piaget) and also in relation to science contents in school (e.g., Vygotsky, Wallon, Claparède).

These studies have had an impact on research on science and mathematics education. In particular, they established a relation between the child's knowledge about the natural and made worlds in his/her everyday experiences, and the child's knowledge in science classrooms at school. One of the most important things studied in science education is children's ideas about the natural and made worlds and the way these ideas are used and interpreted in teaching and learning situations. A vast amount of literature has been produced on this subject (e.g., Duit, 2003; Gilbert, 1982; Major, 2006; Merleau-Ponty, 2002; Schoultz, 2001; Nersessian, 1989; Vosniadou, 1992; Mortimer, 1995; Vygotsky, 1962; Yin, 2008; Piaget, 2004; Mercer, 2004).

In the field of science education, the influences of the individualistic view in psychology and the socio-cultural view can be recognized. Several studies build on a strong individualistic tradition following Piaget's line of thought. Another group of researchers use a combination of Piaget's and Vygotsky's ideas, trying to estimate the impact of everyday experiences in the child's thinking —following Piaget's perspective—, and the relevance of social interaction for learning —using Vygotsky's view. Finally, another group of researchers have based their work on socio-cultural theories following a Vygotskian line of thinking.

INDIVIDUALISTIC CULTURAL SENSIBILITY

The research that follows Piaget's school of thinking assumes that there is an internal, universal, scientific and mathematical knowledge, which is independent from cultural structures and historical forces. They also recognize another kind of knowledge that is taught:

> Some types of knowledge are universally acquired in the course of normal development, while other types are learned only with intervention of deliberate teaching (which includes teaching by any means, such as apprenticeship, formal school, or self-study). For example, all normal children learn to walk whether or not their caretakers make any special efforts to teach them to do so, but most do not learn to ride a bicycle or play the piano without intervention. (Pellegrino, Chudowsky, & Glaser, 2002, p. 29)

The assumption here is that there are some ideas about the natural and made worlds that come with the child, which naturally appear and evolve while the body grows, and time passes. Following Pellegrino, Chudowsky, and Glaser's (2002) reasoning, mathematical concepts such as 'ordinality and cardinality' or scientific reasoning as 'inanimate objects need to be propelled in order to move' are not learned because they are culturally available, but because they are part of human nature:

> Thus in mathematics, the fundamentals of ordinality and cardinality appear to develop in all normal human infants without instruction. In contrast, however, such concepts as mathematical notation, algebra, and Cartesian graphing representations must be taught. (p. 29)

This view assumes a universal knowledge independent of the cultural resources available. Since the 1980's and for some decades now, research tried to characterize these natural ideas and knowledge that are assumed as part of the natural, individual growth of a human being. These ideas constitute typical discourses in science education.

In these discourses, it is assumed that children have their own ideas about scientific phenomena, independent of the historical and cultural circumstances in which they live. In this view, researchers investigate children's thinking by doing interviews. The answers are interpreted as evidence of the existence of mental models (Vosniadou, 1992; Leach, 2003). These mental models have had an influence on several teaching proposals. The purpose of science education has been then to develop strategies to produce changes in the individual's mental models. This is what is known as *conceptual change* (Vosniadou, 1992; Leach, 2003).

Thus, teaching science is viewed as a process that involves learning leading to a conceptual change. It is associated with studies on cognitive science, science education as well as developmental psychology. What many studies show is "that children and adults construct an intuitive understanding which is based on their every day experience" (Vosniadou, 1992, p. 536). The knowledge that children or adults develop in these everyday experiences is referred to by different names in the research literature: preconceptions, misconceptions, alternative frameworks, mental models, folk theories and intuitive theories (Vosniadou, 1992). It is a kind of intuitive knowledge that a child or adult uses to provide explanations of natural phenomena (Schoultz, 2001; Smith, 1992). What is important to recognize here is that those explanations frequently differ from scientific explanations about the same phenomena (Nersessian, 1989; Vosniadou, 1992; Duit, 2003). It is also assumed that these everyday-based explanations interfere with learning science and are resistant to instruction (Nersessian, 1989).

One important aspect about learning in school settings is the recognition that "children use what they know to shape their understanding" (Donovan, 2005) or in other words, "new understandings are constructed on a foundation of existing understandings and experiences" (p. 4). Based on Piaget's genetic epistemology, several teaching and learning theories in science education have adopted the view according to which the student constructs his or her own knowledge (Radford, 2008; Duit, 1996). According to this perspective, the learner brings his or her own knowledge to a given teaching situation. In this view, in order to predict how learners will respond to a particular science-teaching situation, it is necessary to understand the knowledge that students bring to this particular teaching situation. This can be explained in that learners are engaged in an active construction on the basis of their own already existing existing conceptions.

This basic idea is part of a set of principles that characterize what is known as a *constructivist view in science education*. In this sense, teaching within a constructivist perspective implies that learners are encouraged to construct their own knowledge instead of copying it from an authority in a book or delivered by the teacher. The main idea is that it is relevant to use, during the teaching, realistic situations instead of decontextualised or formal situations such as those which predominate in traditional textbooks, and that students learn together with others instead of on their own (Kanselaar, 2002).

The second research tendency in science education combines the individualistic perspective with some socio-cultural elements. It recognizes that the child constructs his/her own knowledge and is able to achieve a conceptual change. At the same time, it is assumed that the child has his/her own ideas about the natural and made worlds that are independent of cultural and historical circumstances. However, another relevant element is assumed in relation to

learning, which is that other children and adults are important in the learning process of the individual. It is in the interaction that the child learns. It is assumed that the construction of meaning happens within a social setting in which the individual is part (Duit, 1996).

James (2006) summarizes the role of the teacher in this line of thinking:

> [...] the role of the teacher is to help 'novices' to acquire 'expert' understanding of conceptual structures and processing strategies to solve problems by symbolic manipulation with 'less search'. (p. 55)

The adult, represented in a classroom by the teacher, is the person who helps the other, the child, to understand the way experts do. Somehow, if the child does it alone, then he/she will take more time to think and act as an expert.

In this kind of discourse group and classroom discussions are seen as important for the learning process. In relation to a classroom environment that helps learning in science, Donovan and Bransford (2005) state:

> [...] students typically work in groups, and the groups question each other and explain their reasoning... One group of students explains to another not only what they concluded about the evolutionary purpose of different coloration, but also the thinking that led them to that conclusion and the background knowledge from an earlier example that supported their thinking. The practice of bringing other knowledge to bear in the reasoning process is at the heart of effective problem solving, but can be difficult to teach directly. It involves a search through one's mental files for what is relevant. If teachers simply give students the knowledge to incorporate, the practice and skill development of doing one's own mental search is shortchanged. Group work and discussions encourage students to engage actively in the mental search; they also provide examples from other students' thinking of different searches and search results. The monitoring of consistency between explanation and theory [...] is preparation for the kind of self-monitoring that biologists do routinely. (p. 579)

This is a typical example of an educational discourse in science education that recognizes the relevance of discussions and at the same time assumes that learning is happening in the individual's mind. The example focuses on the individual process that must take place to succeed in the use of knowledge. The problem of learning is to search in 'one's mental files' for information that is relevant for reasoning in that particular science classroom situation. The cognitive process to solve problems is also highlighted, recognizing that these

skills are part of our human possibilities waiting to be developed with outside stimulation. Another idea is that these individual cognitive processes are similar to those carried out by scientists. The authors claim that in this kind of perspective, the knowledge emerging from the notions such as community of practice is used in classroom settings. This is a possible interpretation of socio-cultural theories, and particularly of Vygotsky's thinking. This position has been called the *socio-constructivist view.*

SOCIO-CULTURAL CULTURAL SENSIBILITY

Although the second tendency described above recognizes the role of inter-individual exchange or interaction between students and teacher as relevant for learning science, the social and cultural dimensions present in socio-cultural views are not considered. The focus is on the individual and his/her internal cognitive process. Looking at the individualistic view that assumes particular conceptions and knowledge as depending on the natural development of the individual, on those ideas that naturally came with the cognitive apparatus, it does not consider the role of culture and social activities on thinking potential. Conversely, if a Vygotskian perspective is assumed, when a child is learning words and participating in social activities, he/she is learning what is already in the collectivity and in the culture. The development is driven by the collectivity. Then how is it possible to distinguish children's knowledge about the world independently from the culture?

The adoption of a socio-cultural perspective leads to different considerations in this respect. One theoretical consideration found in some anthropological views is that teaching science is considered cultural transmission and learning science as cultural acquisition (Cobern & Aikenhead, 1998). In this sense, the system of meanings and symbols used for interactions are crucial to understanding children's ideas about the natural and made worlds. The way conceptual change is viewed differs from the individualistic view. For instance, considering a socio-cultural perspective, Magnusson, Templin, and Boyle (1997) refer to conceptual change in the following terms:

> [...]conceptual change in science is a matter of appropriation by individuals of culturally based knowledge (of the scientific community), and that understanding such change requires a mediated context in which students' activity (actions and thinking) is shaped by a more experienced other who reflects the cultural norms or ideals of the scientific community that facilitate knowledge production. (p. 91)

Conceptual change is defined in relation to cultural based knowledge. In this sense, a change in the mental structure is not expected, or references of

conceptions and ideas that came with the individual. With regard to possibilities of change, those who have had more experiences that somehow involve the norms and ideals of the scientific culture (or school science), and the mediation of context are more recognized. For instance, in relation to teachers (who are more experienced) it is expected that they will reflect the culture of science that is relevant in the science curricula at school. Equally important is the context where individuals are interacting and carrying out a particular social activity. In relation to naïve conceptions or alternative frameworks, these are recognized as conceptions that are current or resistant (Magnusson, et al., 1997). Magnusson, et al. (1997) emphasize that in the socio-cultural perspective, the goal of science education is not to achieve a replacement of existing conceptions in the student's mind. It is a matter of helping students to construct more accurate ideas, that is, ideas that get closer to scientific ideas. Following Radford's (2008) theoretical position of learning, such a statement means that teaching is a matter of helping the student to see the cultural tools developed by the scientific community, and to appropriate these cultural tools.

Following the idea of situated cognition, and based on Bachelard's (1968) work, Magnusson, et al. (1997) propose another perspective for alternative ideas. They assume that "the individual can have parallel conceptions with respect to a specific concept, each conception having functionality within a particular social context (Solomon, 1983)" (p. 94). Using socio-cultural terms, the authors say:

> [...] parallel conceptions develop because of a concept that is sufficient to perceive and understand in one social context and with respect to one culture, but which may not suffice in another. On the other hand, parallel conceptions can also be useful in the same cultural context if they are useful for perceiving or understanding in a particular activity. (p. 94)

In this idea of parallel conceptions of a concept used in different social activities, it is supposed that conceptions are something relevant for social aims. It is not an individual matter. Communication with language and meaning is related to a social purpose. The experiences of an individual in different social contexts provided that person with different senses and ways of using language. Words, symbols, expressions may have different meanings in different contexts and situations. On the other hand, researchers following a socio-cultural perspective and the situatedness of knowledge do not interpret these ideas that seem to be independent from culture in the same way. As Magnusson, et al. (1997) argue, people do have different conceptions about phenomena and they use different meanings according to the social practice they are involved in. As an example, they cite the case of a chemist who uses a different language to refer to the same phenomenon depending on the social situation he is in.

For instance, two different theoretical perspectives can be assumed in relation to children's conceptions of the shape of the Earth, gravity, and the consequences of that on the objects on Earth. One kind of study assumes that conceptions, mental models, or naïve theories are resistant and can be characterized. It is as if those conceptions are in the mind and need to be changed (Vosniadou & Brewer, 1992). Another kind of study shows that when the conditions of the interview change (a contextual change takes place) possible resistant conceptions are not found. The hypothesis behind the study is that the way the interview is conducted and the tools used produce a particular kind of thinking (Schoultz, Säljö, & Wydhamn, 2001).

In the field of children's understanding of astronomical concepts, the difficulties a child may have in conceptualizing these phenomena have been documented (Schoultz, Säljö, & Wydhamn, 2001). The following is an example of the way the conceptualization of the astronomical concept from an individualistic perspective is revealed in Vosniadou and Brewer's (1992) work:

> For example, many children said that the earth is round but also stated that it has an end or edge from which people could fall. A great deal of this apparent inconsistency could be explained by assuming that the children used, in a consistent fashion, mental models of the earth other than the spherical earth model. Five alternative mental models of the earth were identified: The rectangular earth, the disc earth, the hollow sphere, and the flattened sphere. It is argued that these models are constrained by certain presuppositions which children form based on interpretations of their everyday experience. Some of these models (the rectangular earth and the disc earth) seem to be initial models children construct before they are exposed to the culturally accepted information that the earth is a sphere. (Vosniadou & Brewer, 1992, p. 535)

What seems relevant in these discourses is that the culturally accepted model of the Earth, the spherical model, is not what many children express. Vosniadou presents other models that children use. It is argued that everyday experience has given the children elements to constitute these mental models, which differ from the culturally accepted model. It is also argued that these models existed before some kind of learning in relation to the accepted model. This kind of result came from a particular way to research children's conceptions. Schoultz, et al. (2001) argue that the responses of the child depend on the artifacts and language used to refer to the scientific phenomena. While Vosniadou & Brewer (1992) interviewed a large number of children and found categories of stable thinking about the way of conceiving the Earth, Schoultz, et al. (2001) found different results by using a cultural artifact and less abstract language during the interviews. The children in those situations used knowledge and conceptions that

they had learned in different social situations and were able to answer with sophisticated thoughts.

Shoultz, et al. (2001) questioned the mental model perspective and explored phenomena which assumed a socio-cultural perspective and the situated characteristics of cognition:

> Instead of viewing understanding as the overt expression of underlying mental models, children's responses in interview studies should be regarded as situated and as dependent on the tools available as resources for reasoning. By modifying the interview situation through the introduction of a globe as a tool for thinking, the outcomes are radically different from those reported earlier. None of the problems that have been reported, where children, for instance, claim that people can fall off the earth, can be detected. Even among the youngest participants gravitation is often invoked as an explanatory concept. It is argued that the globe in this case serves as an efficient prosthetic device for thinking, and this illustrates the tool-dependent nature of human reasoning. (Schoultz, Säljö, & Wydhamn, 2001, p. 103)

Using another theoretical perspective and modifying the typical methods of interview in traditional studies on children's conceptions, the authors show how children give different and more sophisticated answers than those found in Vosniadou's and Brewer's work. During the interviews, the researchers used a language and situations that were closer and more understandable for children. They explain changes in children's answers by analyzing the way reasoning is produced in the context and modified by it. In the case of Vosniadou's and Brewer's study, the language used is abstract, while in Shoultz et al.'s the language is more concrete and meaningful during the interview, mediated by a cultural artifact. The differences between these studies makes evident that, on one hand, there is the idea that children's answers reveal their mental models, and, on the other, the focus is on the process in which thinking emerges, implying a variability of thinking and reasoning across social activities.

From a socio-cultural perspective it is important to recognize a different view about how children and humans perceive natural phenomena. According to this line of thinking and assumptions, it seems impossible to consider children's ideas about natural phenomena without establishing a link between the child, everyday experiences in the world, the social activities in which the child participates, and the construction of natural phenomena. Phenomena can be seen as something expressed through language and constituted by it, dependent on personal interpretations of language and meanings according to the social context and activity the individuals are involved in (Roth, 2007). This

perspective reveals problematic issues in relation to teaching situations when natural and made phenomena are explored:

> Because interpretation arises from the interplay of existing understandings and experienced world, what one observes depends on what one already knows. This means that students who do not yet know the scientific principles will be unlikely to see just what their investigation is to show, for the very principles that are to be exhibited are prerequisite to seeing the phenomenon that is to be seen. As a result, students perceive different worlds than teachers making science learning through discovery next to impossible (Roth, 2007, p. 140)

Thus, it seems difficult to assume the existence of a phenomenon that every one can see and perceive in the same way. Since interpretation depends on understanding and experiencing the world, the language used to shape phenomena may have different meanings. The interpretation of an experiment can run in many directions in a group of students. This has several implications. If students have not appropriated the scientific principles and scientific language, then they will see only what is possible from the language tools and meanings they have. If they have some school science language, it is not certain that everybody will see the expected phenomenon. It is necessary for teachers to learn how to make visible the phenomenon they want students to see. Therefore, it becomes necessary to give full meaning to the language used to express phenomena. Roth (2007) describes how one phenomenon is a construction of a group of students in a situated activity:

> [...] the phenomena students constructed emerged from the intertwining of discursive and practical activity, interactions with others and the material world that was the focus of their activities. See thus, it is not surprising that students' phenomena often did not correspond to those the teacher wanted them to construct. (p. 166)

Individuals construct phenomena during interactions and practical activities. All the resources of the moment shape the phenomena language and provide language meanings of the moment. There is not one single possible phenomenon that everybody observes. Since phenomena are a discursive process, a group of individuals will construct a common language and meaning in a situated activity. Different discourses can be constructed and used when an experiment is conducted. Children will naturally appeal to their experience in other social activities to constitute the phenomenon.

> The process of abduction, which Gee defined as reasoning that draws on one's own experience to formulate plausible explanations and where aesthetics and taste play a major role, is

> fundamental to understand how children express their understanding of phenomena. This process is fundamental to working in science, but can take on the characteristics of "everyday" abduction. Such everyday abduction relies on everyday language and logic, and on language constructions, which are more typical of story telling. (Bloom, 2001, p. 450).

When children arrive at school, they master different kinds of reasoning according to their experiences in other social contexts. Children's explanations and reasoning about classroom phenomena are shaped by everyday language and logic. There are diverse ways of communicating about and knowing objects and events in a complex society: there are many "speech genres"[13] that reflect how differently social groups or institutions communicate about what they do (Mäkitalo, Jacobsson, & Saljö, 2009). Physical and abstract objects (such as phenomena) are embedded in diverse social practices. Different "speech genres" and conceptual frameworks are used in these practices. Learning and mastering scientific concepts implies being able to contextualize phenomena in discourses that are often at odds with those that are used in everyday settings. Furthermore, in many situations there will be multiple, sometimes rival, scientific discourses that are relevant (Mäkitalo, et al., 2009).

CULTURAL SENSIBLITIES IN SCIENCE EDUCATION

I have presented two different theoretical perspectives to explain children's conceptions about natural and made worlds. On one hand, I showed individualistic tendencies focusing on the observed facts about children explaining and using a particular kind of reasoning in relation to natural and constructed facts. In this perspective, explanations, conceptions and children's ideas are viewed as mental models, misconceptions, naïve theories or alternative theories. Those terms are used in different research studies to express the differences between accepted scientific conceptions and theories, and children's ideas. The attempts of many teaching and learning science theories are to support conceptual change. This means learning is regarded as changes in mental structures. Learning is something that erases one conception and replaces it by another. I also argued that this tendency acknowledges and uses Vygotsky's mediation ideas. Interaction with others, group work and dialogues with the teacher are relevant for learning. However, the interaction is only seen as a

[13]Mäkitalo, Jacobsson, and Saljö used speech genres to refer to different ways as people, in complex society, speak about events. In other words, each speech genres reflect how different social groups or institutions communicate about what they do.

support for the individual's conceptual change. This is why I do not consider this tendency to be a socio-cultural tradition, even though they declare that they have incorporated some of Vygotsky's theoretical tools into their work.

On the other hand, I presented a different theoretical perspective on children's ideas about natural and made worlds: the socio-cultural paradigm. The fact that children show different theories and explanations about natural and made worlds is considered as the way human beings adapt to social activities in different cultures. One conception may be useful in one social setting, where the individual's shared meanings and interpretations of objects and facts, and another conception about the same object can be useful in another social setting. Conceptual change is regarded as the possibility of the child to acquire and appropriate scientific cultural tools (e.g., words as density, relation between variables, scientific explanations). It is to learn a particular kind of language, meanings and reasoning that is accepted in a particular culture and social activity. In that sense, a child at school will appropriate languages and meanings that are useful in the school setting but that are not the same as those of the scientific community. Adopting this theoretical perspective means that phenomena in the world depend on language, meanings and personal interpretations. In a science lesson, it is important to find mechanisms and ways of sharing particular ways to constitute language phenomena.

LOOKING AT ASSUMPTIONS IN ASSESSMENT DISCOURSES

The aim of this section is to use both individualistic and socio-cultural lenses to look at the tendencies in assessment. Two reflections are relevant here. One is about the general tendency to identify assessment activity with testing individuals by observing their performances on tasks. This kind of assessment and assessment for learning also has implications for learning and formative assessment. It is also made a relation of this kind of assessment and assessment for leaning or formative assessment. A second reflection has to do with the role of learning theories on assessment. The analysis refers to scholars' texts making explicit the role of learning theories on assessment.

ASSESSMENT AND TESTING

Assessment practices in classrooms can be different from one country to another, from one school to another, and from one teacher to another. However, it is possible to recognize the same kind of characteristics:

- Assessment is based on testing and quantitative methods measuring individual performances.
- The measurement of learning outcomes determines if someone learned at the end of a particular lesson.
- Assessment is detached from teaching.

These dominant views, reinforced by national —high stakes examinations and tests— and even international systems of school achievement —e.g., TIMMS or PISA— affect the way assessment activity is conducted in classrooms:

> External tests have a constricting effect on the curriculum, resulting in an emphasis on subjects tested at the expense of creativity and personal and social development. High-stakes tests often result in a great deal of time being spent on practice tests, the valuing of test performance and undervaluing of other student achievements, with teachers' own assessment becoming summative in function rather than formative. (Harlen & Crick, 2002, p. 6)

Harlen and Crick (2002) highlight the close relationship between external tests and the curriculum. Furthermore, they call attention to the time that is expended at school by training students to pass tests. Testing practices are viewed as reducing the possibilities of considering other kinds of student performance. Harlen and Crick also focus on the social role of examinations in England and USA societies:

> [...] there is a common sense assumption, widespread among both the educational community and parents, that summative assessment in the form of tests and examinations, is a key source of motivation for learning. In England, as in many states of the USA, where assessment for summative purposes has burgeoned in the past decade, an increase in test scores year on year has been found and this has been attributed, as least in part, to the implementation of tests. (p. 9)

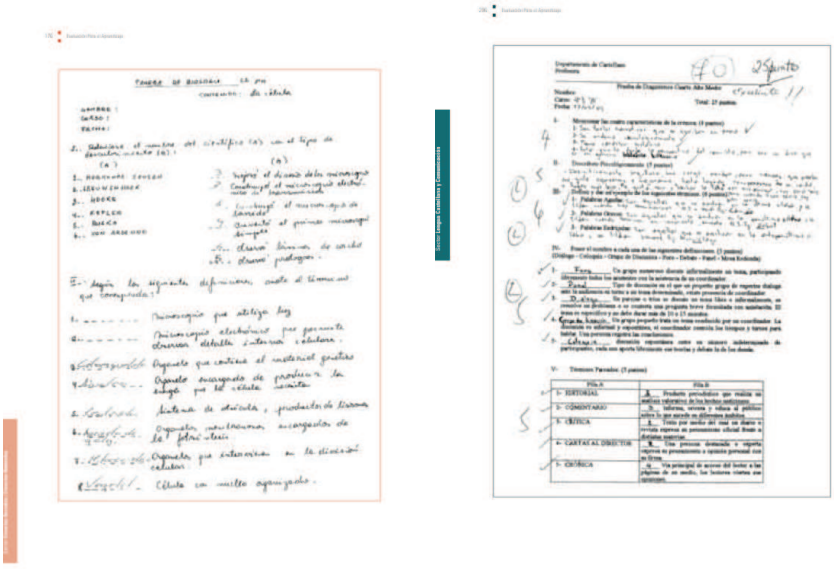
They identified an impact of external test practice on the school. First, the educational community and parents believe that summative assessment is a key source of motivation. Second, that there is an increase in test scores in England and USA.

The practice of test scores assessment is that it is the activity carried out by a teacher at the end of a teaching process, which results in a quantitative (e.g., a grade or a mark) or qualitative (e.g., a value comment or a feedback) valuational statement or judgment about the students' performance, the work done, the attitudes revealed during the teaching and learning sequence, etc. Sentences such as the following express the language used in student

assessment: Maria scored 8/20 in science; the teacher gave a 'Well done' to Juan in history; Cecilia is performing very well in the laboratory activities. In other words, people's common ideas of assessment are often connected to particular types of summative assessment, in other words, the type of valuation that expresses a judgment on the outcome of a learning process. Summative assessment can be compared to a picture of a person taken at a particular place and time. Assessment judgments are taken to be the "picture" of what a person has achieved as a result of learning.

Assessment is also seen as an isolated, individual activity. Individual teachers observe students and produce a valuational statement about their performance. Students are also seen as individual learners, and it is considered important to determine where each person is in the process of learning. More often than not, assessment builds on ideas that highlight the importance of individual thinking and change in individual understanding and performance. This type of individualistic focus appears to contradict the attention paid to interaction and collaboration among students as important resources for learning. Hence, even if many current forms for pedagogy positions students in relation to each other and in interaction with the teacher, the result of learning needs to be individualized in assessment.

To assess learning, teachers currently use "tests with which students struggle in one-on-one combat, where knowledge must be demonstrated out of context, and where collaborating is considered cheating" (Wenger, 1998, p. 3). For instance, images as those in *Picture Nº1* can be associated with individual assessment experiences as a learner or as a teacher at school. The image on the left (Unidad-Curriculo-y-Evaluación-MEN, 2006, p. 296) reflects a typical activity that a child has to deal with as a learner, with the stress of showing what he/she knows, and that he/she knows how to answer a particular question, or to solve a particular problem. The teacher's judgments are produced after observing the child's performance in relation to his/her expectations.

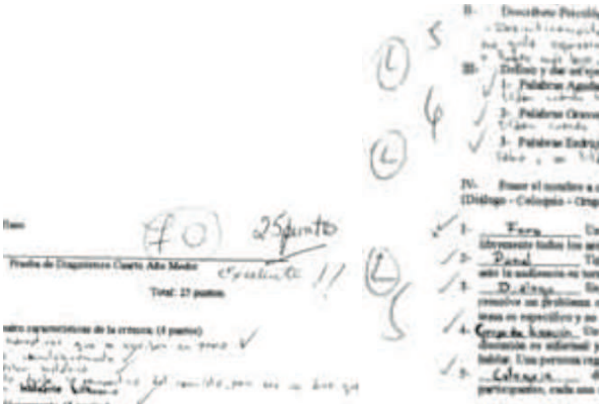


Picture Nº1. Images of typical examinations that make part of learners and teachers' assessment experiences

The image on the left is a biology test that a child has to answer by him/herself, to demonstrate his/her knowledge. Assessment activity presupposes an observation of an individual's cognitive process, and these kinds of questions and formats are currently used to observe learning. It is assumed that the language used and the questions are free of multiple interpretations (Schoultz, Säljö, & Wyndhamn, 2001). It is assumed that a question or activity that enhances the outcome of learning is well proposed when one or more individuals obtain the expected or a similar performance. The terms reliability and validity of the assessment tools are used to show that it is possible to design tools, questions and activities that enhance what is expected, and for which different evaluators will agree on the judgments of answers. It is assumed that the questions can effectively prompt specific knowledge to be used for answering the question.

The image on the right in *Picture Nº1* (Unidad-Curriculo-y-Evaluación-MEN, 2006, p. 176) shows the typical result of teachers' assessment practice. A teacher, as part of his/her job, prepares the test, writes or chooses a question, or looks for which kind of problem might be appropriate to examine learning. The teachers also spend a considerable amount of time in front of many student examinations, reading each one and assigning a mark, then putting it against

each name on a list of the students in the class, and carrying out operations at the end of the year to assign one single grade to each student. If we focus on the image on the right (Picture Nº 2), we can see a number "7,0 and 25 points, Excelent!!", and many other symbols. These marks, symbols and numbers are there as expressions meaning that, for the teacher, the learner performed as expected. With those numbers, the teacher presents the judgment that he/she is making of the learner's possession of knowledge.



Graph Nº 2. Images of typical marcs and signs that are used in assessment practices

In this kind of practice, specific difficulties introduced by the communicative format are not always recognized (Schoultz, Säljö, & Wyndhamn, 2001). It is as if the questions and language were transparent and only had one possible interpretation, and their meanings were the same regardless of cultural and social practices. "It is as if writing in solitude in the context of a test is an unbiased indicator of what people know or understand" (Schoultz, Säljö, & Wyndhamn, 2001, p. 214). In particular, conceptual knowledge that wants to be tested is "something that is more fundamental than thinking and communication in concrete social practices as part of a situated action" (p. 214). The assumption here is that conceptual knowledge has an independent existence from where and when it appears. Similarly, the communicative format used is assumed not to have an impact on thinking. The mediated characteristic of a test is not recognized (Schoultz, Säljö, & Wyndhamn, 2001).

Assessment for learning has another kind of associated practice. However, testing practice and assessment for learning have something in common. The focus of assessment activity is on the cognitive individual processes of learning. The learning goals are expressed as abilities, skills, competences, content knowledge, and concepts. The learning is observed in the individual responses to a task. The interpretations and judgments are based on

comparing the collected information of the individual with the expressed learning goals.

As mentioned in Chapter one, scholars' conceptualizations on assessment for learning maintain that the interaction of student-students, students-teacher, and student-teacher are relevant to the assessment activity. For instance, as part of an assessment activity, feedback is said to be essential for the learning process, both peer, and self-assessment. Feedback is recognized as teacher-learner relationship, and peer and self-assessment as a way of making students aware of the learning intentions (Stobart, 2006). In relation to peer and self-assessment, Stobart (2006) argues:

> The logic of this is that, for these forms of assessment to be effective, students have to be actively aware of the learning intentions and the standard that has to be met. Sadler argued that the ultimate aim of formative assessment is: "to download that evaluative (assessment) knowledge so that students eventually become independent of the teacher and intelligently engage in and monitor their own development". (p. 145)

The emphasis of this kind of argument is on the individual. Each student is expected to be aware of individual learning intentions and standards. The ultimate goal of assessment is to promote the individual monitoring of the development of the individual as well as of others. Feedback is conceived of as the teacher's responsibility aiming at bringing to light the learning intentions and helping each individual learner; providing understanding of criteria and standards; finding ways of closing the gap (what the individual learner did not achieve); focusing on individual tasks; and challenging the learner with actions that are achievable.

Perrenoud (1998) argues that assessment for learning arguments do not consider the context in which the assessment situation takes place. Stobart (2006) recognizes that formative assessment concepts are produced within Anglophone cultures, "with their 'whole child' approaches, individualism and attitude to motivation" (p. 136). Therefore, there is no consideration of what "social and cultural factors may affect what goes on in the classroom, since these are likely to provide differing threats to effective formative assessment" (p. 136). The author identifies some examples of factors: The impact of assessment and education in society having an impact on motivation to learn; the curriculum and how it is assessed or what kind of assessment perspective is considered; inadequate training and resources; and the culture of schooling where different teaching models are assumed and are not congruent with the principles which support assessment for learning.

ASSESSMENT AND LEARNING THEORIES

In summative practices teaching and assessment are normally perceived as two different activities, while in assessment for learning practices there is a tendency to recognize teaching and assessment as related and inseparable. To adopt one or other perspective has an impact on the way learning theories have been historically used in educational settings. (e.g., Shepard, 2000). When assessment and instruction are conceived as separate in both time and purpose, it is possible to find assessment and teaching discourses that do not share learning assumptions. For instance, Shepard (2000) argues that traditional testing historically is based on assumptions supported by behaviorist paradigm, and it is currently found testing used within pedagogical practices based on constructivist paradigm. This highlights inconsistencies between the assessment processes and emerging instructional constructivist practices and curricula. Shepard (2000) makes an historical analysis to show the link between testing practices, behaviorism and the views of teachers, parents and policymakers.

When assessment is conceived of as embedded in teaching it presupposes coherence between the learning theory, teaching and assessment. However, the way assessment operates in diverse environments does not help this coherence. There is often a barrier to the implementation of pedagogies based on particular kinds of teaching and learning theory. Shepard (2000) shows how the behaviorist theories historically influenced assessment practices, and how such influence has been an impediment to pedagogies based on socio-constructivist theories of teaching and learning. Shepard (2000) claimed that the constructivist paradigm is embedded in the praxis of teachers that emphasize close assessment of students' understanding, feedback from peers, and student's self-assessments as the central social process that mediates the development of intellectual abilities, construction of knowledge, and formation of students' identities.

Even though summative assessment is recognized as connected with assessment for learning (Harlen, 2006), for teachers it is difficult to separate them, and to establish boundaries in activities: a student's test information can be used for learning or as summative. However, it is not clear when and why to assume one or other perspective. Taking this into account, it is important to recognize that even though the forms of assessment are different in their purpose, they both face a common theoretical problem: how the learning of 'another' can be seen, and judged. In some cases, even when each learner assesses their own work helped by the contrast with another, the teacher, the problem is still present. The theoretical problem is the alignment between theoretical assumptions on learning, the information collected by the learner, and the production of judgments. This problem is what Biggs (2003) calls alignment between learning goals and assessment (tests).

Although in the conceptualizations of assessment for learning the mediated characteristics of assessment is recognized, what is relevant at the end is the individual process of learning. The situated characteristics of human cognition are not used in scholars' conceptualizations of assessment for learning. The mediation is reduced to a matter of feedback and recognition of individual behavior. What is observed is the individual performance as evidence of the internal learning process.

How can learning goals, learning evidence and judgments shared by diverse conceptualizations of assessment be connected with assumptions on learning theories? How can they be analyzed? Looking at Vygotsky's (1986) comment about tests, and the assumption that the individual must face the task on his/her own in order to see 'real' learning and level of development, assumptions can be deduced:

> [...] we give children a battery of tests or a variety of tasks of varying degrees of difficulty, and we judge the extent of their mental development on the basis of how they solve them and at what level of difficulty. On the other hand, if we offer leading questions or show how the problem is to be solved and the child then solves it, or if the teacher initiates the solution and the child completes it or solves it in collaboration with other children-in short, if the child barely misses an independent solution of the problem- the solution is not regarded as indicative of his mental development. This "truth" was familiar and reinforced by common sense. Over a decade even the profoundest thinkers never questioned the assumption; they never entertained the notion that what children can do with the assistance of others might be in some sense even more indicative of their mental development than what they can do alone. (p. 32)

Although Vygotsky's comment relates to judging the developmental stage of a child, a parallel remark can be used to visualize assumptions behind assessment. First, it is assumed that an isolated individual acting without being engaged in the activity with others is the true evidence of learning. Generally, activities aiming at providing and eliciting information for assessment purposes do not consider the individual acting in social activities with collective purposes as relevant for support learning.

James (2006) presents a specific historical perspective on the individualistic tendency in assessment discourses:

> Historically, much assessment practice was founded on the content and methods of psychology, the kind of psychology especially that deals with mental traits and their measurement. Thus, classical test theory has primarily been concerned with

> differentiating between individuals who possess certain attributes, or the degree to which they do so [...] The focus tends to be on whether some behavior or quality can be detected rather than the process by which it was acquired. (p. 48)

Isolating the individual reveals a clear picture of de-contextualized and general knowledge that needs to be perceived and captured. The performance, behavior and the quality detected are evidence of learning. In assessment for learning discourses, the other, the teacher or peers, as mediators in the learning process, are assumed as an external stimulus which generates a des-equilibrium hoping that the response of the context will allow for assimilation, as Piaget suggested. What is relevant is how the interaction of the individual with others helps each individual student to learn.

Assuming cognitive and constructivist theories of learning "requires the active engagement of learners and is determined by what goes on in people's heads" (James, 2006, p. 55). What is important is in the mind and how the brain functions.

> A particular focus is on how people construct meaning and make sense of the world through organizing structures, concepts and principles in schema (mental models). Prior knowledge is regarded as a powerful determinant of a student's capacity to learn new material. There is an emphasis on 'understanding' (and eliminating misunderstanding) and problem solving is seen as the context for knowledge construction. Processing strategies, such as deductive reasoning from principles and inductive reasoning from evidences, are important. (M. James, 2006, p. 55)

Assessment uses this perspective to help changes in mental models, as that innate hypothesis arriving with the newborn infant, changing while the child interacts with social, natural and made worlds, and assumed as misunderstandings. In this perspective, evidence is essential to know about the world and the way to promote changes in mental structures.

In this perspective, the mediational character of the instruments to collect information is considered as detached from thinking. They are not part of the potential of the individual's thinking and as the way to promote collective and cultural reasoning. The assumption is that the instrument, questions, problems and assessment tasks are free of cultural interpretations and that the individuals' knowledge used to answer or act are a kind of de-contextualized knowledge. To view assessment for learning from the point of socio-cultural theories demand explicitly thinking about the role of cultural artifacts (language and material) in assessment. Their effect on possibilities of thinking and doing, and the consideration of participation of social activities needs to be analyzed.

James (2006) recognizes a new tendency in assessment discourses considering socio-cultural learning theories as

> [...] no longer seen as private activity dependent largely, if not wholly, on an individual's possession of innate and usually stable characteristics such as general intelligence. Interaction between people, and mediating tools such as language, are now seen to have crucial roles in learning. Thus the assessment of learning outcomes needs to take more account of the social as well as the individual processes through which learning occurs. (p. 48)

Following James's reasoning, assessment with a socio-cultural perspective in mind must consider interaction with people and artifacts as mediations for thinking and learning. It is not possible to imagine the isolation perspective that cognitive approaches support. It is also important to recognize that there are social processes of learning and individual appropriation of cultural tools. The individual learns to think and act as culture teaches her/him.

Using assumptions from socio-cultural theories of learning, assessment discourse must consider that teachers and students are part of a social system, and that activities of individuals make sense within these systems. For instance, power relations and impact on identities must be highlighted (William, Bartholomew, & Rey, 2004). Black and Wiliam (2006) developed a theory of formative assessment based on a socio-cultural view. They recognize two groups of elements:

> The first group constitutes the sphere of production –the visible actions undertaken within the system directed towards achieving the desired goals- but these are merely the 'tip of the iceberg'. Underlying these elements are the *social, cultural and historic* conditions within which the goals are sought, and these two groups of elements and the dialectic between them together constitute an activity system. (p. 83)

They identify four components within activity system. A first component is considered as a relationship between teacher, learners and the subject discipline, where goals can be perceived differently according to the local culture of assessment —e.g., focused on concepts— versus new culture of assessment —e.g. focused on characteristics of a task. A second component is presented as the teachers' role and the regulations of learning. For instance, a teacher sees new ways to constitute classroom assessment, to be focused on learning processes instead on what will be taught. A third component is feedback and student-teacher interaction. Different levels and aspects of feedback are recognized. They interpret Vygotsky's ZPD as being connected with a particular theory of development and the need then to consider that in a feedback model:

> The overall message seems to be that in order to understand the determinants of effective feedback, or broaden the perspective whilst detecting and interpreting indicators of effective regulation, we will need theoretical models that acknowledge the situated nature of learning (Black & Wiliam, 2006, p. 91).

Finally, the fourth component is the student's role in learning. In this sense, changes of student relation with their own process of learning are expected, when formative assessment is carried out.

The system is represented by three dimensions: *Tools* such as pedagogical content knowledge, nature of the subject, methods of interaction, feedback, etc., and learning analysis. *Subjects* considered as the role of a teacher, of the student in a group and the role of student as individual. And *objects/outcomes* including the teacher's expectations, the teacher's own test, and externally set tests and criteria. This model does not explain the relationship between learning seen as an individual matter and learning as a more complex issue where cultural and collective ways of thinking are tied to individual possibilities of learning. Although the complexity of assessment within a social system is described, the final meaning of assessment is the individual outcome.

LEARNING ABOUT CULTURAL SENSIBILITIES

During my analysis I identified two kinds of cultural sensibilities on science education: the individualistic and the socio-cultural. My goal with the operations and actions in this sensibility space was to capture the assumptions behind each of the cultural sensibilities. I examined studies carried out by other researchers to understand and learn about how one set of assumptions or another could be identified in areas such as the science of cognition, science education, and assessment. In this process I learned about my own assumptions, and I was also able to differentiate them from the socio-cultural set of assumptions.

In the following table I have summarized the most important differences learned from the analysis. By doing this, I will give my first understanding of the two identified cultural sensibilities. The differentiation of the two cultural sensibilities guided after my analysis of IBSE Network texts. They also determined the configuration of the other sensibility spaces.

INDIVIDUALISTIC ASSUMPTIONS	SOCIO-CULTURAL ASSUMPTIONS
Individual cognition is analyzed separately from social activity. Cognition is a mental activity. The mind, psychological process,	Individual cognition is tied to the social and cultural environment. Learning and cognition are social phenomena. Individual cognition

thinking, and consciousness are conceived as entities lodged in an individual interior space. Learning and cognitive processes are focused on what happens in mental activity.	looks at individual participation in social activities. Socio-cultural conditions support individual modes of life. Learning is focused on social activity and on the individual appropriation of cultural tools while participating in a social activity.
The child's naive conceptions about the world are independent from culture and are within the natural developmental line of individuals. What is relevant for teaching is to support the conceptual change in the individual's mind. Learning is conceived as a conceptual change. The role of society and culture is reduced to an environmental feedback supporting individual conceptual change.	Individual conceptions are socially and culturally constructed. Individual interpretations and meanings emerge from the social activity in which the individual is involved. The individual's meanings about the world vary from one activity to another. The nature of physical tools and intellectual or discursive tools vary from one social setting to another. The role of society and culture is seen as determining the learning process. The activity determines individual learning.
Knowledge is viewed as detached from social activities. There is an a-historical and a-cultural account of knowledge. Knowledge is made up of personal viable constructs. Naïve ideas are unstructured knowledge or a collection of unstable misconceptions that need to be replaced.	Knowledge is not separable from the activity, and it is situated and dependent on cultural meanings constructed by the community. Knowledge is tied to the historical moment and culture where individuals are acting. Contextual features involved in the process of knowing shape learning, such as where, when, with whom and meaning shared by the community in a situated action.

Table Nº 1. The groups of assumptions differentiating cultural sensibilities

These groups of assumptions are a reduction of the complexity that I found on my journey. However, they are the most important aspects for my analysis since I selected them as being relevant to understand assessment activity. They represent the guide to assessment activity. Indeed, if the objective of assessment for learning activity is promote 'better individual learning' and if it supports and helps the learner to achieve this, then it is necessary to examine assumptions about learning and knowledge. At the same time, assessment for learning

activity within inquiry-based classrooms is about changing the misconceptions and naïve theories of the child about the natural and made worlds. Thus, it was relevant to understand the differences of interpretation relating to distinct cultural sensibilities about how children understand the world. Finally, learning is about knowing, so it was relevant to look at assumptions, which describe how researchers see knowledge.

I found that in the individualistic cultural sensibility, the tendency is to look at learning in mental activity. This in turn, guided my perception of the theoretical constructions of the researchers who account for this assumption. In particular, I identified the way learning goals are constituted and communicated, as well as how evidence, interpretations and judgments follow such assumptions. For instance, the learning goals are defined in relation to the individual (individual skills, conceptual knowledge). In socio-cultural sensibility, learning is focalized in the unity between individual-activity. The individual and the social activity in which learning is experienced are inseparable. In this sense the tools and the meaning available in the social setting are sources for the learning process. A new conceptualization of assessment activity is needed to account for this understanding.

The second set of assumptions focus on interpretation of about child theories and conceptions. For the individualistic cultural sensibility, a set of concepts exists that develop with the child and that only can be changed by some environmental feedback that makes the individual adapt. However, in socio-cultural in the socio-cultural sensibility, the different social activities are shaped by interpretations, theories and conceptualizations that are shared by the individuals involved in the activity. Conceptualizations are socially constructed.

Finally the third set of assumptions differentiates how knowledge is perceived. In individualistic cultural sensibility, knowledge is detached from the situations where individuals are living. In this sense, assessment activity gives an account of the mastering of such existing knowledge. However, in socio-cultural sensibility, knowledge emerges and is related to the diversity of social activities in which the individual is immersed. The assessment activity should consider the quality of knowledge emerging during the learning and teaching situation.

The analysis allows me to see my individualistic view of educational activities. This aspect became difficult since it was not possible to design an assessment for learning activity taking socio-cultural assumptions into account. In the other sensibility spaces I will address this difficulty and how I found ways to change my own perception of the world.

5. SENSIBILITY SPACE TWO: NATURALIZING

> La psychanalyse en général, mais plus particulièrement celle des tout petits et celle des adolescents, nous apprend que la personne se construit et se constitue à partir de l'objet et simultanément avec lui. Il y a là quelque chose d'un paradoxe merveilleux et tragique dans cette nécessité de l'autre pour fonder l'identité la plus subjective. C'est à la fois le drame humain et la condition de l'humain (Rojas-Urrego, 2002). Nous avons besoin des autres pour devenir nous mêmes. Plus nous nous nourrissons des autres, plus nous sommes en mesure de devenir nous-mêmes. Il s'agit là de notre plus grande chance et aussi notre plus grand risque. L'authenticité la plus solide ou l'aliénation la plus extrême de soi peuvent résulter d'une telle condition. Mais il n'est pas possible de l'éviter. (Rojas-Urrego, 2012)[14]

Rojas-Urrego's (2012) words represent what this sensibility space means for the analytical process. This chapter is about the researcher's identity as teacher educator within an IBSE Network. It is about my identity. Interpreting Rojas-Urrego words, my identity was built in the interaction with objects —others and the cultural objects circulating in the network. My perception of assessment activity and inquiry-based teaching and learning was shaped by those cultural

[14] Psychoanalysis in general, but especially the psychoanalysis of new born babies and teenagers, tells us that a person is constructed and is constituted from the object, and simultaneously with it. There is something of a paradox in this beautiful and tragic need of other to build the most subjective identity. This is both the human drama and the human condition (Rojas-Urrego, 2002). We need others to become ourselves. The more we are nourished by others, the more we are able to become ourselves. This is our greatest opportunity and also our greatest risk. The authenticity of the strongest or most extreme alienation of the self can result from such a condition. But it is not possible to avoid it.

signs and objects used in the collective activity. My individualistic sensibility is what it is because of others: I was nourished by researchers', teacher educators', and teachers' ideas and activities. We shared an activity with a common object/motive. It was to transform teaching and learning activities —including assessment activity— at schools into inquiry-based activity classrooms. It is in this encounter with objects —others and artifacts— that I became myself. At the same time, by visiting analytically, during my research journey, those objects of my practice, and acknowledging different objects, such as those ideas produced by scholars from a socio-cultural perspective, I recognized my own assumptions. I took distance from them. I observed these different objects in order to become aware of them. As Rojas-Urrego said, it is not possible to construct our subjectivity alone. A new subjectivity can only emerge by looking towards others and finally to identify with the new others.

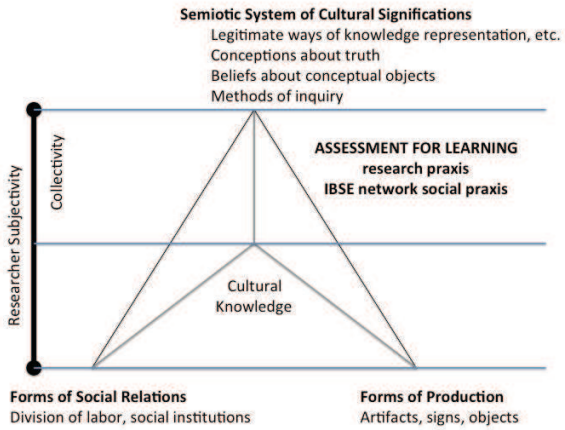
By participating in the IBSE Network social activity, I acted naturally without knowing that I had a collective cultural sensibility about learning, knowing and thinking. The actions with the analytical process presented in Chapter four allowed me to recognize and to awake those individualistic sensibilities learned in my interaction with others. To recognize the socio-cultural sensibility shaped by other forms of representing learning, knowing and thinking, enabled me to identify elements of the cultural artifacts used in the praxis as being supported by an individualistic perspective. I called this sensibility space *naturalizing* to explain this process of noticing my belonging to the existing individualistic cultural sensibility. I also used the word naturalizing to emphasize that this was my natural, or common sense, way of being, and perceiving classroom activities. This Space materializes my actions, operations and goals in the identification of the individualistic cultural sensibility in my practice. My intention here was to highlight ideas and reasoning resonating with assumptions behind individualistic cultural sensibility.

In the first part, I present the actions with each of their goals. I present the way I constructed my analysis. After that, I describe the IBSE Network. I present activities and ways in which information is shared and used. In the third part of the chapter, I identify and describe the dominant IBSE frameworks in the IBSE Network and the mechanism by which the dominant discourse is constructed. After that, I focus my attention on the research-based assessment for learning discourses used in some projects, and their origins. In sections four, five, six and seven, I organize the IBSE and assessment for learning text-pictures around the main ideas that characterize the discourse: Children learn science by looking and exploring the natural and made worlds and phenomena; children's experiences, their own ideas, and their knowledge about the natural and made worlds are taken into consideration during teaching and learning activities; children planning and doing experiments; and children learning science in interaction with peers and the teacher. In the final part of the chapter, I conclude

by presenting the result of the analysis. This involves relating the main ideas presented in the chapter with individualistic cultural sensibility.

THEORETICAL AND METHODOLOGICAL CONSIDERATIONS

Radford and Empey (2007) see social praxis as a source of cognition and the self. They represent cultural knowledge as embedded in the social praxis and in the elements constituting the complexity of such social praxis. I use their representation of this complexity and interpret it in terms of my research.



Graph N° 1. Representation of assessment for learning research praxis and IBSE Network social praxis, subjectivity and the collectivity based on Radford and Empey's (2007) representation of social praxis

I consider Assessment for learning within IBSE as a research praxis using cultural knowledge produced by IBSE social praxis. I also see the IBSE Network as a social praxis sharing cultural knowledge with the research praxis. These practices are connected since they share the same set of principles about learning, knowledge and thinking. They are supported by individualistic cultural sensibility. This sensibility space goal aimed at identifying the similarities of the theorizations produced by researchers and practitioners of those social practices, and individualistic cultural sensibility.

Radford and Empey's (2007) representation contains only the triangle and the four elements, which make up a social praxis —Cultural knowledge,

Semiotic System of Cultural Significations, Forms of Social Relations and Forms of Production. I added two more elements to their representation: individual subjectivity and the collectivity. By doing that I wanted to highlight that the social praxis constructed particular subjectivities that can be identified. For my research, this is relevant, since I am claiming that my experience and the fact of belonging to the IBSE Network shaped my sensibility, and at the same time, made me part of the collectivity in this way sharing the fourth component of social praxis. The three blue lines that intersect each of the vertexes of the figure connect them to the researcher subjectivity and the collectivity. With these lines I want to represent cultural sensibility.

Roth (2006b) supports the use of a first person methodology in research by arguing that looking at ourselves means to look at the generalized other. I argue that by using my knowledge to find individualistic sensibility, I am looking for a collective cultural sensibility:

> As bodies among bodies, we cannot achieve removed and disembodied knowledge; all our knowledge is singular and embodied but also representative of the collective in that it constitutes a concrete realization of cultural-historical and socio-cultural possibilities. Rather than pretending to create objective observer-independent knowledge or retreating into an inner subjectivity, we can use critical methods together with inner subjectivity to bring about maximum of intersubjectivity, that is, understanding the Self to understand the Other. (Roth, 2005b, p. 15)

In this space, I share my singular and embodied knowledge. I considered such knowledge as representative of the collective knowledge produced in the IBSE Network. Thus, I will not present here my inner thoughts and inner experience. I visited my artifacts circulating in the space of praxis. I analyzed those artifacts that were used in the IBSE Network at the time I was working there. I considered that these were a concrete realization of cultural-historical and socio-cultural possibilities. By adopting a critical perspective, in my analysis, I was looking at my own assumptions and how to take distance from them. This was possible thanks to the analysis carried out in Chapter four. Indeed, by identifying another cultural sensibility —the socio-cultural—, different from my own, I was able to recognize my set of assumptions and cultural sensibility.

I used the term *discourse* to represent the ideas and reasoning in connection to assumptions about cognition, development and learning that were identified as individualistic cultural sensibility in Chapter four. These ideas and reasoning are frequently found in the artifacts that I chose to look at. I referred to *dominant discourse* as the link between the set of assumptions and the ideas that allowed me to identify the individualistic cultural sensibility behind assessment

for learning research praxis and IBSE. Furthermore, these are assumptions and ideas that repetitively appear in a variety of the written artifacts that make part of that praxis. As I have previously argued, by using the term discourse I am recognizing the social praxis and the role of language in the constitution of subjectivity and subjectivities immersed in a social praxis.

In order to carry out the analysis, I looked at the texts and interpreted them. I identified repetitions and regularities in the ideas. In my analysis I present pictures or digital photographs of the artifacts, reasoning, languages, and texts as part of my IBSE and assessment for learning culture. Instead of using transcriptions of the texts or writing them myself again in my research text, the strategy of treating texts as if they were photographs that had been taken by a tourist when coming to an unknown place, helped me observing those texts with a distance. This distancing was important for me to be able to see them differently, given that they were familiar artifacts that belonged to my own praxis.

I chose the photographs by identifying words, ideas, sentences, utterances or graphics that could be supported by individualistic cultural sensibility. The photos are taken from different sources which support IBSE practices: web sites, articles, and curricula material. I highlight the language that shapes practices in the Network. I travelled through the IBSE Network focusing on aspects that shed light on a particular kind of learning and theories of knowledge, which supported practices inside the Network. My purpose was to show a discursive tendency circulating in the IBSE Network. For that, I present and describe some text-pictures giving meaning to the IBSE Network teaching and learning discourses. I constructed a photo album with shots from different documents in French, English and Spanish. My concern was to present statements, models and words that regulate what is expected to happen in a classroom where the IBSE discourse is used. It is meant to describe the discursive practice in the IBSE Network.

The decision of include these pictures with their original language had a purpose. I wanted to highlight the diversity of languages that constitute the activity within the network. This is important since not all the participants of the network understand other languages. This has had consequences, because the inquiry-based curricula needed translation from English to Spanish, or workshops of a teacher educator from France in Chile, Colombia or Panama has to be translated. It also has implied that practitioner from the network, who does not understand other languages, have had access to some ideas mediated by those who understand other languages. In the constitution of my chapter, I decided to give, in the same way, access to Spanish and French texts-pictures by paraphrasing the texts' ideas in English, in the same way as I use to work in the network —presenting in Spanish my interpretation of English and French texts and conversations with other teachers educators. This is the reason why I

omitted the translation to English of the text-pictures in the first version of this chapter. However, for better understanding of the interpretation phenomena, I will translate each picture in a footnote.

Another important decision was to present text-pictures where the same ideas of IBSE and assessment for learning are expressed in different forms, and with different purposes. I wanted to communicate the dominance of some ideas in the IBSE-network by showing them in texts-pictures from different sources. A consequence of this decision is that the text of this chapter are structured around ideas that appears repetitively.

The questions below guided my analysis and the selection of artifacts:

- How can the social activity of the IBSE Network be delimited?

- Which are the elements of the documents, which have greater impact on the activities in the network? That is, which are the documents that many people working in the Network refer to, and that seem to function as a foundation for the conceptualization of new documents?

- What are the repeated sentences, statements or words in these documents that could be supported by one or other theoretical learning assumption? In other words, which are the formulations and ideas that repeatedly appear in the documents and that constitute the pillars of the conceptualizations in the Network?

I decided to focus on those texts that are clearly related to teaching activities among the network. My assumption is that these are mainly normative texts that both reflect and contain the dominant discourses in the network. They are aimed at shaping classroom and school science curricula. There are other discourses in the network that I will not consider for my analysis, but I will mention them only to give an idea of the way the network is configured. For instance, there are discourses about school organization, the justifications for introducing IBSE, the evaluation of IBSE programs, and the use of materials.

Members of the IBSE Network use the documents for planning, organizing and developing activities within a project or among projects. For instance, the curricula material is used to plan workshops, teacher training programs, classroom and school activities, documents describing inquiry and assessment resulting from conferences, academic events, evaluation activities and websites. The focus on teaching activities is the mechanism by which the discourse is sustained and diffused.

I chose to look at documents from the websites of different partners in the Network: IndagaLa, in Latin America countries, and Pollen in European

countries. The reason for my choice is that those documents are used by projects in each country in order to set up their activities. Therefore, they are texts that have an impact influencing IBSE practices in many countries. Since the members of the most experienced countries produced those documents (for instance, United States, France, England, and Chile), I expected that the newcomers use them to become familiarized with IBSE discourses.

I also selected documents that are used to support curricula at schools and teacher training programs. My assumption is that those documents represent IBSE Network discourses. In particular, they are texts that, by supporting teacher educators and teachers during their daily activities, are designed to introduce have the function of introducing teachers to IBSE ideas and practices, as well as propagating central principles in IBSE. These assumptions are based on my own experience as member of the Latin-American network for 9 years. As a central participant in these practices, I know these were the texts that are used as reference in the initiations of IBSE activities.

It is important to point out here that those documents support the practice of teacher educators and teachers. However, in this part of my analysis I will not be able to say that this represents the dominant discourse of teachers' practices at school. Nor will I be able to say that those texts are interpreted with the same meaning in the different contexts in which those texts are used. I imagine that each project interprets them according to the local science education culture. This assumption is supported in my own experience as teacher educator in different countries such as Chile, Brazil, Argentina, Panama, Bolivia, Mexico, Peru, France, and Denmark. In my practice I have identified differences in interpretation, use and meanings when these texts are appropriated and re-contextualized by teachers and teacher educators. However, what is important about the documents is that they are taken to be references for structuring and shaping local practices with their particular interpretation and meaning possibilities.

In order to represent different dimensions involved in my analysis, I used various techniques and ways to construct my own text analysis. For instance, I found it was necessary to delimit the IBSE Network existence and practice. My intention in doing this was to show that there are mechanisms such the organization, activities and support of the network that ensure the uses of the artifacts and languages produced by IBSE practitioners.

I show, for instance, how some participants repeat and incorporate into their language IBSE strategies; how the IBSE Network is organized by projects at national and international level to support teacher training programs and IBSE school curricula development; activities in which the Inquiry-based teaching and learning discourses are used by members of the network; curricula material for dissemination of that discourse; the places around the world where the IBSE Network is developed; and finally, boundaries of the IBSE Network where

Inquiry-based teaching knowledge shapes the learning of members and their current practice. These elements are what I consider the IBSE Network.

I also focus the analysis on the IBSE Network dominant discourse constituted by IBSE teaching and learning strategies and specific research on IBSE assessment for learning theory. I assume that assessment for learning is connected to the IBSE discourse. As I mentioned before, assessment for learning discourses presume that assessment is embedded in teaching. I decided to organize my analysis following the IBSE Network tendencies and frameworks consistent with Inquiry-Based teaching and learning, and using assessment for learning research discourse. I suppose that those elements became normative because they say what *should* be happening in the classroom to consider that practice as Inquiry-based, and assessment for learning as a support for learning in an IBSE context. Those frameworks and tendencies are also used to shape evaluations of practices among projects and to design new curricular material.

I also deliberately only looked at those aspects which were connected to particular learning and teaching discourses. I wanted to highlight recurrent sentences and words that could be found in other educational discourses supported by a specific theory of learning. At the same time, I decided to show text-pictures that are the first source and second source of the framework or principles. My assumption is that this provides evidence of the stability of the general discourse and at the same time how it is contextualized for a particular project.

In similar fashion, I focused on the assessment for learning research discourse in IBSE. My interest centers on two studies that are related to various projects. It is different from the IBSE discourse, because I cannot expect that they are used systematically in IBSE Network activities, as is the case in the IBSE discourse. I took pictures from research texts that are used in some particular IBSE projects. I recognize that the curricular material used in the projects contains assessment frameworks, but I did not consider these in this specific analysis.

For the analysis, I present the source of inspiration for those research movements, which influenced the network. I make the assumption that the research discourse is supported by previous research on assessment. After that, I organize some categories that guide my analysis. I assume that assessment for learning has structural activities supported by learning theory assumptions.

Assessment models used by researchers guided my choice of those relevant activities. The first is the focus of the assessment activity, for instance if it is designed to evaluate a capacity or a product. The question that guided me was: what causes something to be identified as an object to be assessed? My assumption is that this something is chosen based on a specific cognitive and learning theory. I look at those elements of the text that resonate with a

particular learning theory. A second relevant activity is how evidence of learning is constituted. I asked a question while I reviewed the texts: what sentences and expressions give me information about a learning theory supporting the constitution of learning evidence? Finally, assessment for learning aims at helping students to learn. In that sense, the activities designed for this purpose must be supported by assumptions behind a learning theory.

In order to construct this part of my text, I hypothesized that two learning theories could be connected to the IBSE discourse: one based on Piaget's ontogenetic theory and constructivist theory, and other on Vygostky's theory of learning and development. I want to highlight the dominant tendency towards an individualistic view of learning, although some elements of Vygotsky's theoretical view are also interpreted and used. I conclude the chapter by presenting a number of categories that characterize the dominant discourses of IBSE and assessment for learning.

I identify four actions, which make up this sensibility space. The chapter sections reflect each action. In the first part I delimitated the existence of the IBSE Network and the Forms of Relations that characterize the existence of such network. In the second, I chose to analyze the frameworks guiding the teaching of teacher educators and the design of curricular material. After this analysis, I identified recurrent ideas and reasoning where the assumptions were materialized. In the third section, I documented those ideas and reasoning by looking at artifacts. Finally, I constituted the dominant discourse by making a link between the individualistic assumptions and the recurrent ideas and reasoning.

ACTION 1: DELIMITATING THE IBSE NETWORK

The action described in this part, which goal is aimed at characterizing the forms of labor and social relations that give existence to a social praxis that I called the IBSE Network. This is important because there are other social praxis where inquiry based science education is at the core of activities, such as PRIMAS[15] for instance. I acknowledge that the IBSE Network evolved. The social praxis I am describing is not the same nowadays. However, I recognize it continue to exist. The Fibonacci Project European Conference[16], held the 26 to 27th April 2012 in Leicester UK, is an example of the existence of the network in Europe.

[15] http://www.primas-project.eu/artikel/en/1298/Partners/view.do

[16] http://www.fibonacci-project.eu/leicester

What is relevant is that the evolution of the IBSE Network continues to involve different researchers, teacher educators, teachers, students, policy makers, businessmen, parents and scientists. For those different social actors, IBSE meaning is constructed on the collective experiences they have with their own culture of science education and scientific knowledge. This is why people from different countries and social settings share spaces where they try to construct a common meaning for IBSE. In order to do this, different social organizations provide opportunities for different actors to have meetings, discussions, teaching and learning sequences, and joint development projects. Different sectors of society in several countries and continents try to build a common interpretation of the phrase Inquiry Based Science Education —IBSE.

IBSE is an area of science education that is developed in different countries, mainly in the United States of America. Their standards for Science education are Inquiry Based (e.g., NRC (1996)). Standards and national examinations in other countries such as Colombia (Ministerio-de-Educación-Nacional-MEN, 2006) have also joined this initiative. This kind of initiative has evolved and many changes can be found since it started in the 1950s. It has been well received by important scientists, such as George Charpak, a French physics Nobel laureate, who with other members of the French academy of science, Pierre Léna and Ives Quéré started *La main à la pâte* and promoted inquiry principles in the French educational system[17]. This project became a leading inspiration for developments in Latin America and Europe (See website IndagaLa, Pollen and La main à la pâte). This is a starting point for the IBSE Network, the *International Network of Programs for the Reform of Science Teaching and Learning in the World,* which is supported by the International Academic Panel of National Science Academies (IAP)[18].

The IBSE Network is a growing network in different cultures, social environments and continents. People that make up the IBSE Network share an approach to teaching and learning science at school: Inquiry. It means that teachers and teacher educators from the network teach science through inquiry methods, and students and teachers learn science through inquiry. First, I will describe the participants, then the organization, activities, curricular material, communication and practice.

---

[17] http://www.lamap.fr/?Page_Id=53

[18] The IAP – International Academic Panel – an association of science academies throughout the **w**orld, declared two subjects to be a priority in its line of work: water and scientific education. Within this last subject, it supports an international network of projects of science teaching based on inquiry. Countries from different continents make up this network. In Europe, the French were the first to develop this type of approach, with their project *La main à la pâte*; they currently lead the European Project *Pollen*, which covers 8 European cities. *Pequeños Científicos*, a Colombian project, is also part of this international network, and is at the source of many of the ideas of this project.

DESCRIBING THE IBSE NETWORK PARTICIPANTS

The key participants in the IBSE Network are researchers, teacher educators, teachers, and students. They are those who support and disseminate the principles, methodologies and who assign a meaning to them within their educational culture. There are other participants such as the members of Science Academies in different countries, project administrators, university partners, and school administrators. I will not mention these actors since I am concentrating on those closely connected to teaching.

The most important participants of the network are the students (the inquiry learners), and the teachers. All the projects of the network aim at teaching science through inquiry. I quote some words of a student and a teacher involved in the Colombian project from a document that they created for me many years ago. It was their testimony about their experiences in the project. They reflect many of the principles and common activities that characterize the Colombian project *Pequeños Científicos*.

The learner's words are:

Picture Nº 0,1

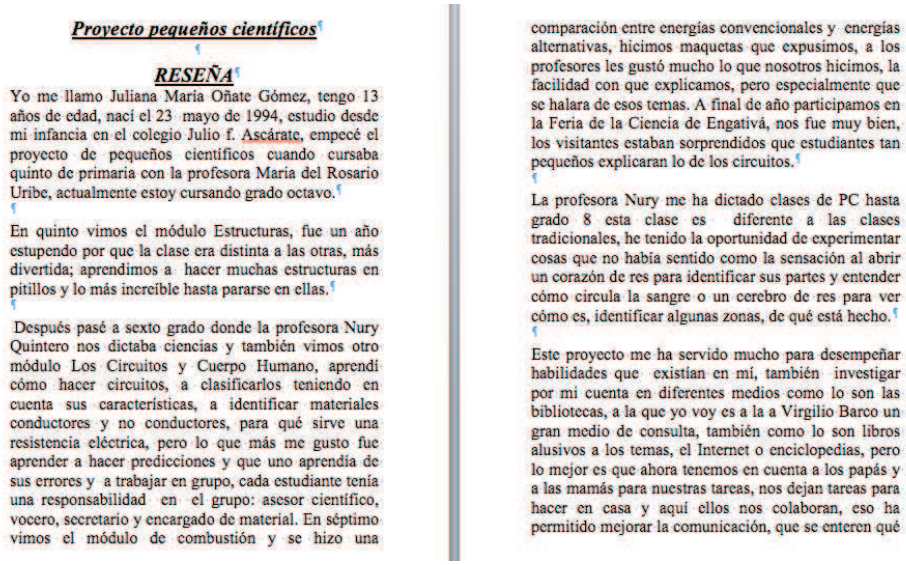
Student experience in inquiry-based classroom[19]

[19] My name is Juliana María Oñate Gómez, I am 13 years old, I was born in May 23 1994; since I was a child I I have been studying in the Julio f. Ascárate school. I started the project of Pequeños Científicos (Little Scientists) when I was in fifth grade, with the teacher María del Rosario Uribe; I am currently in eighth grade.

Afterwards I was promoted to sixth grade, in which the teacher María Benitez taught us science and we also saw another module Circuits and Human Body; I learned how to make circuits and to classify them considering their characteristics; I learned to identify conductors and non-conductors, the use of an electrical coil, but what I liked the most was learning to predict and learning from my mistakes and to work in groups; every student had a responsibility in the group: scientific advisor, spokesperson, secretary and material assistant. In seventh grade, we saw the combustion module and we made a comparison between conventional energies and alternative energies; we did models and exhibited them; teachers liked very much what we did, the easiness with which we could explain, but especially they liked the fact that we were speaking of those subjects. At the end of the year, we participated in the Engativa Science Fair and we did very well; visitors were really surprised to see small students explaining circuits so well...

The Little Scientists Project has taught me to talk in public and to value the work of my peers; to share a pleasant moment in class with all of them; to learn to listen, work in teams, share my material and thanks to this I will be able to teach people who are not well educated. This project has been very useful for me discover abilities that I had; also to investigate on my own by different means such as in libraries; I currently go to the Virgilio Barco Library, which is a great consultation aid; I also consult books on the different subjects, Internet or encyclopedias, but the best thing is that now we take into account our parents for our homework. They give us homework and our parents help us at home; that has improved communication and lets them know what we are learning at school (Translated from spanish by Verónica Fornaguera.)

Project: Pequeños Científicos, Bogotá, Colombia.



Proyecto pequeños científicos

RESEÑA

Yo me llamo Juliana María Oñate Gómez, tengo 13 años de edad, nací el 23 mayo de 1994, estudio desde mi infancia en el colegio Julio f. Ascárate, empecé el proyecto de pequeños científicos cuando cursaba quinto de primaria con la profesora María del Rosario Uribe, actualmente estoy cursando grado octavo.

En quinto vimos el módulo Estructuras, fue un año estupendo por que la clase era distinta a las otras, más divertida; aprendimos a hacer muchas estructuras en pitillos y lo más increíble hasta pararse en ellas.

Después pasé a sexto grado donde la profesora Nury Quintero nos dictaba ciencias y también vimos otro módulo Los Circuitos y Cuerpo Humano, aprendí cómo hacer circuitos, a clasificarlos teniendo en cuenta sus características, a identificar materiales conductores y no conductores, para qué sirve una resistencia eléctrica, pero lo que más me gusto fue aprender a hacer predicciones y que uno aprendía de sus errores y a trabajar en grupo, cada estudiante tenía una responsabilidad en el grupo: asesor científico, vocero, secretario y encargado de material. En séptimo vimos el módulo de combustión y se hizo una comparación entre energías convencionales y energías alternativas, hicimos maquetas que expusimos, a los profesores les gustó mucho lo que nosotros hicimos, la facilidad con que explicamos, pero especialmente que se halara de esos temas. A final de año participamos en la Feria de la Ciencia de Engativá, nos fue muy bien, los visitantes estaban sorprendidos que estudiantes tan pequeños explicaran lo de los circuitos.

La profesora Nury me ha dictado clases de PC hasta grado 8 esta clase es diferente a las clases tradicionales, he tenido la oportunidad de experimentar cosas que no había sentido como la sensación al abrir un corazón de res para identificar sus partes y entender cómo circula la sangre o un cerebro de res para ver cómo es, identificar algunas zonas, de qué está hecho.

Este proyecto me ha servido mucho para desempeñar habilidades que existían en mí, también investigar por mi cuenta en diferentes medios como lo son las bibliotecas, a la que yo voy es a la a Virgilio Barco un gran medio de consulta, también como lo son libros alusivos a los temas, el Internet o enciclopedias, pero lo mejor es que ahora tenemos en cuenta a los papás y a las mamás para nuestras tareas, nos dejan tareas para hacer en casa y aquí ellos nos colaboran, eso ha permitido mejorar la comunicación, que se enteren qué

In her words, she speaks about a module for learning electricity that is part of the curricula used in all schools involved in the project. She also mentions particularities that many children of the project express: They learn to speak and to share activities with their peers. Another important aspect is that her parents are involved in her process of learning science. Juliana's words are representative of the experiences of many students who participated in the Colombian project. Her words reflect the meanings constructed for Inquiry in our culture. The teacher gave her testimony in the following way:

Picture Nº 0,2
Student experience in inquiry-based classroom[20]

[20] My name is María Benitez Ruíz, I was born in Samacá, a town 3 hours and a half from Bogota. Since I was little I always liked being with children and when I grew up, to take care of them. I studied primary school up to ninth grade in Tunja and then I moved to Bogota, where I finished my high school in 1980. After that, I went to Barbosa where I studied Biology.

The school, the classroom, the science class become so rich that you don't have enough words to speak about Little Scientists. Definitely, the project has contributed significantly to my formation; I feel that participating in the project has provided me with tools to renew myself constantly, to reflect on my pedagogical duty, about my conceptions about teaching and learning; it is something like giving sense and meaning to what we do. The need of inquiring more about the discipline we teach arises, as well as the educational and didactic components of science. When I started my training and they gave me the module of electric circuits I was afraid; I thought that this was a subject for the physics teacher; today I feel that it was all worth it, that I have learned a lot. The time devoted to it is totally worth it; you acquire a

Project: Pequeños Científicos, Bogotá, Colombia.

Bogotá, agosto 1 de 2007

Mi nombre es María Banitez Ruiz, nací en Samacá, un pueblo a 3 horas y media de Bogotá. Desde muy pequeña siempre me agradó estar al lado de los niños y cuando era un poco más grande cuidar de ellos. Estudié la primaria y hasta noveno grado en Tunja, luego me trasladé a Bogotá donde terminé el bachillerato en el año 1980. Posteriormente, viajé a Tunja donde estudié Biología.

El colegio, el aula, la clase de ciencias cobra tal riqueza que uno se queda corto al hablar de Pequeños Científicos, definitivamente el proyecto ha contribuido significativamente en mi formación, siento que participar en él me brinda herramientas para renovarme permanentemente, para reflexionar sobre mi quehacer pedagógico, sobre mis concepciones de enseñanza, de aprendizaje; es algo así como darle sentido y significado a lo que hacemos. Surge la necesidad de indagar más acerca del conocimiento disciplinar que se trabaja, así como el componente pedagógico y didáctico de las ciencias.

Cuando inicié mi formación y me entregaron el módulo de Circuitos eléctricos sentí mucho susto, consideraba que eso le correspondía al profesor de física, hoy siento que valió la pena, he aprendido mucho. Vale la pena el tiempo que hay que dedicar, se adquiere un nivel de conciencia de lo que se hace.

El año pasado iniciamos una investigación acerca del impacto del proyecto Pequeños Científicos en el colegio, las encuestas realizadas a la comunidad educativa muestran el papel que ha jugado el proyecto en el desarrollo de competencias comunicativas y ciudadanas. Para nosotros ha sido muy gratificante ver el proceso de los estudiantes que iniciaron hace 4 años. Se observa mayor seguridad en ellos, fluidez al hablar, respeto por sus compañeros, capacidad para trabajar en equipo, interés por abordar temáticas de la ciencia, buen nivel de consulta. Veo como los niños asimilan fácilmente la metodología del proyecto y la interiorizan de tal manera que ha impactado a sus familias, los padres así lo expresan cuando mencionan que sus hijos escuchan, respetan la palabra, intentan hacer acuerdos.

The teacher's words are an example of the impact that the project had in her practice. She evidences changes in her conceptions of teaching and learning, in acquiring new subject knowledge, and strengthening her inquiry abilities. She also shows what she observed about the students' learning process and their families. There are several similarities between her words and the students' words.

---

level of awareness of what you do. Last year we started some research about the impact of the Little Scientists Project on the school. The surveys applied to the educational community show the role played by the project in the development of communication and citizenship skills. For us, it has been really satisfying to see the process of the students that began 4 years ago. You can see they are more self-confident, more fluent when they speak, have more respect for their peers, ability to work in teams, interest to address scientific matters, good consulting abilities. I can see how these children have easily assimilated the methodology of the project and have appropriated it in such a way that it has produced an impact on their families; their parents have expressed this when they mention that their children listen, respect turns to speak, and try to come to agreements. (Translated from Spanish by Verónica Fornaguera.)

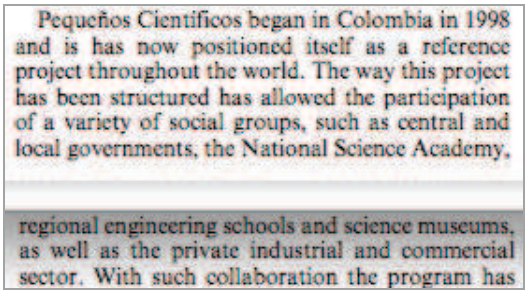
Another set of IBSE Network participants is the teacher educators, and researchers. Most often than not, these are the same people: teacher educators at universities are in charge of both training teachers and researching the implementation of IBSE in schools. They are also in charge of giving meaning to inquiry-based teaching and, in some projects, curricular material. The implementation of IBSE does not work in the same way in every country. What is common is that teacher educators and researchers are in charge of teaching and dissemination of inquiry practice among the projects. They prepare teachers for teaching science through inquiry.

THE ORGANISATION OF IBSE PROJECTS

The IBSE Network is comprised of projects, organized in countries in such a way that different social actors and institutions are involved. It is stated that an IBSE project must be connected to the educational community: politicians, school administrators, scientists and parents. It is said that in order to have an impact on the local educational system, it is relevant to involve the community through diverse strategies.

Picture Nº 1

Relationship between a project and the community
Project: Pequeños Científicos, Carulla, Duque, Molano, and Hernández, (2006), p. 2, Colombia


Pequeños Científicos began in Colombia in 1998 and is has now positioned itself as a reference project throughout the world. The way this project has been structured has allowed the participation of a variety of social groups, such as central and local governments, the National Science Academy,

regional engineering schools and science museums, as well as the private industrial and commercial sector. With such collaboration the program has

For instance, this is the case of an IBSE project of the network, Pequeños Científicos in Colombia. As is stated in the picture, the way the project was structured to include the participation of a variety of social groups such as the local administrations, the National Science Academy, regional engineering schools, science museums, as well as the private industrial and commercial sectors.

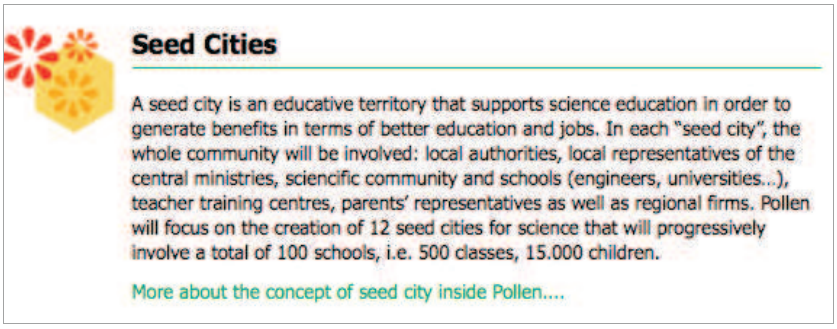
Another example can be found in the configuration of the IBSE European project called Pollen. This project is not currently active, but the new Fibonacci

Project has emerged in the European countries using the principles which underlie Pollen. Pollen stated that the community must be involved in the development of the teaching strategies at school. They call the configuration of supporting community towards science education 'a Seed City'. Projects in each European country were supposed to need the support of different social organizations.

As stated in the picture, a seed city is an educative territory aimed at generating benefits for education and future jobs for students. The assumption is that a seed city will support science education. Different social organizations are expected to be involved. These include people belonging to the public sector, to academic organisations, to industry, as well as parents. It is also said that the project aimed at involving around 500 classes in 100 schools.

Picture Nº 2

European project including the community
Project Pollen. Website Pollen[21], Europe



This kind of organization can be found in many projects of the Network, not only in Europe. In Latin America there is also a Chilean project and a Mexican project (see website IndagaLa). The idea of the need for wider community involvement is supported by the assumptions that the educational system can only be changed through the participation of different sectors in society. The aim of the Network is to make possible a systemic transformation of science education practices in schools.

[21] http://www.pollen-europa.net/?page=f1cgzpZaXXQ%3D

IBSE NETWORK ACTIVITIES

Projects are organized around activities where different social actors interact. There are international activities involving members from different country projects, and there are also national and local activities that characterize each project. Both kinds of activities include conferences, symposia, workshops, training programs, University courses and different kinds of administrative activities. The Inter Academic Panel, a congregation of science academies (IANAS for Latin America), supports many of the activities in Latin America. It also helps members to move to other countries.

One kind of activity is related to international conferences that bring together key speakers specialized in IBSE, and practitioners within the network.

Picture Nº 3

Final Pollen Conference
Project Pollen. Website[22], Europe

As shown above, this conference took place at the final stage of the European Pollen project. As the central subject, the organizers chose to address possible milestones for IBSE in Europe. It is also important to highlight that they are talking about IBSE in primary schools in Europe. Another issue addressed was if it might be possible to generalize such an approach within the European educational systems.

Another example can be found in one of the two Mexican IBSE projects. INNOVEC —Inovación en la Enseñanza de las Ciencias— organizes an

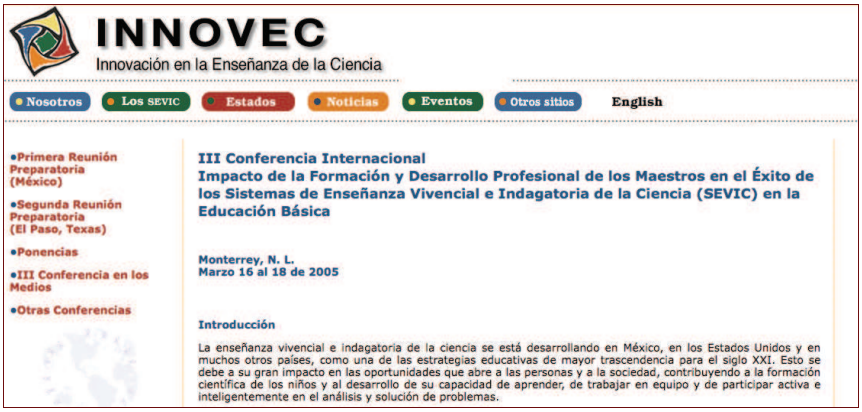
[22] http://www.pollen-europa.net/?page=8sam2hdh4%2Bw%3D

international conference every two years. They choose critical issues that need to be addressed by IBSE projects and invite researchers and people involved in the IBSE Network in Mexico.

As shown above, in 2005 the subject for the Third International Conference was the impact of teacher training programs on IBSE systems teaching in primary schools.

Picture Nº 4

International Conference, Monterrey México, 2005
Project INNOVEC. Website Conference[23], Mexico



It has been claimed that teaching with an experiential approach and through inquiry is one of the most relevant approaches for the XXI century it has also been claimed that this kind of teaching approach opens a door to people and society. This door is related to the contribution to scientific education of children, their capacity to learn, to work in groups and to participate in the analysis and solution of problems.

There are also other kinds of activities that define the social interactions of people in the network, such as international workshops. During those workshops there are different activities aiming at creating a common meaning to

[23] http://www.innovec.org.mx/conferencia3.htm. Introduction. The experiential and inquiry based learning of science is developing in Mexico, in the United States and in many other countries, as one of the most transcendental educational strategies in the XXI century. This is due to its great impact on the opportunities that it opens up for people and society, contributing to the scientific education of children and to the development of their ability to learn, work in teams and participate actively and in an intelligent way in the analysis and solution of problems.

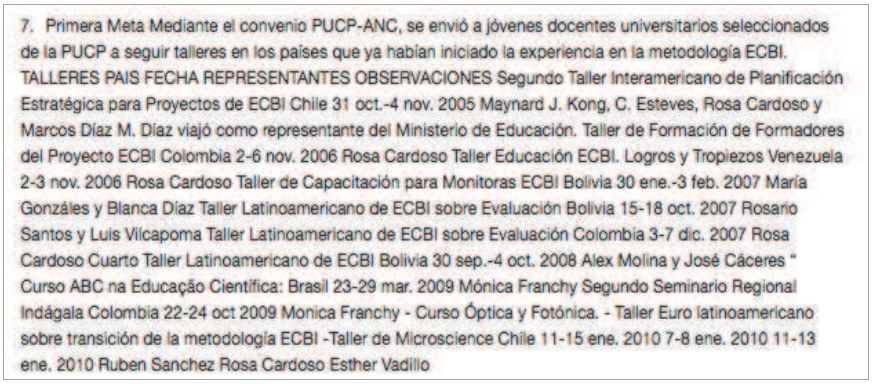
IBSE teaching and learning principles. People from different countries share their expertise and create interactional spaces similar to those that are expected to happen in school classes. An example of the interchanges of experiences is a report of the IBSE project in Peru.

As described in the text of the next picture, taken from a report of the Science Academy in Peru, administrators from the Peruvian Ministry of Education and university teachers were sent to participate in all the different activities of the Latin American network. They were sent for several years to participate in workshops held in countries that had already implemented an IBSE methodology. The workshops were organized around various topics: Project configuration in a specific country considering diverse communities, development of regional projects, IBSE methodology, and particular scientific subject matter.

Picture Nº 5

Participation Report from Peruvian Science Academy
Project ECBI Peru, Website[24], Peru

[24] http://www.slideshare.net/observatorioperuanoCTIS/educacion-en-ciencias-basado-en-indagacion. First Goal by Means of the agreement PUCP-ANC, selected young teachers from universities of the PUCP to attend workshops in the countries that had already begun the experience in the IBSE. WORKSHOPS COUNTRY DATE REPRESENTATIVES OBSERVATIONS Second Inter-American Workshop on Strategic Planning for IBSE Projects Chile, Oct. 31 – Nov. 4, 2005 Maynard J. Kong, C. Esteves, Rosa Cardoso and Marcos Díaz M. Díaz travelled as representative of the Ministry of Education. Workshop on Training of Trainers of the IBSE Project of Colombia Nov. 2-6, 2006 Rosa Cardoso Workshop on IBSE. Achievements and Difficulties Venezuela Nov. 2-3 2006 Rosa Cardoso Workshop on Training of IBSE Monitors Bolivia Jan. 30- Feb. 3 2007 Rosario Santos and Luis Vilcapoma Latin-American IBSE on Evaluation Colombia Dec. 3-7, 2007 Rosa Cardoso Fourth Latin-American Workshop on IBSE Bolivia Sep. 30 – Oct. 4 2008 Alex Molina and José Cáceres ABC Course on Scientific Education Brasil, Mar. 23-29 2009 Monica Franchy – Optics and Photonics Course –Euro-Latin-American Workshop on Transition of the IBSE Methodology – Micro-science Workshop Chile Jan. 11-15, 2010; Jan. 7-8, 2010; Jan. 11-13, 2010 Ruben Sanchez Rosa Cardoso Esther Valdillo


7. Primera Meta Mediante el convenio PUCP-ANC, se envió a jóvenes docentes universitarios seleccionados de la PUCP a seguir talleres en los países que ya habían iniciado la experiencia en la metodología ECBI. TALLERES PAIS FECHA REPRESENTANTES OBSERVACIONES Segundo Taller Interamericano de Planificación Estratégica para Proyectos de ECBI Chile 31 oct.-4 nov. 2005 Maynard J. Kong, C. Esteves, Rosa Cardoso y Marcos Díaz M. Díaz viajó como representante del Ministerio de Educación. Taller de Formación de Formadores del Proyecto ECBI Colombia 2-6 nov. 2006 Rosa Cardoso Taller Educación ECBI. Logros y Tropiezos Venezuela 2-3 nov. 2006 Rosa Cardoso Taller de Capacitación para Monitoras ECBI Bolivia 30 ene.-3 feb. 2007 María Gonzáles y Blanca Díaz Taller Latinoamericano de ECBI sobre Evaluación Bolivia 15-18 oct. 2007 Rosario Santos y Luis Vilcapoma Taller Latinoamericano de ECBI sobre Evaluación Colombia 3-7 dic. 2007 Rosa Cardoso Cuarto Taller Latinoamericano de ECBI Bolivia 30 sep.-4 oct. 2008 Alex Molina y José Cáceres " Curso ABC na Educação Científica: Brasil 23-29 mar. 2009 Mónica Franchy Segundo Seminario Regional Indágala Colombia 22-24 oct 2009 Monica Franchy - Curso Óptica y Fotónica. - Taller Euro latinoamericano sobre transición de la metodología ECBI -Taller de Microscience Chile 11-15 ene. 2010 7-8 ene. 2010 11-13 ene. 2010 Ruben Sanchez Rosa Cardoso Esther Vadillo

Each project has its own activities and ways to work around the IBSE principles. This can be in the form of workshops or more structured training programs. Each IBSE project is organized differently according to the country, so the internal activities vary. Nevertheless, in this palette of activities the same curricular materials to support training processes, as well the activities at school are used.

IBSE NETWORK CURRICULAR MATERIALS

Each project is based on teaching sequences using IBSE principles. Different experts and practitioners have constructed the sequences in different countries, bearing in mind the IBSE Network way of seeing learning and teaching science at school. This means that teachers trained within projects have contact with instructional materials that are constructed by other people. Teachers take the curricular materials and use, adapt or take them as inspiration to teach through inquiry in their own context. In many countries, and particularly in the United States, researchers on science education, scientists and educators have constructed units that contain both particular teaching activities for a specific scientific subject, and the experimental material that allows children to explore different phenomena. Those units are based on an "Inquiry perspective", that assumes that children can learn science inquiring about the physical world, teachers can teach taking into account scientific knowledge and the way that scientists construct knowledge, in order to help children to inquire.

During the last 10 years, people in countries in Europe (France, and other countries in the Pollen project[25]), Asia (China), Oceania (Australia), and the Americas (United States, Colombia, Panama, Chile, Argentina, Brazil, Mexico

[25] See http://www.pollen-europa.net

and others[26]), with diverse cultural backgrounds, are using these curricular materials, especially for teaching science in primary and the first years of secondary school. At the same time, new materials and tools based on "Inquiry principles" have been developed in order to support teachers' training processes in the Network. I will come back to the curricular materials later in my analysis.

IBSE NETWORK COMUNICATION

Important mechanisms of interaction in the network are the Network websites. On these those websites, practitioners can find learning sequences, ask scientists questions, share experiences, and also find different kinds of resources. The aim is to support teachers' and teacher educators' work at schools. The most well-developed is the website of La main à la pâte in France. Their technology was used to develop the Latin American IBSE website: IndagaLa.

The French project La main à la pâte, with the support of the French Academy of Science, has played an important role in the expansion of the Network over the last 10 years. This can be seen in the international component of the project, where many countries are connected in some way to the French project.

Picture Nº 6

IBSE projects around the world connected with France IBSE project
Project La main à la pâte, Website[27], France

[26] See http://www.indagala.org

[27] http://www.lamap.fr/international/countrypartnersmap

The picture represents the places in the world where IBSE projects are active. As shown in the map, there are two kinds of links between the French project and other country projects: bilateral (in blue) and multilateral cooperation (in red). It can be seen that the IBSE Network involves more than 50 projects around the world, in different continents.

The European IBSE project *Pollen* and now *Fibonacci* started with the support of the French project. As can be seen, it involves different projects in many European countries.

Picture Nº 7

IBSE projects involve in Fibonacci
Project Fibonacci, Website[28], Europe

As stated in the picture, the aim of the project is to spread information about IBSE and also to add a new component, mathematics. The new tendency is

[28] http://www.fibonacci-project.eu/

called IBSME. They want to transfer a methodology suitable for a larger dissemination in Europe. As they say, the project involves 3.000 teachers and 45.000 students. It will be finished in 2013. The map in the picture 7 shows that different places in the countries are involved in the project.

As well as in Europe, many IBSE projects emerged in Latin America. Some countries have several projects that are organized by different institutions. Some of the projects sharing the Internet space can be seen on the IndagaLa Website.

The text in the picture 8 explains that IndagaLa is a group of several countries. The organisation of Science Academies supports it. Every country has its own strategies but they share inquiry curricula and a space of collaboration for the creation of more curricular materials. Moreover, they support each other. As can be seen on the Latin American website, each project can be reached by following the links. For example, the Chilean project is supported by The Ministry of Education and The Chilean Academy of Science. The aim of the project is for the students to gain the capacity to explain by themselves the world that surrounds them, using the typical procedures of science. It is expected that this will give them tools for life, which can help them to learn by themselves. Some of the mechanisms by which they reach their aim are also explained on the website. For instance, use of curricular materials, involvement of Universities to coordinate and design strategies and teacher training programs, and use of pedagogical tools based on IBSE principles.

Picture Nº 8

IBSE projects from Latin America countries
Projects ECBI Latin America, Website IndagaLa[29], Latin America

[29] http://www.indagala.org/?Page_Id=80. IndagaLa close to you. The IndagaLa group that links different Latin-American countries was created by an initiative of IBSE programmes in Latin-America and France, supported by the Science Academies.

Every country has their strategies for training, accompaniment, follow-up, advice, and support to teachers in the different zones and regions. However, there are shared needs in relation to the inquiry protocols, cooperative work spaces for the creation of new materials, as well as spaces for scientific and pedagogical advisory.

The following map shows the network of programmes in Inquiry Based Science Education, IBSE, in Latin-America. Click on one region to get a brief description of its programme, centre or nucleus.

5 – Inquiry Based Science Education, Chile

Visit the Website of Inquiry Based Science Education, Chile

Advanced Search

IBSE NETWORK PRACTICE AND IBSE DISCOURSE

Up to now, I presented different dimensions of what I called IBSE Network. My aim was to set it up as an existing social activity involving persons with different

---

This project is a joint initiative with the Ministry of Education and the Chilean Academy of Science addressed to children in basic education.

Its objective is to generate in the students the ability to explain by themselves the world that surrounds them using procedures typical of science. This will allow them to use science as a tool for life and for learning by themselves.

The project provides support and advice to the participant schools in the implementation of the curriculum and the transformation of practices in the area of science, through learning modules, a model of transference to the classroom and the advice or training to the school and the community. The training that the teachers receive is provided by means of the modules or didactic units that include experimental material (box of material), and guidelines for students and teachers.

In 2007, 100 institutions participated in the IBSE project, distributed in the regions IV, V, VII, VIII, RM.

social roles (administrators, politicians, researchers from education and science, teachers, teachers educators, students); persons participating in activities and events among countries (construction of curricula, workshops, seminars, academic programs, constructing websites, activities in classrooms and schools, conferences); and persons organized in projects in several countries (Pollen and Fibonacci for Europe, La main à la pâte for France, Pequeños Científicos for Colombia, ECBI Peru for Peru).

Particular discursive practices structure the activities of the Network represented by the label of Inquiry Based Science Education. There are two kinds of activities: administrative support, activities that guarantee the expansion and maintenance of the Network, and activities that produce and maintain the discourse about how science is taught at school. Most of the activities in the Network aim at constructing situated meanings for IBSE.

ACTION 2: DOMINANT FRAMEWORKS IN THE IBSE NETWORK

The action I perform in this section had a goal, which aimed at characterizing the theoretical frameworks that guide the teaching and learning activities in the IBSE Network. This is important since it gives an account of the languages, which determine teaching activities in workshops, and which shape the curricular materials used by teachers and teacher educators. I used those ideas and the reasoning supporting frameworks to identify the link with the group of assumptions behind individualistic cultural sensibility and my own group of assumptions.

Some principles and methodology are followed in the IBSE Network in Latin America and Europe. I present some typical characteristics supporting teacher educators and teachers' curricular material. Despite the fact that IBSE is defined and practiced in different ways in each country, there are two dominant frameworks for IBSE within the Network: One is based on the principles established by La main à la pâte[30] and the other by principles and curricula developed by the National Science Resource Centre (NSCR)[31], a Smithsonian Institution in the USA. Although those are the largest tendencies, each project in the country adapts and takes principles and methodologies from both and takes other approaches into consideration as well.

[30] http://www.lamap.fr/

[31] http://www.nsrconline.org/

In what follows, I present text-pictures of Websites, curricula materials, and research texts of those two frameworks. My aim is to make evident the discursive tendencies and to show the mechanism by which that discourse arrives at teacher educators, teachers and students of the IBSE Network.

DISCURSIVE FRAME OF LA MAIN À LA PÂTE

The French IBSE framework is based on 10 general principles. They are divided into two groups: Those referring to teaching and learning science, and the others related to the support needed during the teaching and learning process by different communities. IBSE projects inspired by La main à la pâte use these principles as a starting point. I will focus on the first group.

Picture Nº 9

10 Principles set and used by *La main à la pâte*
Project *La main à la pâte,* Website[32], *France*

[32] http://lamap.inrp.fr/?Page_Id=59. Children observe an object or phenomenon in the real, tangible world and experiment with it.

In the course of their investigations, children use arguments and reasoning, pooling and discussing their ideas and results, constructing their knowledge, as purely manual activity is insufficient.

The activities the teacher proposes to pupils are organized in sequences within a teaching module. They are related to official programs and offer pupils a great deal of independence.

A minimum of two hours a week is devoted to the same theme over several weeks. Continuity of activities and pedagogical methods is ensured throughout the school program.

Each pupil keeps an experiment book, written and updated in his own words.

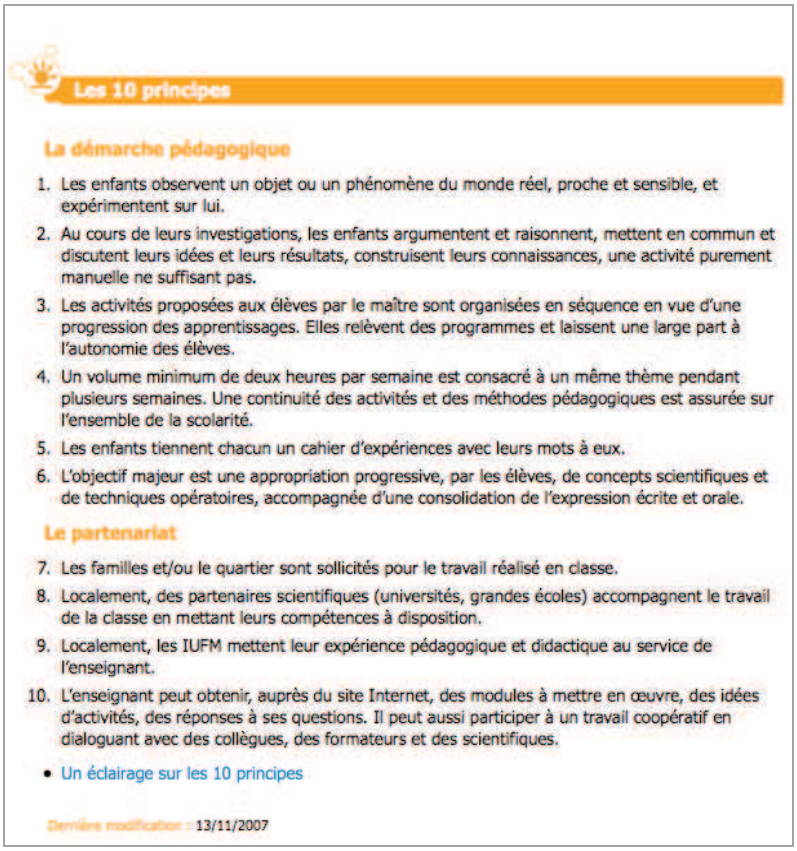
The main objective is a gradual appropriation by pupils of scientific concepts and techniques, along with consolidation of oral and written expression.

Families and/or the neighborhood take part in work done in class.

Locally, scientific partners (universities, engineering schools) support class work by making their skills available.

Locally, teachers' colleges make their pedagogical and didactic experience available to teachers.

Teachers can obtain the teaching modules, ideas for activities, and answers to various questions at the website www.lamap.fr. They can also take part in collaborative work by exchanging ideas with colleagues, trainers and scientists.



Les 10 principes

La démarche pédagogique

1. Les enfants observent un objet ou un phénomène du monde réel, proche et sensible, et expérimentent sur lui.
2. Au cours de leurs investigations, les enfants argumentent et raisonnent, mettent en commun et discutent leurs idées et leurs résultats, construisent leurs connaissances, une activité purement manuelle ne suffisant pas.
3. Les activités proposées aux élèves par le maître sont organisées en séquence en vue d'une progression des apprentissages. Elles relèvent des programmes et laissent une large part à l'autonomie des élèves.
4. Un volume minimum de deux heures par semaine est consacré à un même thème pendant plusieurs semaines. Une continuité des activités et des méthodes pédagogiques est assurée sur l'ensemble de la scolarité.
5. Les enfants tiennent chacun un cahier d'expériences avec leurs mots à eux.
6. L'objectif majeur est une appropriation progressive, par les élèves, de concepts scientifiques et de techniques opératoires, accompagnée d'une consolidation de l'expression écrite et orale.

Le partenariat

7. Les familles et/ou le quartier sont sollicités pour le travail réalisé en classe.
8. Localement, des partenaires scientifiques (universités, grandes écoles) accompagnent le travail de la classe en mettant leurs compétences à disposition.
9. Localement, les IUFM mettent leur expérience pédagogique et didactique au service de l'enseignant.
10. L'enseignant peut obtenir, auprès du site Internet, des modules à mettre en œuvre, des idées d'activités, des réponses à ses questions. Il peut aussi participer à un travail coopératif en dialoguant avec des collègues, des formateurs et des scientifiques.

- Un éclairage sur les 10 principes

Dernière modification : 13/11/2007

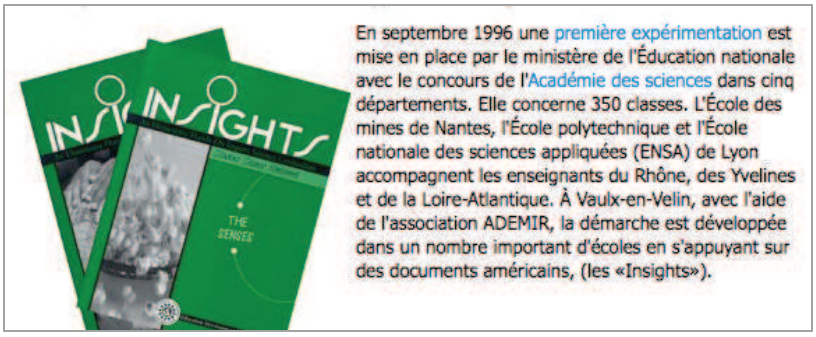
As a fundamental part of the IBSE teaching procedure, it is stated that children will observe an object or a phenomenon from the real world. The phenomenon or object is something near or close to them and can be perceived by their senses. In this sense, they can carry out an experiment on the object or phenomenon. During their investigation, children are expected to have opportunities to argue and reason. They emphasize the relevance of discussing and presenting their own ideas and results. Children need a framework to share and record with the group what is done during the experimentation. It is also expected that during this process they will construct their knowledge and the expectations are that during the learning sequences children will progressively appropriate scientific concepts and technical procedures, supported by the use of oral and written language. The notebook, that each learner uses to record his or her experiences, is essential.

The source that inspired the French project was the curricular material called *Insight Collection*, produced in the United States of America. As stated on

in *La main à la pâte* website, those materials were used at the beginning as a support. As the project evolved, teachers and practitioner started to produce their own materials.

Picture Nº 10

History of the project *La main à la pâte*
Project *La main à la pâte,* Website[33], *France*



On their website[1], teachers and educators share their learning and teaching sequences.

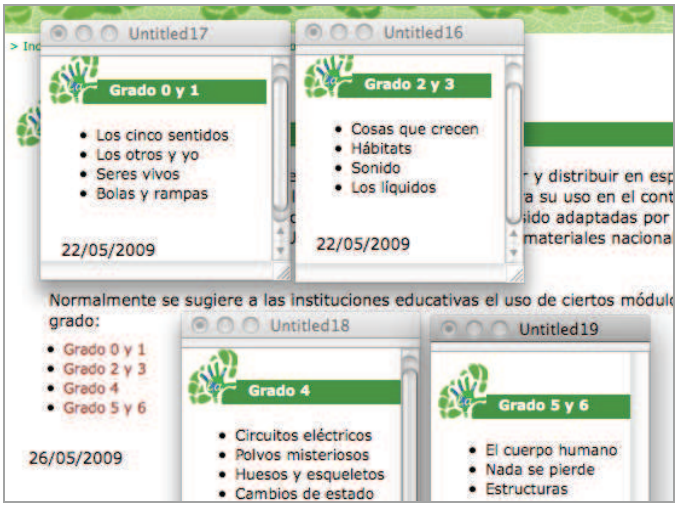
The Insight curricula are very important documents in the IBSE Network. Their pedagogical frame is used to learn and conduct inquiry teaching, and also to construct new learning sequences. Argentina, Brazil, and Colombia also started from this view. The booklets describing the curricula were translated into Spanish and then adapted to Portuguese.

Picture Nº 11

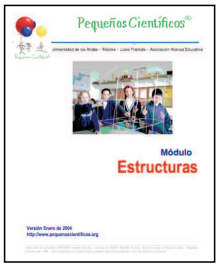
Curricula based on Insight material[34]
Project *Pequeños Científicos, Website* (IndagaLa)[35], Colombia

[33] http://lamap.inrp.fr/?Page_Id=53. On September 1996 a first experimentation is tried by the Ministry of National Education with the support of the Academy of Science in five departments. 350 classrooms were part of the experiment. The engineer school of Nantes, the engineer school Polythecnique and the national school of science applied science (ENSA) of Lyon, supported teachers of Rhône, des Yvelines et de la Loire-Atlantique. In Vaulx-en-Velin, with the help of the association ADEMIR, the method is developed within an important number of schools with the support of the American document (the “Insight”).

[34] The picture is a composition of several pictures I took from the website.



Picture 11 shows an example of the way Insight materials are used in *Pequeños Científicos*. As in other IBSE projects, those materials support teaching and learning activities carried out in primary and lower secondary school, in the schools involved in the project. For each grade and age group there is a teacher's book and a box with materials for each student, to support inquiry processes in the classroom. Each book explains a series of learning sequences designed to last 2 or 3 months. Different science topics are taught: How to observe the outside world (five senses, grade 0), What lives and how in the school garden (Habitats, grade 3), Why things around us are standing up (structures, grade 6), etc.



The picture shows the cover of one of the Insight curricular Materials translated into Spanish by the Colombian IBSE project. Inspired by these materials, teachers and educators started to produce their own learning sequences as can be seen on the Latin American website IndagaLa[36]. This booklet chose topic structures as the phenomenon to be studied by the children.

---

[35] http://www.indagala.org/?Page_Id=1190. Grade 0 and 1: The five senses, The others and me, Living things, Balls and ramps; Grade 2 and 3: Things that grow, Habitats, Sound, Liquids; Grade 4: Electrical circuits, Mysterious powders, Bones and skeletons, Changes of state; Grade 5 and 6: Human body, Nothing is lost, Structures.

[36] http://indagala.org. The module "Structures" is part of the curricula Insights of elementary science. This curricula of scientific studies, based on research and personal experience, was conceived with the aim of achieving two important objectives:

1. Offer the students exciting scientific experiences that increase their natural fascination with the external world. Help them acquire the scientific knowledge and

Picture Nº 12

Introduction of the Insight collection in each booklet
Project Pequeños Científicos, *Módulo Estructuras*, p. 8, Colombia

Los libros *INSIGHTS*

El módulo "Estructuras" forma parte del programa *Insights* de ciencia elemental. Este programa de estudios científicos, basado en la investigación y la experiencia personal, fue concebido con el fin de cumplir dos objetivos importantes:

1. Ofrecer a los alumnos experiencias científicas apasionantes que aumenten su fascinación natural con el mundo exterior. Ayudarles a adquirir los conocimientos y conceptos científicos que necesitarán durante sus futuros años escolares y en la vida cotidiana.
2. Proporcionar al profesor los consejos y documentación básicos necesarios para enseñar ciencias en el verdadero espíritu de la investigación y el descubrimiento científico.

Los módulos *Insights* tienen en cuenta el hecho de que cada niño llega al colegio con un importante bagaje de experiencias que determina su manera de comprender y aprehender el mundo exterior. En cada módulo, los niños utilizarán materiales nuevos e interesantes, con el fin de estudiar fenómenos y explorar un tema científico de manera profunda. Desarrollarán su reflexión y sus capacidades mediante la observación, el cuestionamiento, la experimentación, poniendo sus ideas a prueba y cometiendo errores, discutiendo, analizando e intercambiando ideas y descubrimientos con sus compañeros.

La ambición de *Insights* es hacer que usted y a sus alumnos se conviertan en verdaderos aprendices de científicos, y que su proceso sea divertido. Ante todo, la ciencia es un medio para hacernos compartir las maravillas del universo. ¡Disfrute su papel a lo largo de este proceso!

It is stated in the text, that the Insight books series support a program for science studies and that these are based on children doing research and that their personal experience is taken into account. In addition, an important purpose of the books is to provide students with scientific experiences that will stimulate their passion and fascination for the natural and made worlds. The expectation is to help them to acquire knowledge and scientific concepts that they will need in the future. At the same time, they must take into consideration that each child comes to school with an important set of experiences that influences the way they understand and learn about the outside world. Children are expected to study phenomena and explore particular scientific issues in depth. Children will develop their reflection and capacities through observation, questioning, testing

---

concepts that they will need during their future school years and in their everyday life.

2. Provide the teacher with the basic advice and documentation needed to teach science in the true spirit of research and scientific discovery.

The Insights modules consider the fact that every child arrives at the school with an important background of experiences that determines their way of understanding and grasp the external world. In each module, the children will use new and interesting materials with the aim of studying phenomena and explore a scientific topic in a deep manner. They will develop their reflection and abilities by means of observation, inquiry, and experimentation, testing their ideas and making mistakes, discussing, analyzing and interchanging ideas and discoveries with their mates.

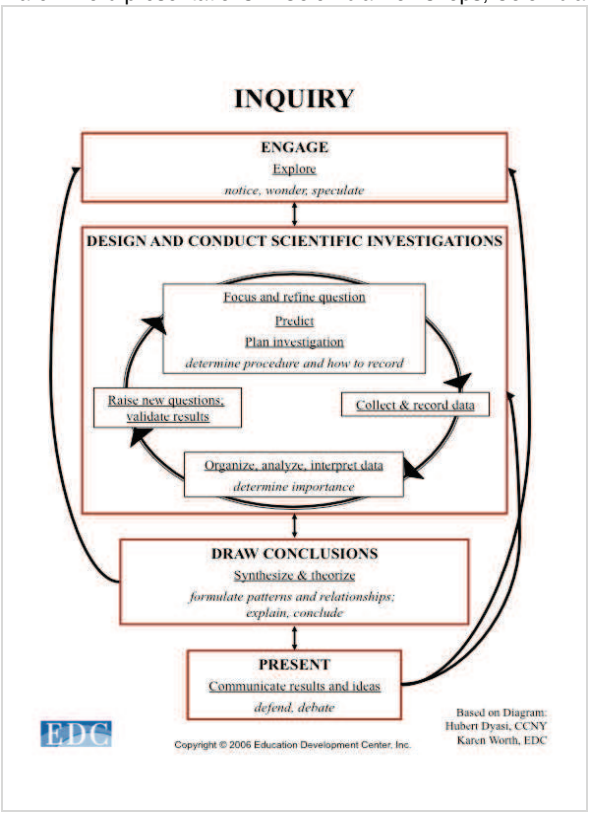
The ambition of Insights is to make you and your students become actual scientific learners, and this process to be fun. Above all, science is a medium to make us share the wonders of the universe. Enjoy your long-term role in this process!

their own ideas, making mistakes, discussing, analysing and exchanging their ideas and discoveries with their partners.

Behind the Insight teaching materials there is a framework that supports choices for every lesson and learning sequences. The following picture presents this framework. There are four phases, which guide children's learning experiences.

Picture Nº 13

Framework for Inquiry teaching and learning
Karen Word presentations in Colombia workshops, Colombia

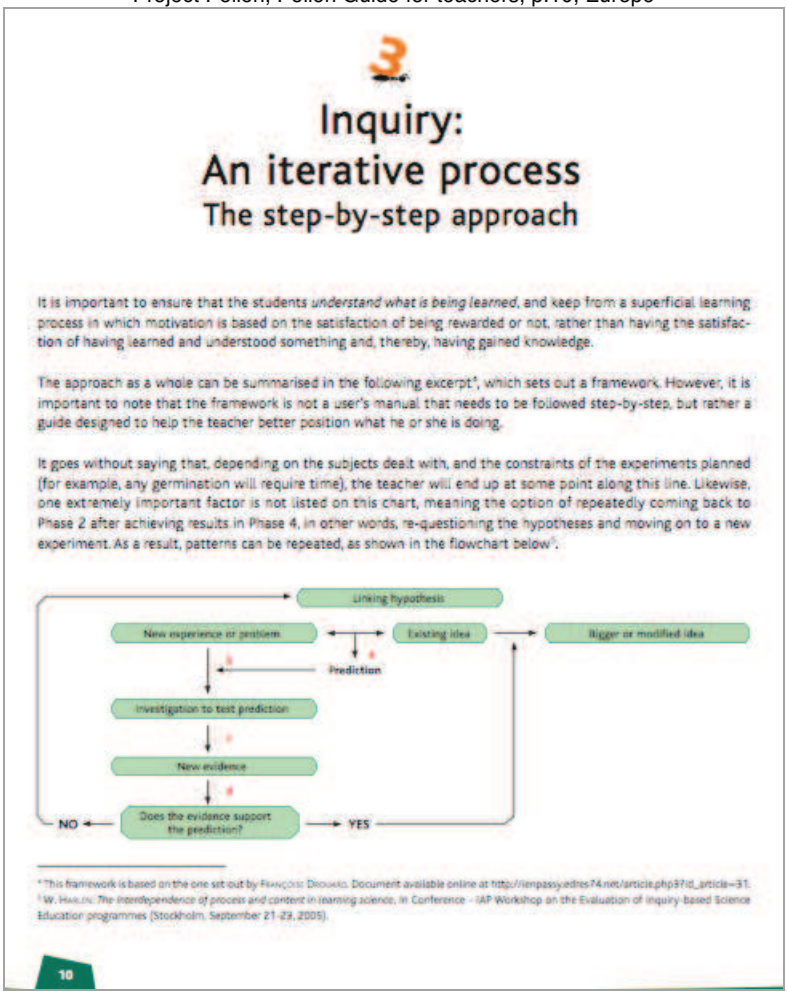


As a starting point, children need to be engaged in exploring, noticing, wondering and speculating in relation to something. Once they are engaged, children have to design and conduct scientific investigations, draw conclusions, theorize and synthesize. Finally each of them has to present their findings to the others in order to debate and defend their ideas. The arrows indicate the non-linear character of the diversity of activities carried out by children during the phases.

Another framework is presented in the *Pollen* project to support and justify IBSE work. Wynne Harlen, member of the Academy of Sciences Inter Academic Panel, is one of the researchers within the IBSE Network whose work has theorized teaching and learning. Her work has been influential in the way different participants in the IBSE Network —both teachers and researchers— view IBSE. The Pollen guide for teachers includes a flow chart that illustrates her 'Constructivist model of learning through inquiry' (Harlen, 2007).

Picture Nº 14

Harlen's framework for IBSE
Project Pollen, Pollen Guide for teachers, p.10, Europe



3

Inquiry:
An iterative process
The step-by-step approach

It is important to ensure that the students *understand what is being learned*, and keep from a superficial learning process in which motivation is based on the satisfaction of being rewarded or not, rather than having the satisfaction of having learned and understood something and, thereby, having gained knowledge.

The approach as a whole can be summarised in the following excerpt[1], which sets out a framework. However, it is important to note that the framework is not a user's manual that needs to be followed step-by-step, but rather a guide designed to help the teacher better position what he or she is doing.

It goes without saying that, depending on the subjects dealt with, and the constraints of the experiments planned (for example, any germination will require time), the teacher will end up at some point along this line. Likewise, one extremely important factor is not listed on this chart, meaning the option of repeatedly coming back to Phase 2 after achieving results in Phase 4, in other words, re-questioning the hypotheses and moving on to a new experiment. As a result, patterns can be repeated, as shown in the flowchart below[2].

[1] This framework is based on the one set out by François Dechamp. Document available online at http://lenpassyedres74.net/article.php3?id_article=31.
[2] W. Harlen, *The interdependence of process and content in learning science*, in Conference - IAP Workshop on the Evaluation of Inquiry-based Science Education programmes (Stockholm, September 21-23, 2005).

10

During the teaching situation, the learner is confronted with a 'new experience or problem' (e.g., objects floating or sinking in liquid). The learner makes explicit his/her 'existing idea' in a 'prediction' (e.g., what will happens to the objects in water and why?), and engages in an 'investigation to test the prediction' (e.g., place the objects in water, observe if the objects float or sink). The learner observes whether 'evidence supports the prediction or not' (e.g., a big object is on top of the water and a little one goes to the bottom, contrary to the student's expectation that the little will float on the top, because it is smaller and heavier than the big one). The learner, by confronting his/her ideas with the evidence, formulates a new hypothesis in case the evidence does not confirm what s/he thought, or reinforces his/her existing ideas.

In the text-pictures coming from La main à la pâte, some tendencies can be recognized in the IBSE Network discourse. Some important facts in teaching and learning situations are that children must observe an object or a phenomenon from the real world, that is near to them, and that it is possible for them to make experiments connected with the phenomenon. Children are also expected to share their own ideas, argue and reason based on their observations and experiments: their experience within the natural and made worlds is used in classrooms. Finally, the relevance of interactions between peers and teacher is recognized, sharing their own ideas, reasoning and arguing. Furthermore, the principles on the Website, the Insight curricula, and the frames (Insight and Pollen) are the tools that support teacher educators and teachers.

NSCR DISCURSIVE FRAME

The NSCR approach is based on 5 principles[37]. These involve different dimensions: Aspects concerning teaching and learning science, organization of curricula at school, professional development of teachers, support of the community, and evaluation. Each project adapted those principles and gave meaning to them. For instance, The European project

[37] The picture is taken from Carulla et al. (2008). The Colombian project Pequeños Científicos adapted their principles and used them in the evaluation system.

Pollen used the dimensions in their principles:

Picture Nº 15

Principles state by Pollen project
Project *Pollen,* Website[38], *Europe*

1 INQUIRY-BASED SCIENCE EDUCATION (IBSE)

IBSE is at the core of the pedagogical approach supported by Pollen. By combining global research, scientific learning, experimentation and evidence-based reasoning, language and debating skills, IBSE enables pupils to further their understanding of the objects and phenomena around them, as well as enhance their curiosity, creativity and critical skills.

- Experimental, evidence- and inquiry-based teaching and learning are powerful ways of understanding the very nature of science.
- IBSE takes time to implement. A clear teaching and long-term planning methodology is necessary.
- IBSE allows for a cross-disciplinary approach involving maths, languages and other subjects as part of the process. It also connects the school to its external environment by focusing on relevant issues.

2 TEACHER TRAINING

Research has clearly established that teacher training and tutoring are the main components required for a profound change in practices, especially to combat the reluctance related to science teaching that is common among primary teachers. By providing in-service training sessions and tutoring in the classroom, Pollen has contributed to enhancing IBSE teaching skills and has thus succeeded in achieving lasting changes in practices.

- Teacher training should include classroom simulations, during which teachers experiment directly with the inquiry-based approach.
- Steady, progressive and consistent training sessions are most effective when it comes to changing practices.
- Experienced teachers are effective trainers. Peer-to-peer best practice exchange is an effective method.

3 COMMUNITY INVOLVEMENT

Schools are part of a broader setting, in which interaction with other local stakeholders is also important in order to strengthen educational innovation. Pollen has fostered community participation, involving families, the scientific community, universities, public services, industries, and other entities on a local level to better incorporate science education policy within the city agenda, as well as to provide teachers and pupils with field experience and visits. In a POLLEN Seed City, a community board brings together representatives of the various actors involved in the local project.

- The involvement of the scientific community as a stakeholder and to support teachers is a key factor. Outreach activities involving science students provide effective support for teachers.
- Sustainability is obtained through multi-partner agreements, with clear support from major institutions. Public events have a catalyst effect when it comes to achieving consensus.
- Initiatives that are well integrated in local policies enable innovation and effective changes.

4 RESOURCES AND MATERIAL

Equipment is a key factor, although it does not necessarily have to be expensive or based on advanced technology. Pollen has made available for teachers sets of basic scientific material for the classroom, as well as ready-to-use protocols based on this material. Usually provided in the form of kits or boxes containing all the necessary elements for teachers and pupils to start with, it has helped to reduce the practical difficulties teachers are usually afraid of, as well as to structure practices around common frameworks underpinned in the teaching protocols.

- Quality resources and material, with ready-to-use experimental kits, should be easily available to teachers.
- Experienced teachers can be involved in the design of quality homemade resources and material.
- Resources and material have a structuring effect that contributes to the homogeneity, coherence and dissemination of IBSE.
- Coherence with local curricula and school projects must be sought. The social relevance of the learning content is important.

5 FOLLOW-UP AND EVALUATION

A formative assessment of how teachers react and perform in the classroom is essential to educational innovation. It shows the kind of specific difficulties they face when implementing innovation and whether and under which conditions they benefit from changing their teaching practices. An overall evaluation dealing with the global impact of the project is also necessary in order to justify changes based on concrete evidence to policy-makers and education authorities.

Both aspects were taken into account in the Pollen project: first, through close follow-up of teachers in the classroom, and then through a questionnaire filled in by teachers and pupils participating in the project, in order to measure how their attitudes towards science were affected by Pollen. The quality of community participation in each Seed City was also assessed in order to identify the most important factors involved in the successful commitment of local actors.

- Teacher training sessions must be followed up by visits to schools.
- Follow-up of how teachers respond and perform is required, but this should not be seen to be judgemental. A formative approach is needed, where by feedback from teachers is used to work towards improvement.
- Evaluation is necessary for quality-based scaling up.

[38] http://www.pollen-europa.net/?page=NmRQUQ87rUI%3D

The first *Pollen* principle is that IBSE is based on a combination of strategies: Global research, scientific learning, experimentation and evidence-based reasoning and use of language and debating skills. The purpose is to enable pupils to gain understanding of the objects and phenomena around them. At the same time, the idea is to enhance children's curiosity, creativity and critical skills. As they say, experimental, evidence-based and inquiry-based teaching is a powerful way of understanding the nature of science. The other principles focus on teacher training programs, community involvement in IBSE, the use of resources and materials to support science education practice, and follow up and evaluation.

As for principle number 4, it is relevant to have materials that support teaching and learning situations. This principle is shared by many IBSE projects.

Picture Nº 16

History of curriculum material
Project Hagamos Ciencias, Website[39], Panamá

A principios de los años ochenta del siglo XX, surgieron distintos grupos de trabajo que planteaban estrategias de enseñanza por indagación, ente otros el Centro de Recursos Científicos de Estados Unidos (NSCR por sus siglas en inglés), conformado por el Instituto Smithsonian y las Academias Nacionales, y que desarrolló una estrategia para llevar la indagación al salón de clases como forma innovadora de aprendizaje de la ciencia.

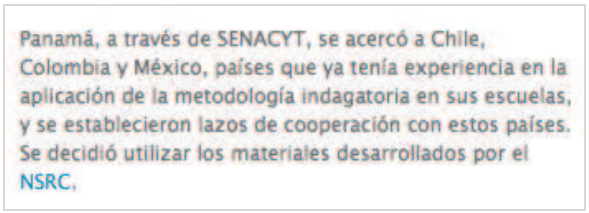
The NSCR developed a strategy to bring inquiry to classrooms as an innovative way to learn science. Many IBSE projects adopted, translated and adapted those materials —for instance Mexico, Chile, Peru, Panama and Venezuela[40].

Picture Nº 17

Use of curriculum material by IBSE Panama project
Project Hagamos Ciencias, Website[41], Panama

[39] http://www.senacyt.gob.pa/hagamosCiencia/aprender/ensenar/mas.php. At the beginning of the 80's in the 20th Century, different work groups that proposed inquiry based teaching strategies appeared, among these, the NSCR, comprised by the Smithsonian Institute and the National Academies, which developed a strategy to take inquiry into the classroom as an innovative way of learning science.

[40] I learned that during my work in each country.



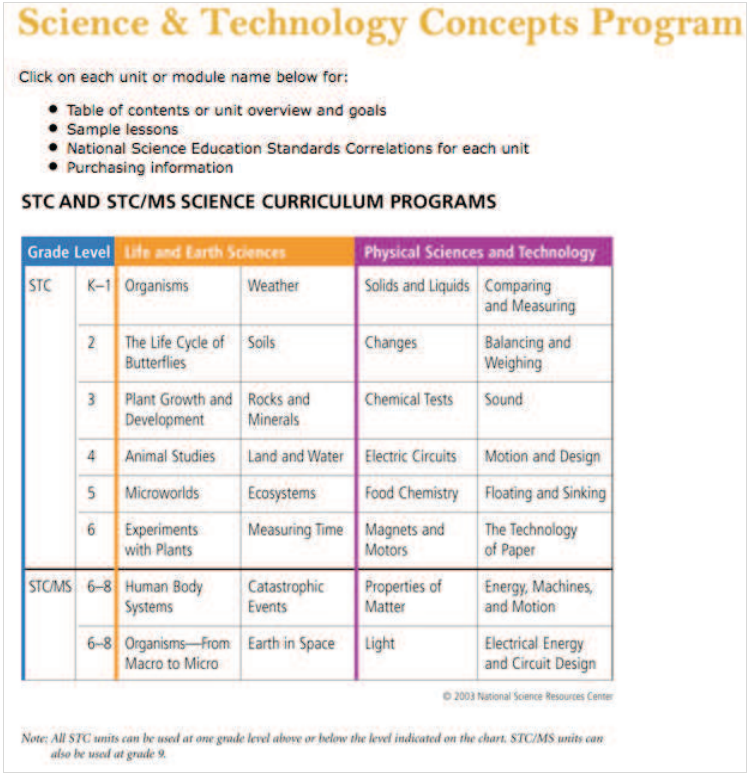
As has been explained, the Panama IBSE project is supported by more experienced colleagues from other Latin American IBSE projects. Even though different projects adopted different curricular materials to support teachers at schools, educators from these projects shared a common approach. For instance, the IBSE project in Panamá worked with the NSRC materials, as stated in the picture above, but used technical support from a Colombian project based on the Insight framework as well.

Picture Nº 18

STC Science Curriculum
NSRC, Website[42], USA

[41] http://www.senacyt.gob.pa/hagamosCiencia/aprender/panama/. Through SENACYT, Panamá became close to Chile, Colombia and Mexico, countries that already had experience in the application of an inquiry methodology in their schools, and so cooperation links were established among these countries. The decision was to use the materials developed by the NSRC.

[42] http://www.nsrconline.org/curriculum_resources/stc_program.html



Science & Technology Concepts Program

Click on each unit or module name below for:

- Table of contents or unit overview and goals
- Sample lessons
- National Science Education Standards Correlations for each unit
- Purchasing information

STC AND STC/MS SCIENCE CURRICULUM PROGRAMS

Grade Level		Life and Earth Sciences		Physical Sciences and Technology	
STC	K–1	Organisms	Weather	Solids and Liquids	Comparing and Measuring
	2	The Life Cycle of Butterflies	Soils	Changes	Balancing and Weighing
	3	Plant Growth and Development	Rocks and Minerals	Chemical Tests	Sound
	4	Animal Studies	Land and Water	Electric Circuits	Motion and Design
	5	Microworlds	Ecosystems	Food Chemistry	Floating and Sinking
	6	Experiments with Plants	Measuring Time	Magnets and Motors	The Technology of Paper
STC/MS	6–8	Human Body Systems	Catastrophic Events	Properties of Matter	Energy, Machines, and Motion
	6–8	Organisms—From Macro to Micro	Earth in Space	Light	Electrical Energy and Circuit Design

Note: All STC units can be used at one grade level above or below the level indicated on the chart. STC/MS units can also be used at grade 9.

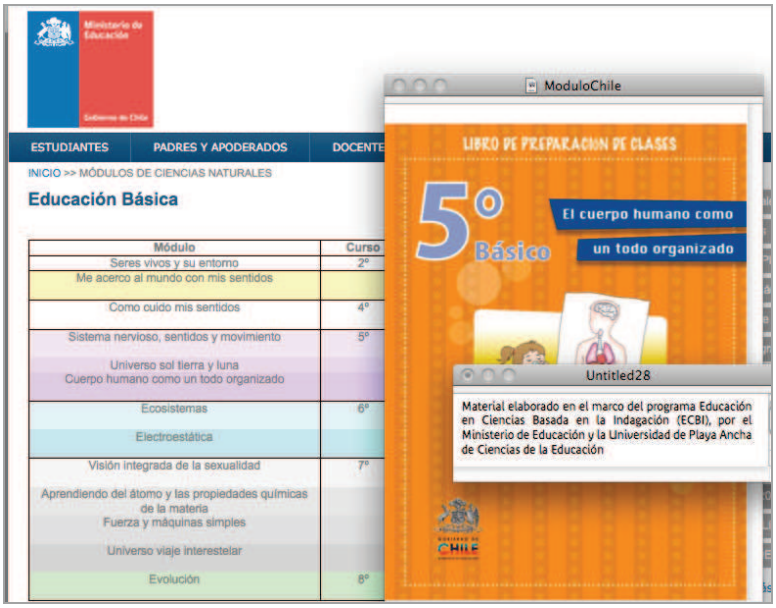
The Science and Technology Concept Program (STC) can be found on the NSRC website. Each national project uses some of their corresponding materials to implement IBSE in schools. The STC project produced a set of booklets with the corresponding hands on materials for each science subject, according to the American Science Standards. The IAP also participated with their views on how to consolidate the international network. Harlen has an important role in this since she produces materials, conducts workshops and gives presentations that clarify the IBSE principles.

For instance, the Chile IBSE project combined materials from the STC with some local curricula development in its national curricula. The material developed by Chilean educators is based on the STC principles and teaching and learning assumptions.

Picture Nº 19

Chilean science curricular materials

Project ECBI Chile, website Ministry of Education Chile[43], Chile



Diversity of teaching and learning materials for different science topics are developed based on the IBSE teaching and learning principles. The STC modules are used as inspiration for those prepared by people working for the project. In this way, the STC framework for IBSE is used and spread through the practices of the Network.

Picture Nº 20

Booklet description
Project ECBI Chile, Booklet Human Body[44], p.3, Chile

---

43 http://www.mineduc.cl/index2.php?id_portal=17&id_seccion=3211&id_contenido=12939. Material prepared within the framework of the programme Inquiry Based Science Education (IBSE), by the Ministry of Education and the Science Education Playa Ancha University.

44 The module has been structured in learning sequences, which enable a progressive advance in the depth in which the knowledge related to the human body are acquired, and at the same time, the development of scientific abilities and attitudes that favor inquiry is fostered, such as searching for knowledge, recording evidence, contrasting hypotheses, predictions, among others.

El módulo se ha estructurado en secuencias de aprendizajes, las cuales permiten avanzar progresivamente en la profundidad con que se adquieren los conocimientos relativos al cuerpo humano, y al mismo tiempo, se potencia el desarrollo de habilidades y actitudes científicas que favorecen la indagación, como pueden ser la búsqueda del conocimiento, registro de evidencia, contrastación de hipótesis, predicciones, por nombrar algunas.

Cada secuencia está dividida en "lecciones" que representan las situaciones de aprendizajes que deben desarrollar los(as) estudiantes, en las cuales se propone una variedad de experiencias orientadas a promover el aprender a aprender, estimulando de esta manera la curiosidad, formulación de preguntas, observación, experimentación, obtención y análisis de datos, entre otros. Estas actividades permitirán a los estudiantes hacer una reflexión personal y grupal basada en evidencia para sistematizar sus aprendizajes e integración conceptual a través de la orientación y mediación docente.

El módulo se presenta en dos versiones: Libro de Preparación de Clases dirigido a el(la) profesor(a)

In this picture it is stated that learning sequences allow a progressive advance towards an in depth acquisition of knowledge about the human body. At the same time, it is expected that skills and attitudes towards science will be developed. It is expected that these skills will be used for inquiry, viewed as looking for knowledge, registering of evidences, contrasting hypothesis, predicting etc. Each lesson proposes a variety of experiences oriented towards learning to learn. In this way, it is expected that children will be curious, inquirers, observers, experimenters, data collectors and analysts. It is also said that students will make personal and group evidence-based reflections that allow them to systematize their learning. Furthermore, it is assumed that children will make a conceptual integration helped by the teachers' mediation.

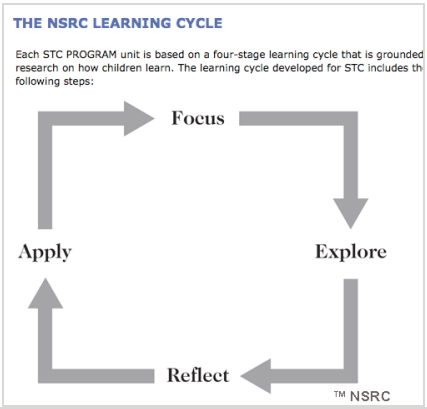
The NSRC approach uses a framework called *learning cycle*, involving four steps: Focusing, exploring, reflecting and applying. Their curricular materials provide activities that will give teachers and students opportunities to experience each stage.

Picture Nº 21

NSRC Learning cycle
NSRC, website[45], USA

Each sequence is divided into "lessons" that represent the situations of knowledge that must be developed by the students, in which a variety of experiences is proposed aimed at promoting the learning to learn, thus stimulating curiosity, asking questions, observation, experimentation, data collection and analysis, among others. These activities will allow the students to carry out a personal and group reflection based on evidence to systematize their learning and conceptual integration through the teacher's guidance and mediation.

[45] http://www.nsrconline.org/curriculum_resources/learning_cycle.html



™ NSRC

- **Focus**

Students and teachers focus on what students already know about a topic and develop new goals for learning through brainstorming and discussion

- **Explore**

Students engage in hands-on exploration that builds upon their previous knowledge

- **Reflect**

Students analyze their observations and data, review their original ideas related to the phenomena investigated, and provide evidence for their explanations of what they have observed

- **Apply**

Students apply their recently developed understanding of science concepts to new situations.

In this approach students and teacher focus their attention on what is known by children in relation to a topic and develop new goals for future lessons. Brainstorming and discussions are suggested as the way to stimulate the students' ideas. After that, students are engaged in hands-on explorations. These explorations are expected to help children to build upon their previous knowledge. Materials that allow students to carry out the explorations are provided for each one of them. Then, it is assumed that students will reflect on what they did. They analyze their observations and data, review their original ideas about the investigated phenomenon, and provide evidence for their explorations of what they have observed. The last learning cycle stage is the application of what students learned. Students apply their developed understanding of scientific concepts to new situations. Another context provides opportunities for students to use the same kind of knowledge.

There are similarities between the NSCR and the La main à la pâte frameworks. Although with slightly different formulations, both frameworks

expect children to do hands-on activities using their previous knowledge of a phenomenon, and explore it. Children experiment with materials and observe what happens. They base their observation on their own ideas, explain them, share their ideas and review them in the light of the evidence; children apply their knowledge. They interact with their peers and with the teacher.

I have shown the mechanisms by which teacher educators and teachers involved in the different activities in the Network construct meaning to teaching and learning through inquiry. The most important are the configuration and sharing of principles, the use of pedagogical frameworks and the configuration of primary curriculum based on curricular materials for each science area.

THE DISCOURSE OF ASSESSMENT FOR LEARNING RESEARCH

In order to describe and characterize assessment for learning in the IBSE Network, I analyzed text-pictures taken during my "visit" to research texts on formative assessment. The text-pictures come from different kinds of documents used or referred to in several places of the IBSE Network: Research articles and workshop documents. By doing this, I will present some ideas that appear in assessment research in the IBSE Network. At the same time, this will give me the opportunity to focus on those aspects that are connected to particular theories of learning.

Formative assessment is present in the IBSE Network in different ways. One way is through formative assessment strategies included in inquiry teaching and learning sequences. Teachers who use these pre-designed materials (e.g., Insight collection) may use these strategies. Some general strategies have also been proposed as ways to implement formative assessment in the classroom. It is the case of the use of students' notebooks. What students write in their notebooks can be used for formative assessment purposes. The French and Mexican projects developed tools for that[46]. There is also work done at Ministerial levels to reaffirm the principles of formative assessment and to provide tools to develop it in the classroom. This is found in, for example, an Assessment for Learning Booklet from the Chilean Ministry of Education website[47] (Unidad-Curriculo-y-Evaluación-MEN, 2006).

In addition, research on formative assessment has been presented. The Panama project *Hagamos Ciencia* developed a course on assessment for learning for inquiry facilitators (people that go to schools in order to train and support

[46] I know this because I participated in some workshops where a member of the French project presented the tools and I received information directly from a member of the Mexican project.

[47] www.mineduc.cl

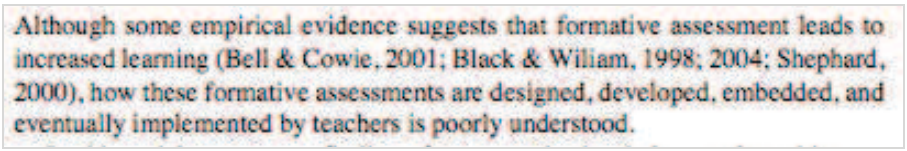
teachers in the process of teaching science through inquiry). María Ruiz-Primo ran this course for the first time in 2006. I had the opportunity of attending the course and then to run it myself three times. I also used these ideas to develop some workshops on assessment for the Latin American network. All the ideas presented were supported by the research of a group of researchers from different Universities in the USA (Shavelson, et al., 2008). I also had access to another line of research in a set of workshop designed by Wynne Harlen for the Institute of Inquiry (http://www.exploratorium.edu/ifi/) at the Exploratorium Museum in Washington. These workshops were based on her research in collaboration with a group of English researchers. This workshop was used in the Pollen network.

My aim here is to present some ideas behind assessment for learning research or formative assessment applied to Inquiry-teaching. In contrast to my previous analysis of the IBSE discourse where I used documents connected to the practice in the Network, here I use research documents associated with two lines of research in this area: The North American tradition represented by authors such as Richard Shavelson and Miki Tomita from Standford University, María Araceli Ruiz-Primo from the University of Colorado, Erin Furtak from Max Planck Institute for Human Development, Donald Young, Paul Brandon and Yui Yin from University of Hawaii and, Carlos Ayala from California State University. The other line is the British line represented by Wynne Harlen from the University of Bristol. I will include text-pictures that give a sense of learning theories that support assessment. My purpose is not to show text-pictures that describe the research processes and the results. Rather, I show them to highlight the elements supported by assumptions about learning, knowledge and thinking.

Both lines of research are based on the hypothesis that assessment for learning or formative assessment is a teaching praxis that supports students' learning. Black and Wiliam's (1998a) literature review provides empirical evidence that supports this hypothesis. In their review they also provide information about the characteristics that constitute formative assessment in order to support the learning process of students: Assessment whose purpose is to help students to learn. Black and Wiliam's (1998b) contended that students whose teachers systematically applied formative assessment techniques performed better than those who were not exposed to this kind of approach. Moreover, the study showed evidence to demonstrate that this kind of assessment is of benefit for students with lower achievements. It is said that Black and William's review on assessment for learning was conclusive about the need to embrace assessment for learning as part of educational reforms.

Picture Nº 22

Need for further investigation in assessment for learning
Research article, Shavelson, et al. (2008), p. 316, USA


Although some empirical evidence suggests that formative assessment leads to increased learning (Bell & Cowie, 2001; Black & Wiliam, 1998; 2004; Shephard, 2000), how these formative assessments are designed, developed, embedded, and eventually implemented by teachers is poorly understood.

The USA line of research uses knowledge emerged from this review. In picture 22 a need for research on formative assessment is indicated. The empirical evidence provided by Black and William, among others, is accepted. It is recognized that formative assessment leads to increased learning. However, it is also said that it is necessary to find how this type of assessment became effective during teaching. There is a need for research that explains the way teachers use and develop these kinds of teaching techniques. The aim of this line of research is to understand the diversity of elements involved in assessment praxis: to design it, develop it, embed it and implement it. The knowledge produced by the group is connected to the research process developed between designers, researchers and teachers to embed assessment in FAST[48] Inquiry Based curricula. Some of their results were used in Panama and Colombia to train teachers on formative assessment.

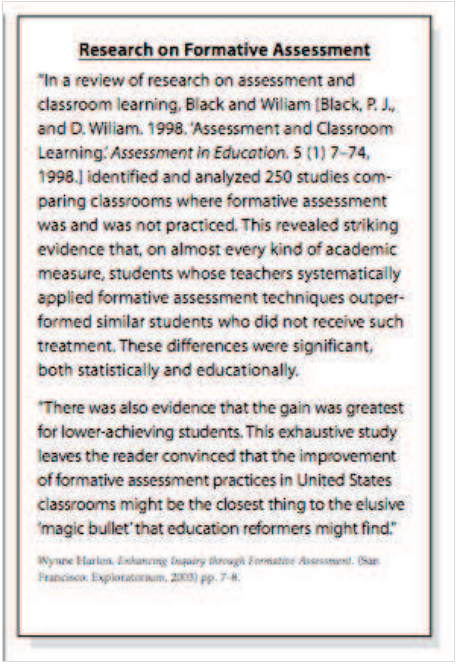
The British research line also used the review by Black and Wiliam (1998a) on formative assessment to characterize and develop assessment for learning in IBSE contexts.

Picture Nº 23

Formative assessment based on Black and Wiliam's review (1998a)
Workshop I, Harlen (2006a), p.12, Pollen and Inquiry institute Website[49], Europe and USA

[48] Curricula material similar to Insight and STC: Booklets containing learning sequences, activities and materials.

[49] http://www.exploratorium.edu/ifi/



Research on Formative Assessment

"In a review of research on assessment and classroom learning, Black and Wiliam [Black, P. J., and D. Wiliam. 1998. 'Assessment and Classroom Learning.' *Assessment in Education*. 5 (1) 7–74, 1998.] identified and analyzed 250 studies comparing classrooms where formative assessment was and was not practiced. This revealed striking evidence that, on almost every kind of academic measure, students whose teachers systematically applied formative assessment techniques outperformed similar students who did not receive such treatment. These differences were significant, both statistically and educationally.

"There was also evidence that the gain was greatest for lower-achieving students. This exhaustive study leaves the reader convinced that the improvement of formative assessment practices in United States classrooms might be the closest thing to the elusive 'magic bullet' that education reformers might find."

Wynne Harlen, *Enhancing Inquiry through Formative Assessment*. (San Francisco: Exploratorium, 2003) pp. 7–8.

One of the most important aspects of the assessment research is to find ways to identify each student's learning process. The aim is to help each student to achieve the learning goals. Mechanisms are developed to: formulate learning goals connected to inquiry; get information from each student and be able to say something about the learning goals; transform information into learning evidence and to interpret it in terms of what it is expected; and finally to produce a judgment. This is to establish the gap between what is expected and what the students are learning. It is also expected that students will learn to see this gap and know what they need to do in order to reach the learning goal.

Picture Nº 24

Formative assessment as gathering information, interpreting it and using it
Workshop I, Harlen (2006a), p.11, Pollen and Inquiry institute Website[50], Europe and USA

[50] http://www.exploratorium.edu/ifi/

deciding their next steps. All these aspects of teaching—gathering information about students' learning, interpreting it in terms of their progress, using it to decide next steps, feeding back to students how to move forward, and helping students understand the goals of their work and assess their own progress—are encompassed in the concept of formative assessment, and form the basis for the ASSESSING FOR LEARNING curriculum.

The concept of formative assessment is linked to certain aspects of teaching. One of these is to gather information about students' learning. Another is to interpret it in terms of the students' progress. It is expected that the interpretation will support teaching decisions for the following steps in learning. The feedback that students need to move forward is also mentioned. Feedback will help the students to understand the goals in their work and they will be able to assess their own progress. These ideas are represented and summarized in the following diagram.

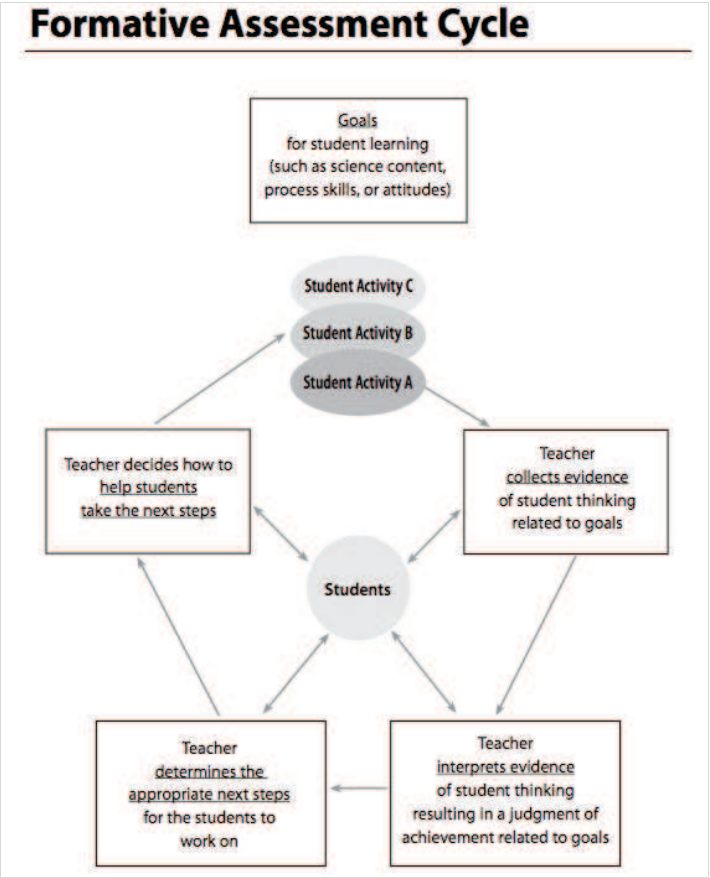
The *formative assessment cycle* (see picture 25 below) shows the assessment activities that are part of inquiry teaching. The aim is to establish the gap between the learning goal expected by the teacher and what the students are actually learning. This can be accomplished by analysing the answers students give to questions asked by the teacher and/or by observing their performance in class activities. The evidence collected by the teacher will allow the teacher to change the teaching activities in order to reduce the gap. In this sense, once the teacher selects the educational goals, the assessment activity consists in planning class activities that allow the teacher to collect evidence of learning and make judgments based on that evidence. Thus, it will be possible to establish the gap between the students' performance and the learning goals. This new information will then be used to plan new teaching activities that can support the students' learning process. During IBSE classroom activities, the teacher is expected to collect the evidence of the learning process in informal and formal ways[51], and use the ideas that students bring to the classroom.

Picture Nº 25

Assess progress at every step of the student's investigation

[51] Ruiz-Primo and Furtak (2006)

Workshop I, Harlen (2006a), p.13, Website Pollen and Inquiry institute[52], Europe and USA



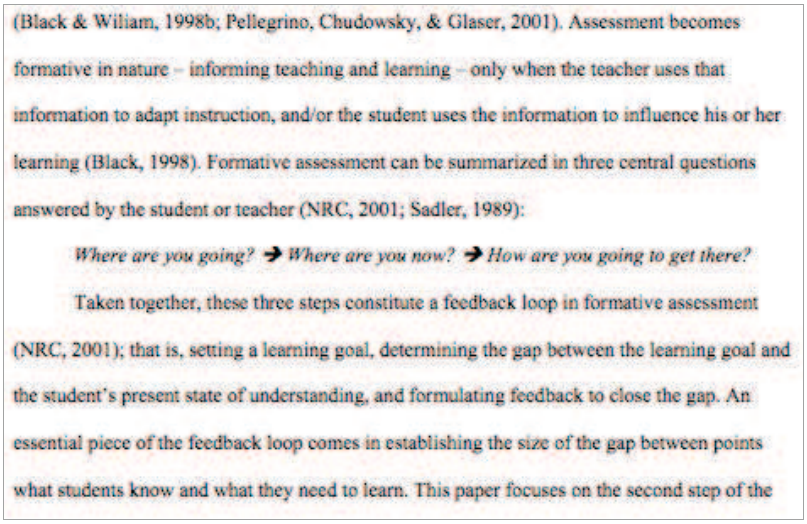
The goals are expressed in terms of individual student's learning. In the above diagram, the goal box is on top of all the other assessment activities. Once the students are involved in activities (A, B or C), the teacher must collect evidence of every student's thinking. The teacher will interpret that evidence in order to produce a judgment of achievement related to the formulated goals. The teacher uses their findings to determine the appropriate steps to follow for the students to work on. Hence, the teacher will plan the students' future activities based on these findings. This is a cycle that should continue permanently.

[52] http://www.exploratorium.edu/ifi/

The USA line of research also said that the assessment activity is aimed at determining whether every student is reaching the intended learning goal and at doing something that will change the student's learning process if such goals are not reached.

Picture Nº 26

The logic of assessment for learning discourse
Research article, Furtak and Ruiz-Primo (2007), p.2, USA



(Black & Wiliam, 1998b; Pellegrino, Chudowsky, & Glaser, 2001). Assessment becomes formative in nature – informing teaching and learning – only when the teacher uses that information to adapt instruction, and/or the student uses the information to influence his or her learning (Black, 1998). Formative assessment can be summarized in three central questions answered by the student or teacher (NRC, 2001; Sadler, 1989):

Where are you going? ➔ *Where are you now?* ➔ *How are you going to get there?*

Taken together, these three steps constitute a feedback loop in formative assessment (NRC, 2001); that is, setting a learning goal, determining the gap between the learning goal and the student's present state of understanding, and formulating feedback to close the gap. An essential piece of the feedback loop comes in establishing the size of the gap between points what students know and what they need to learn. This paper focuses on the second step of the

It is said that the nature of formative assessment is determined by the use of information: Teachers adapting their teaching according to that information, and each student using the information to influence his or her learning. Formative assessment can be summarized as teachers or students answering some fundamental questions: Where are you going? Where are you now? How are you going to get there? It is said that those questions constitute steps: setting a learning goal, determining the gap between the learning goal and the student's present state of understanding, and formulating feedback to close the gap. Then, it is relevant to establish the gap between what students know and what they need to learn.

Picture Nº 27

Formative assessment logic
Research article, Yin, et al. (2008), p.336, USA

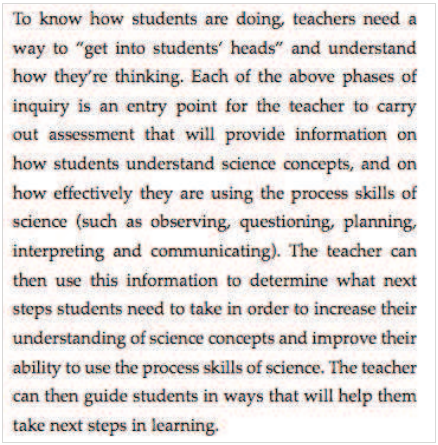
> The logic of formative assessment—identifying learning goals, assessing where students are with respect to those goals, and using effective teaching strategies to close the gap—is compelling and has led to the expectation that formative assessment would improve students' learning and achievement (Ramaprasad, 1983; Sadler, 1989). This hypothesis has received substantial empirical support (Black & Wiliam, 1998a; Black & Wiliam, 1998b). However, the empirical evidence comes mainly from either laboratory studies or anecdotal records (e.g., Black & Wiliam, 1998a). As Black and Wiliam (1998a) pointed out, studies conducted in laboratory contexts may suffer "ecological validity" problems and encounter reality obstacles when applied in classrooms. The effects of formative assessment have rarely been examined experimentally in regular education settings.

It is stated that formative assessment will improve students' learning and achievement. Formative assessment is considered a pattern that follows a line of identification of learning goals, assesses where the students are with respect to these goals, and uses effective teaching strategies to close the gap. The USA research line did a study to see, what kind of obstacles can be found in normal educational settings.

Assessment research has developed tools to get information and to somehow monitor the internal learning process of each individual. It is fundamental for assessment to have access to the internal cognitive process of individuals. Learning is connected to students' performance and achievement. Assessment techniques are designed in order to gain access to students' knowledge.

Picture Nº 28
Assess progress at every step of student's investigation
Workshop I, Harlen (2006a), p.10, Website Pollen and Inquiry institute[53], Europe and USA

[53] http://www.exploratorium.edu/ifi/



To know how students are doing, teachers need a way to "get into students' heads" and understand how they're thinking. Each of the above phases of inquiry is an entry point for the teacher to carry out assessment that will provide information on how students understand science concepts, and on how effectively they are using the process skills of science (such as observing, questioning, planning, interpreting and communicating). The teacher can then use this information to determine what next steps students need to take in order to increase their understanding of science concepts and improve their ability to use the process skills of science. The teacher can then guide students in ways that will help them take next steps in learning.

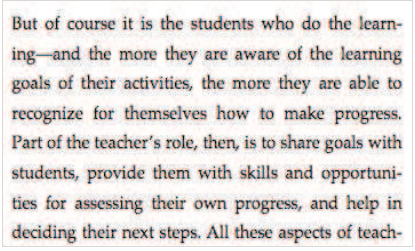
Assessment is viewed as a way to provide information to the teacher about how students understand scientific concepts and how they are using their skills in each phase of the inquiry process. This information is considered crucial to determine the way the teacher plans learning. The aim is to increase the students' understanding of scientific concepts and to improve their ability to use science process skills. This process is expected to allow the teacher to guide the students, helping them to follow new steps in their learning process.

Although assessment is presented as a teaching strategy for the teacher, students' participation in the process is relevant too. Students need to develop a capacity to assess their own learning process.

Picture Nº 29

Assess progress at every step of student investigation

Workshop I, Harlen 2006, p.11, Website Pollen and Inquiry institute[54], Europe and USA



But of course it is the students who do the learning—and the more they are aware of the learning goals of their activities, the more they are able to recognize for themselves how to make progress. Part of the teacher's role, then, is to share goals with students, provide them with skills and opportunities for assessing their own progress, and help in deciding their next steps. All these aspects of teach-

[54] http://www.exploratorium.edu/ifi/

It is said that students also have an important role in the assessment process. They need to be aware of the learning goals involved in the activities. If they recognize them, they will know how to make progress. It is expected that students will know the goals set for different activities, and will have the necessary skills and opportunities to assess their own progress.

ACTION 3: IDEAS AND REASONING

After visiting the activities and frameworks, four ideas and reasoning emerge from the analysis. The analysis aimed at seeing how those ideas and reasoning are presented, and how they constitute a dominant discourse about what assessment for learning in IBSE is. This analysis prepared me to look at the group of assumptions supporting these ideas and reasoning.

The discursive elements present in assessment for learning research within the IBSE Network are based on some of the principles of the IBSE Network discourse such as that children must face a phenomenon, use evidence to support their own ideas, carry out experiments, share observations, and reason about the natural and made worlds. Furthermore, the discourse is based on Black and Wiliam (1998b) review focusing on the learning goals on the child's performances, inquiry skills and scientific concepts; mechanisms and ways to find individual learning evidences; establishing a gap between the expected goals and what is observed; helping a child to know about the natural and made worlds based on their ideas and to recognize what he/she is learning; and making children participants in their own assessment process as well as involve in the assessment other children's views.

From La main á la pâte, NSCR and assessment for learning IBSE discourses, four ideas and reasoning that repetitively appear can be highlighted:

- children will learn in contact with materials, and observing phenomena during the teaching and learning situations;
- children must express and use their experiences, their ideas about the phenomena, and knowledge;
- children learn by contrasting their ideas and theories with what they observe by doing experiments;
- children must learn by sharing, listening, debating and arguing about their ideas which come from their experiences and experimentations.

I expected that behind those ideas about children's learning processes there was a view about learning, thinking and knowledge that supports assessment for learning discourse. For each idea and reasoning, in the following paragraphs, I present text-pictures that illustrate these ideas and reasoning that could be

supported by assumptions. As explained before, I took pictures from different sources. In that sense, for the same idea I presented several texts-pictures and paraphrased their content, which was relevant for communicate the idea. This choice ended in a text that seems as a repetition. The purpose is to communicate the repetition of the idea across different sources

1. THE CHILD AND PHENOMENA

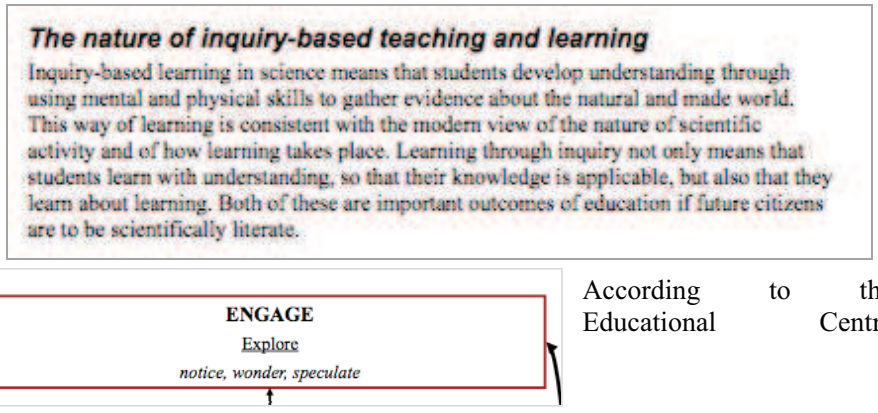
IBSE and IBSE assessment research discourses share the idea that children will learn in contact with the natural and the made worlds, and with phenomena. There is constant reference to the idea that a fundamental part of a learning process is to give children the opportunity to explore a phenomenon from either the natural or the made world. It is expected that phenomena or objects to study are in the children's vicinity and can be perceived by their senses.

A central aspect of the nature of inquiry-based teaching and learning is that children must gather evidence about natural and made worlds, and also that they learn how to explore and learn about the world.

The next text-picture presents one meaning of learning through inquiry as students developing understanding by using mental and physical skills. Using these skills to gather evidence about the natural and made worlds is crucial for learning. It is said that understanding means that knowledge is applicable. Through inquiry, children also learn about learning.

Picture Nº 30

The nature of inquiry-based teaching and learning
IAP, Harlen (2004) inquiry learning[55], Europe



According to the Educational Centre

[55] http://www7.nationalacademies.org/BOSE/WHarlen_Inquiry_Mtg_Paper.pdf

framework[56], the first step in inquiry teaching is to engage children in activities that allow them to "explore, notice, wonder and speculate" about a particular science subject. Normally, children are involved in an activity, which focuses on some facts and events that surprise them. For instance, the teacher presents some fruit to the children and asks them to predict if they will float or sink in the water. The children are surprised when some of their predictions are not correct as the fruit is put in a recipient full of water. The idea is that they will start noticing something that they had not noticed before. They will be wondering about something and they will begin to speculate about it. After that, a central idea is to give children the opportunity to develop meaningful, researchable questions, based on an exploration of that particular situation[57].

This first step of the framework is shared by the NSRC approach. "Students and teachers focus on what students already know about a topic and develop new goals for learning through brainstorming and discussion" (NSRC website). An interpretation of this is found in an example of new curricula based on the same framework in the ECBI Chile project. The starting point is to let children express their ideas about a particular context of their reality. It helps to bring children's ideas into a classroom. One suggestion is that the teacher can introduce questions to challenge the students' thinking.

Picture Nº 31

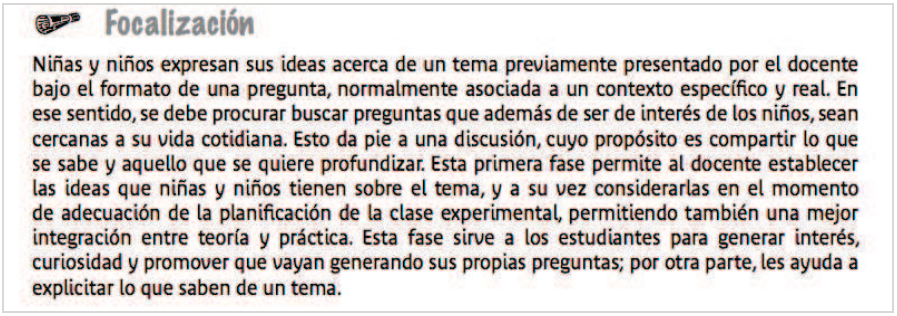
Starting point for NSRC framework: Focus
Project ECBI Chile, Men Chile, Módulo cuerpo humano[58], p.10. Chile

[56] The picture is taken from the top of the Educational Center framework that I presented above.

[57] The example is taken from one teaching sequence of the Insight material (Liquids).

[58] www.mineduc.cl. Focusing

Girls and boys express their ideas about a topic previously introduced by the teacher in the form of a question, normally associated with a specific and real context. In this sense, it is important to try and find questions that as well as being interesting for the children, are close to their everyday lives. This encourages a discussion whose purpose is to share what they know and what needs to be deepened. This first phase enables the teacher to establish the ideas that girls and boys have about the topic, and at the same time consider these ideas at the moment of adapting the planning of the experimental class, also allowing fora better integration between theory and practice. This phase is useful for the students to generate interest, curiosity and promote the formulation of their own questions; it also helps them to make explicit what they know about a subject.



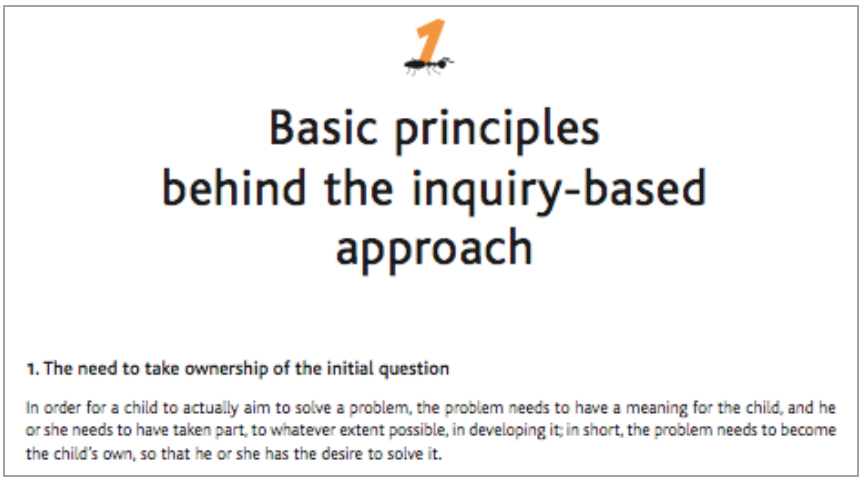
As has been stated, the teacher brings to the classroom a question related to a particular topic and normally associated with a specific real context. It is important that questions that can be easily associated with children's every day life are used. Girls and boys express their ideas about the topic and in relation to the question. This allows for a discussion aiming at sharing what students know. This strategy is considered a means for the teacher to hear the students; ideas about the topic, and to use that information to incorporate changes to a planned teaching sequence in the experimental part. The expectation is that this will allow for an integration of theory and practice.

This crucial point for inquiry-based teaching and learning is expressed as a "Principle" in a Pollen methodological guide for teachers. The principle is expressed as "the need to take ownership of the initial question".

The next picture shows that if a child must solve a problem, it is important that he or she gives meaning to the problem. The problem needs to become the child's own so that they will want to solve it.

Picture Nº 32

The starting point in Pollen guide for teachers: ownership
Project Pollen, Saltiel (2006), p.5, Europe



In IBSE research discourse, children's learning processes will happen through the interaction between the child, the natural and made worlds and the phenomena. This is expressed in IBSE discourse as the need to be engaged, which referred to the need for ownership, to use his/her curiosity to question the natural and made worlds, at the beginning of teaching sequences. It is the starting point for learning. In this sense, the child's perception of the world is relevant for learning. From the beginning of the inquiry learning sequence, it is expected that the child will be engaged in establishing links with his/her experience in the world, and what is to be observed in the classroom. Since assessment for learning aims at looking at the learners' own ideas about the natural an made world and phenomena, and it is part of the teaching, then the relation between the child, the natural and made worlds and phenomena is crucial for assessment purposes.

2. CHILD EXPERIENCE AND OWN IDEAS

One of the fundamental ideas of IBSE and IBSE assessment is that students arrive at school with knowledge and ideas about the natural and made worlds and phenomena. This knowledge comes from previous experiences within the natural and made worlds. On the one hand, it is said that it is relevant to take into account children's experiences within the natural and made worlds outside the school, as shown in the previous section. On the other hand, that it is important to provide students with experiences which are similar to scientific experiences. It is also said that children's experiences influence the way they understand the outside world. Children will construct their knowledge based on the knowledge they already constructed while they experienced the natural and made worlds. This is connected to personal theories about phenomena that children generate

for themselves. Assessment for learning discourse pays particular attention to this. It seems crucial to find evidence of the child's learning by establishing changes in his or her representations of the phenomena in question.

Individual experiences are relevant for the learning process in inquiry-based instruction. Two kinds of experiences are recognized: the experiences children have since birth, and those that they experience in the science classroom. These are the basis for knowledge that will be constructed during the science teaching lessons. The art of inquiry teaching is to bring those experience-based ideas into the classroom and base teaching on them. The experiences allow each child to make sense of the world around them.

Picture Nº 33

Children's ideas making sense of the world
IAP, Harlen (2004)[59], p.8, Europe

Both of these points link to the third reason for inquiry-based instruction; that it enables us to take account of the ideas that students have already formed. The considerable volume of research revealing students' own ideas in science testifies to the way that children strive to make sense of the world around them, whether or not they are taught science. The ideas they use in explaining things make sense to them in terms of their (limited) experience and process skills. Although these ideas often seem strange and illogical to adults, it only takes a little reflection to see how students might come to hold them. These ideas reflect what the students have experienced and clearly indicate effort to make sense of their experiences. For example, the eight-year-old, who wrote about origin of the rust found on a nail in Box 4, was using experience of the observations of the form and occurrence of rust.

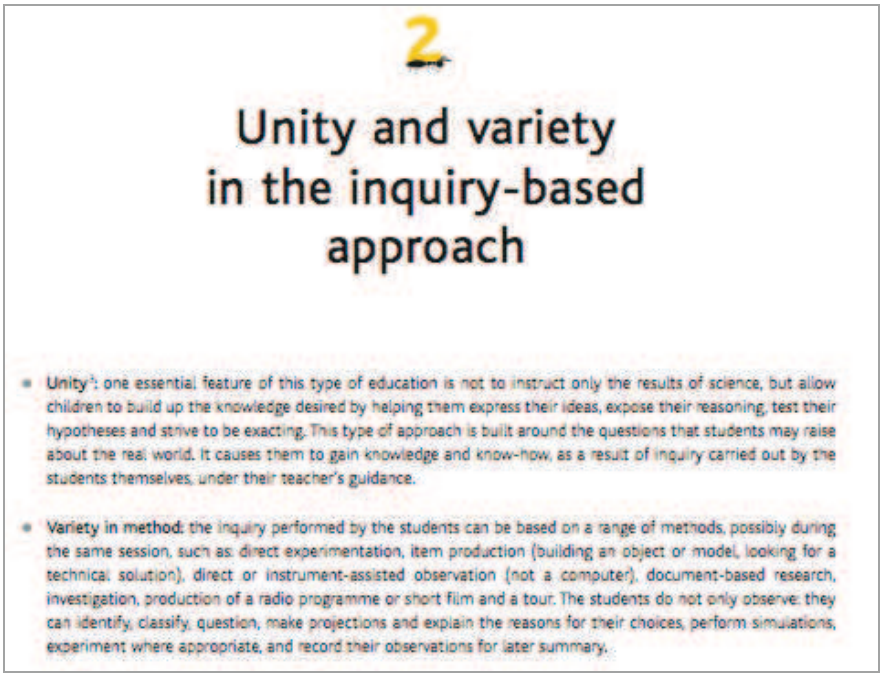
It is recognized that inquiry-based instruction enables teachers to take into account the ideas that students have already formed. These individual ideas are ideas about the world around them and related to what it is taught in science. It is stated that such ideas are used to explain facts in the natural and made worlds based on the limited experience and process skills of the students. It is also said that these ideas may seem strange and illogical to an adult, but they reflect what the students have experienced and how they make sense of their experiences.

Every student, learner or child learns through a process called *inquiry*. That means that children are engaged in an exploration of the world by questioning what they experience. It is expected that teachers guide their students' individual exploration of the world during classroom activities.

[59] http://www7.nationalacademies.org/BOSE/WHarlen_Inquiry_Mtg_Paper.pdf

Picture Nº 34

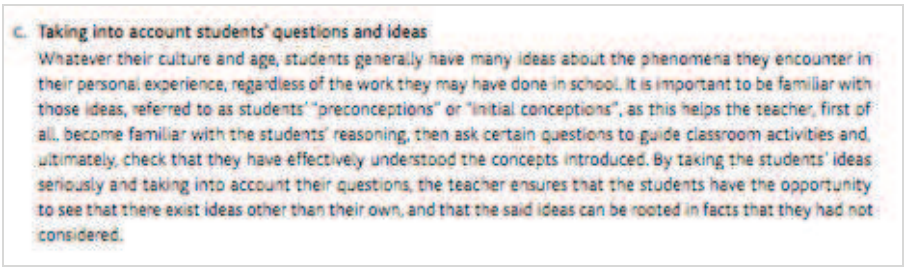
Ways to construct knowledge
Project Pollen, Saltiel (2006), p. 9, Europe



The purpose of this kind of education is to allow children to construct expected knowledge. The central idea is to help children to express their ideas and reasoning, as well as to test their hypotheses and strive to be exact. This learning process is built around the questions that students may raise about the real world. In this way, students gain knowledge and know-how. A key idea is that the students with the teacher's guidance do inquiry. It is also stated that children may use a diversity of methods in this endeavor. It is not only by manipulating materials that they will build their knowledge. In fact, this could be the result of a document based research, the production of a radio program, etc.

Picture Nº 35

Children's ideas about phenomena, taking into account different cultures and ages
Project Pollen, Saltiel (2006), p.14, Europe



c. **Taking into account students' questions and ideas**

Whatever their culture and age, students generally have many ideas about the phenomena they encounter in their personal experience, regardless of the work they may have done in school. It is important to be familiar with those ideas, referred to as students' "preconceptions" or "initial conceptions", as this helps the teacher, first of all, become familiar with the students' reasoning, then ask certain questions to guide classroom activities and, ultimately, check that they have effectively understood the concepts introduced. By taking the students' ideas seriously and taking into account their questions, the teacher ensures that the students have the opportunity to see that there exist ideas other than their own, and that the said ideas can be rooted in facts that they had not considered.

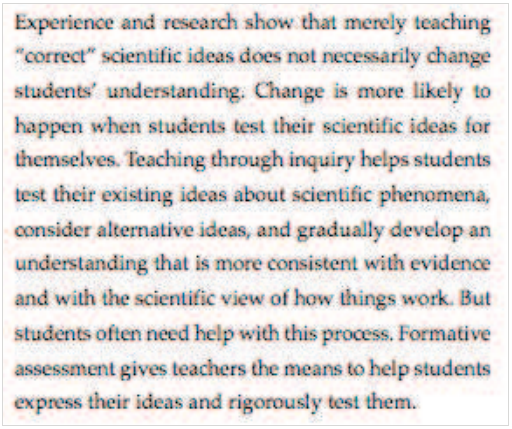
An essential part of inquiry education is taking into account the students' questions and ideas. As has been explained, children's personal experience gives them many ideas about the phenomena that they find, regardless what they do at school. These ideas are called *preconceptions* or *initial conceptions*. Teachers must be aware of the ideas and ways of reasoning that children may have, since these ideas influence what is done during classroom activities. It is expected that the students will have opportunities to be exposed a diversity of ideas different from the ones they have. During the process, they will see how their ideas change when some unexpected things occur. Something important is recognized: children from different cultures and ages have ideas about the phenomena they encounter in their personal experience, regardless of the work they may have done at school.

Formative assessment is closely connected to the idea that children have particular ideas of scientific phenomena based on their daily experiences. Assessment processes in the classroom are expected to support the change of students' ideas in the direction of accuracy. For both lines of research, it is relevant to understand and provide mechanisms to stimulate students' ideas in classroom settings, and to use these ideas during teaching activities. The aim is to help children to learn and gain understanding of scientific concepts and inquiry skills based on what they already know. This is also connected to the idea that students who learn through inquiry will change their mental representations and will make the conceptual change needed. This idea can be found in different documents and different places. Both lines of research make visible the need to use children's ideas about the natural world and the made world.

This thought can be found at the beginning of the document of the first workshop about assessment, which is aimed at showing differences between formative and summative assessments.

Picture Nº 36

Justification of Formative assessment to support changes in children's ideas
Workshop I, Harlen (2006a), p.10, Pollen and Inquiry institute Websites, Europe and USA


Experience and research show that merely teaching "correct" scientific ideas does not necessarily change students' understanding. Change is more likely to happen when students test their scientific ideas for themselves. Teaching through inquiry helps students test their existing ideas about scientific phenomena, consider alternative ideas, and gradually develop an understanding that is more consistent with evidence and with the scientific view of how things work. But students often need help with this process. Formative assessment gives teachers the means to help students express their ideas and rigorously test them.

Formative assessment is viewed as something that will give teachers the means to help students express their ideas and rigorously test them. Teaching through inquiry is said to be able to help students to change their understanding. This will happen while they are testing their own ideas or their ideas about phenomena. Students are expected to gradually develop an understanding that is more consistent with evidence, and a scientific view of how things work. It is understood that students will need help for this to happen. Formative assessment is recognized as a way to help students in this process.

The relevance of assessing students' progress during the inquiry process is also recognized. Assessment is expected to help in identifying students' ideas and the progress towards more scientific conceptualizations.

As shown in the next picture, formative assessment is also viewed as a way to inform inquiry teaching. It is stated that it is important to follow students' work during every step of their ideas about research. Children use research to test their own ideas. Assessment is expected to help students to develop more fully more their scientific ideas. By assessing children's progress at every step of the investigation teachers must ensure that these will allow students to draw useful conclusions. It is expected that in this way children will develop their scientific ideas.

Picture Nº 37

Assess progress at every step of student's investigation
Workshop I, Harlen 2006, p.11, Website Pollen and Inquiry institute, Europe and USA

specific needs. Using assessment to inform teaching is important in any instructional approach. However, it is critical to inquiry, in which students are raising questions and designing investigations to test their own ideas. Teachers must assess progress at every step of the investigation in order to ensure that their investigations are sound enough for students to draw useful conclusions that help them more fully develop their scientific ideas.

The role of assessment for learning to support changes in children's own ideas is also found in Shavelson and his collaborators' research (Shavelson, et al., 2008). One of their research projects aimed at constructing embedded assessment to ensure at different stage of learning sequences that each student is changing his or her ideas about particular scientific phenomena.

Picture Nº 38

Formative assessment promotes conceptual change
Research article, Shavelson, et al. (2008), p. 299 Source, USA

Before describing the program of research more fully, we note several unique features of the work. First, through a series of iterative studies we refined the embedded assessments. This curriculum-and-assessment development work culminated in a final study that tested the effects of embedded assessments on teaching and students' learning in a small randomized field trial. Second, we went beyond the usual definitions of science achievement as largely acquisition of declarative and procedural knowledge and evaluated the claim that formative assessment promotes *conceptual change*. We conjectured that formative assessment would do so directly and possibly indirectly through enhancing student motivation and/or achievement. Third, we studied the collaboration itself—a "study within a study"—trying to understand its ups and downs with the intent to informing future such attempts. We followed Cronbach and Associates' (19

According to this, one of the aims of the research was to test the effects of embedded assessments on the teachers' way of teaching and students' learning. The research explored to assess different type of knowledge from the traditional focused on declarative (to know) and procedural knowledge (to know how). Further more, the researchers maintain that formative assessment is a way to promote conceptual change (to know why). Their conjecture was that formative assessment would do that by directly and indirectly enhancing the students' motivation and /or achievement.

Achievement and conceptual change are associated with kinds of knowledge that are not declarative and procedural. They are also associated with mental representations and ideas that each student has in their minds. This kind of knowledge has been referred to as *schematic knowledge* or *knowing why* and *reasoning why*.

Picture Nº 39

Schematic knowledge and mental representations
Research article, Shavelson, et al. (2008), p 304, USA

Their justifications and explanations reveal their schematic knowledge (knowing and reasoning why) and become the focus of classroom discussion with the goal of closing the gap in "mental models" for explaining what they saw, based on empirical data.

Students' justifications and explanations are said to reveal their schematic knowledge. Likewise, discussions in the classroom need to take into account these explanations and justification in order to close a gap in mental models. This gap is related to a kind of explanation, justification of what students saw based on empirical data. It is said that the students' explanations and justification of certain phenomena stem from their experiences and mental models. The basic idea is that children will have some theories that do not correspond to the empirical evidence. This is what is called *misconceptions*.

In the next picture, sinking and floating is seen as a common phenomenon that students are familiar with. It is said that the students have personal theories or mental models related to this particular phenomenon. Their sinking and floating explanations reveal their theories and mental models. Furthermore, these theories may not be valid or may only be valid under certain circumstances. This is what is called misconceptions or conceptions that are only valid under certain circumstances. Some examples of the explanations that reveal students'theories about floating and sinking are presented: big and heavy things will sink, things with holes in them sink, hollow things float, things with air in them float, or flat things float. These conceptions are seen as rooted in the students' minds and that it is difficult to change them. The researchers also point out that just giving the scientific explanation of the phenomenon does not change the ideas, which are firmly rooted in the students' minds.

Picture Nº 40

Mental models, students' theories and misconceptions
Research article, Yin, et al., (2008), p. 338, USA

Despite its complexity in science, sinking and floating is a common phenomenon. Most students have rich experiences and personal theories or mental models for explaining sinking and floating. Unfortunately, many of their theories are either misconceptions or conceptions that are only valid under certain circumstances—for example, big/heavy things sink, things with holes in them sink, hollow things float, things with air in them float, or flat things float. Those conceptions are so deeply rooted in students' minds that it is difficult for students to change them, even after students have been intensively exposed to scientific conceptions such as, "If an object's density is less than a liquid's density, the object will float in the liquid regardless of the size or mass of the object" (Yin et al., 2008).

These misconceptions are seen as independent of the cultural and social context, and they are present in people of different ages. They can be found in relation to different phenomena.

Picture Nº 41

Mental models, students' theories and misconceptions
Research article, Yin, et al. (2008), p. 338, USA

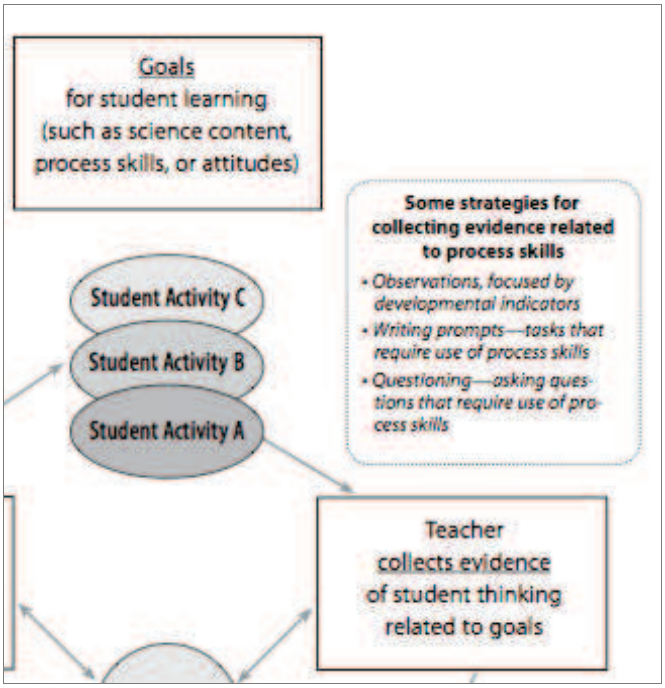
Similar to children's misunderstanding of the shape of the planet earth and "why things sink and float," many other misconceptions are deeply rooted in everyday experiences, widely across different subject domains, among people of different ages, across different cultures, and through the history of the development of scientifically justifiable ideas. These alternative conceptions inhibit students from acquiring scientific conceptions (Yin, 2005).

As explained, misconceptions are deeply rooted in everyday experiences. This is something that can be seen across different subjects, domains, people of different ages, different cultures, and throughout the history of the development of scientifically justifiable ideas. The fact that these alternative conceptions inhibit students from acquiring scientific conceptions is also explained.

Information is also seen as evidence of learning. In order to collect evidence, it is relevant for research to establish mechanisms by which information will be collected. There are multiple ways to do this. It is recognized that some are more effective than others.

Picture Nº 42

Strategies to get evidence of learning
Workshop II, Harlen (2006d), p.73, Website Pollen and Inquiry institute, Europe and USA



Some strategies used to collect evidence are mentioned. The first is to carry out an observation guided by some developmental indicators. Another is to have prompts or tasks that will require the students to use the process skill to carry them out. In the same way, teachers can ask questions that students will answer depending on the use of process skills.

This is also found in Furtak and Ruiz-Primo's (2007) research. These researchers focus their attention on the way prompts should be developed and used for eliciting the required information. They also give directions about different ways to collect information. They emphasize the relevance of thinking about ways to elicit the inappropriate conceptions that students may have about a particular phenomenon.

Picture Nº 43

Prompt, information and misconceptions
Research paper, Furtak and Ruiz-Primo (2007), p.3, USA

> Eliciting students' ideas can be done on an *informal* basis through questioning and discussions or through more *formal* written prompts. We use the term "prompt" to denote a particular format of a formative assessment; for example, asking students to interpret a graph or to provide an explanation in response to a question. For a prompt to be considered effective tool for formative purposes, it must elicit students' multiple understandings, especially the inappropriate conceptions, since this is the information teachers need to make appropriate instructional decisions to reduce the gap. Therefore, the relative effectiveness of a particular assessment prompt can be determined by identifying the range of student conceptions elicited by that particular prompt.

Two different ways to elicit students' ideas are distinguished: informal and formal. Questioning and discussions are identified as the informal way. The term *prompt* is used to refer to a particular format of a formative assessment and it is the formal way to elicit the students' ideas. This prompt must be conceived in such way that it elicits the student's multiple understanding, particularly his/her misconceptions. This information is what the teacher will need to adapt his or her teaching in order to reduce the gap. The effectiveness of a particular assessment prompt is judged by the teacher's capacity to identify the range of the student's conceptions.

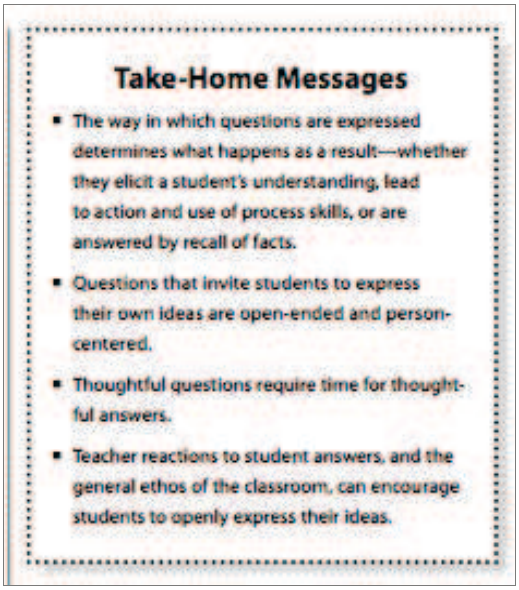
Questioning is recognized as a key element of formative assessment. Harlen's assessment workshop is dedicated to the art of asking particular questions with which the students feel comfortable to express their own ideas.

It is recognized that the way questions are constructed determines the result. They may elicit the student's understanding and lead to action and use of process skills. However, they can also cause the student's answer to be a recall of facts. The kinds of questions, which are considered useful, invite students to express their own ideas. These ideas are known to be open-ended and person-centred. It is also said that thoughtful questions require time for the student to provide a thoughtful answer. The teacher's reactions to the student's answers are seen as relevant to promote a classroom ethos that encourages students to openly express their ideas.

Picture Nº 44

Questioning

Workshop III, Harlen, (2006c), p.8, Website Pollen and Inquiry institute, Europe and USA



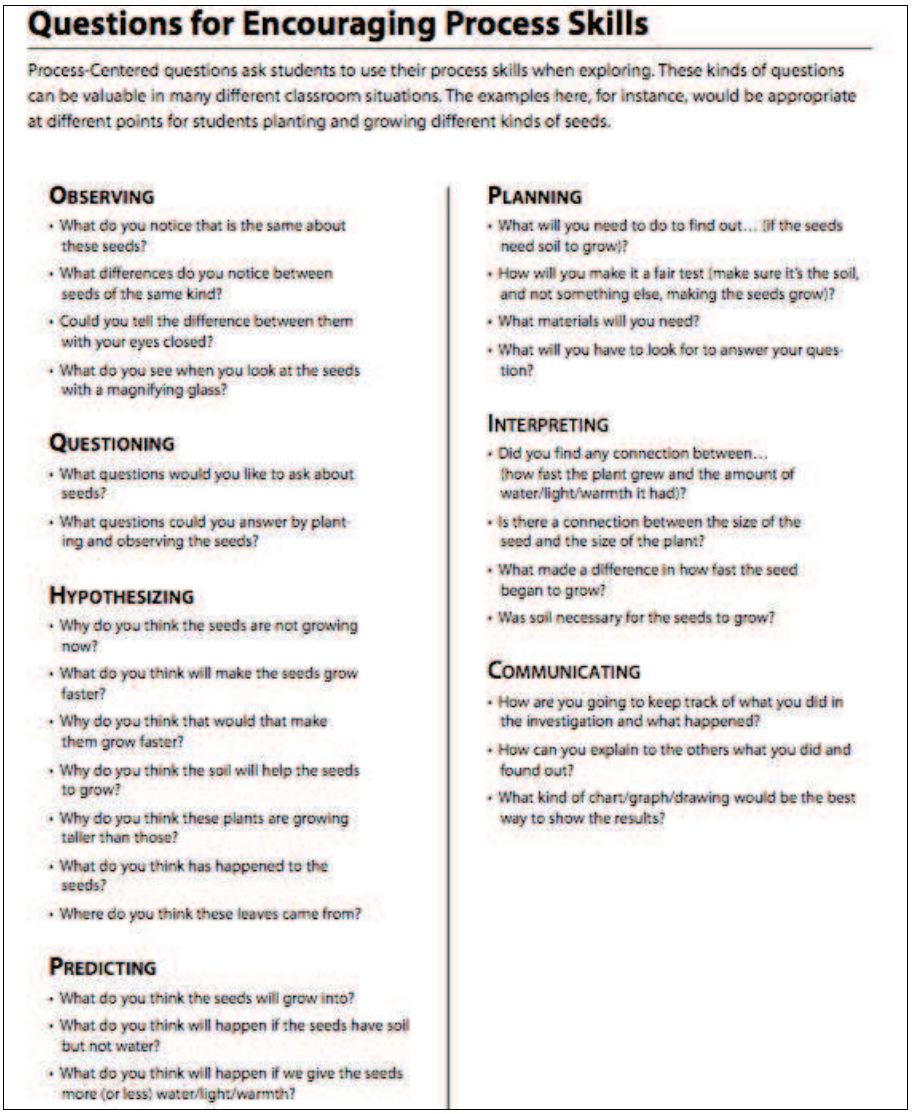
Both the USA and the British lines of research have constructed tools to identify and promote prompts, questions and activities that will elicit the student's own ideas, connected to a particular phenomenon. For instance, the above text-picture shows a diversity of questions that can be used to elicit student's ideas and process skills. There are questions triggering skills to make hypotheses: "Why do you think the seeds are not growing now?" "Where do you think these leaves came from?", or questions triggering prediction skills: "What do you think will happen if the seeds will grow into?" "What do you think will happen if we give the seeds more (or less)/light/warmth? (Harlen, 2006c, p. 49).

Then again, it is also relevant to have a tool to interpret the information; a tool to tell somehow why this information will be evidence of an expected understanding and student's knowledge.

Picture Nº 45

Questions and process skills

Workshop III, Harlen (2006c), M6, Website Pollen and Inquiry institute, Europe and USA



Questions for Encouraging Process Skills

Process-Centered questions ask students to use their process skills when exploring. These kinds of questions can be valuable in many different classroom situations. The examples here, for instance, would be appropriate at different points for students planting and growing different kinds of seeds.

OBSERVING

- What do you notice that is the same about these seeds?
- What differences do you notice between seeds of the same kind?
- Could you tell the difference between them with your eyes closed?
- What do you see when you look at the seeds with a magnifying glass?

QUESTIONING

- What questions would you like to ask about seeds?
- What questions could you answer by planting and observing the seeds?

HYPOTHESIZING

- Why do you think the seeds are not growing now?
- What do you think will make the seeds grow faster?
- Why do you think that would that make them grow faster?
- Why do you think the soil will help the seeds to grow?
- Why do you think these plants are growing taller than those?
- What do you think has happened to the seeds?
- Where do you think these leaves came from?

PREDICTING

- What do you think the seeds will grow into?
- What do you think will happen if the seeds have soil but not water?
- What do you think will happen if we give the seeds more (or less) water/light/warmth?

PLANNING

- What will you need to do to find out… (if the seeds need soil to grow)?
- How will you make it a fair test (make sure it's the soil, and not something else, making the seeds grow)?
- What materials will you need?
- What will you have to look for to answer your question?

INTERPRETING

- Did you find any connection between… (how fast the plant grew and the amount of water/light/warmth it had)?
- Is there a connection between the size of the seed and the size of the plant?
- What made a difference in how fast the seed began to grow?
- Was soil necessary for the seeds to grow?

COMMUNICATING

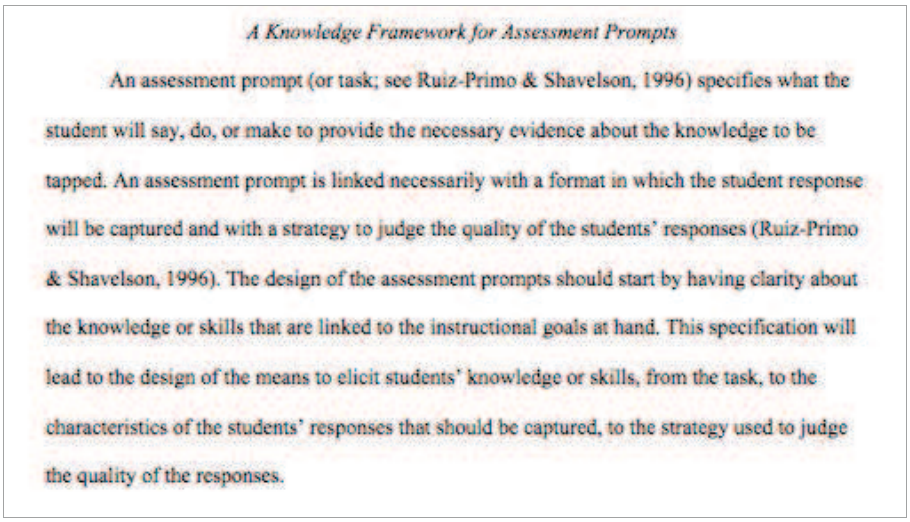
- How are you going to keep track of what you did in the investigation and what happened?
- How can you explain to the others what you did and found out?
- What kind of chart/graph/drawing would be the best way to show the results?

During the assessment process it is necessary to interpret the information given by students. Both lines of research provide frameworks and tools to do this.

Information needs to be processed in order to establish the gap between what students understand and know and the learning goals.

Picture Nº 46

Needs of Knowledge framework linked to prompts
Research paper, Furtak and Ruiz-Primo (2007), p.4, USA



A Knowledge Framework for Assessment Prompts

An assessment prompt (or task; see Ruiz-Primo & Shavelson, 1996) specifies what the student will say, do, or make to provide the necessary evidence about the knowledge to be tapped. An assessment prompt is linked necessarily with a format in which the student response will be captured and with a strategy to judge the quality of the students' responses (Ruiz-Primo & Shavelson, 1996). The design of the assessment prompts should start by having clarity about the knowledge or skills that are linked to the instructional goals at hand. This specification will lead to the design of the means to elicit students' knowledge or skills, from the task, to the characteristics of the students' responses that should be captured, to the strategy used to judge the quality of the responses.

As stated, one starting point in the design of assessment prompts is to clarify the knowledge or skills that are linked to the instructional goals. It is relevant to design prompts eliciting the student's knowledge or skills. This design must include the specific task, the characteristics of the students' responses that must be recorded, and the strategy used to judge the quality of the responses. An assessment task should specify what the student will say or do to provide the necessary evidence on the knowledge to be trapped. Two kinds of tools are recognized in relation to assessment prompts: a format where students' responses will be recorded, and a strategy to judge the answers.

The learner's achievement is essential for the assessment process. This is why a theoretical framework is needed to make it explicit and to define it. Shavelson et al. (2008) recognize different dimensions involved in achievement: cognition, emotion and motivation. A specific framework is developed to describe cognition.

Picture Nº 47

Achievement and Knowledge

Research article, Shavelson, et al. (2008), p. 304-303, USA

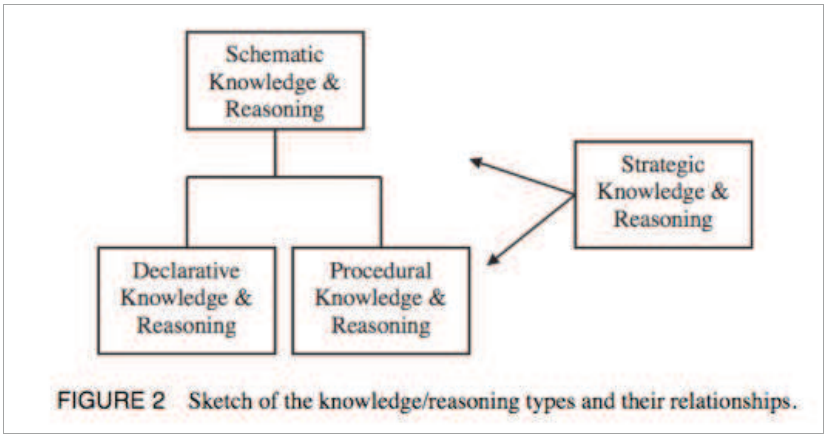


FIGURE 2 Sketch of the knowledge/reasoning types and their relationships.

We conceived of science achievement as involving cognition, emotion, and motivation (e.g., Shavelson et al., 2002) but for this study, focused directly on cognition. Nevertheless, we also examined the impact of formative assessment on motivation and emotion. Our working definition of science achievement (Li, Ruiz-Primo, & Shavelson, 2006; Shavelson & Ruiz-Primo, 1999; see also National Assessment Governing Board, 2006) involved four types of knowing and reasoning in a subject matter (Figure 2). One type of such knowledge is "knowing that"—*declarative* (factual, conceptual) knowledge. For example, knowing that force equals mass times acceleration and being able to reason with this knowledge. Achievement also involves "knowing how" to do something—*procedural* (step-by-step or condition-action) knowledge and reasoning with this knowledge. For example, procedural knowledge involves knowing how to get the mass of an object or how to carry out and reason through a comparative investigation by manipulating the variable of interest and controlling others. Achievement also importantly involves "knowing why"—*schematic* ("mental model") knowledge. Such knowledge builds on and connects declarative and procedural knowledge; it is used to reason about, predict, and explain things in nature. For example, schematic knowledge is involved in explaining why some things sink in water and others float. Finally, achievement involves "knowing when and where to apply

Untitled4

knowledge," and to check if the application of this knowledge is reasonable—*strategic* knowledge. For example, experts know when to apply Newton's first law given a force and motion problem whereas novices are attracted to the surface features of the problem (Chi, Feltovich, & Glaser, 1981).

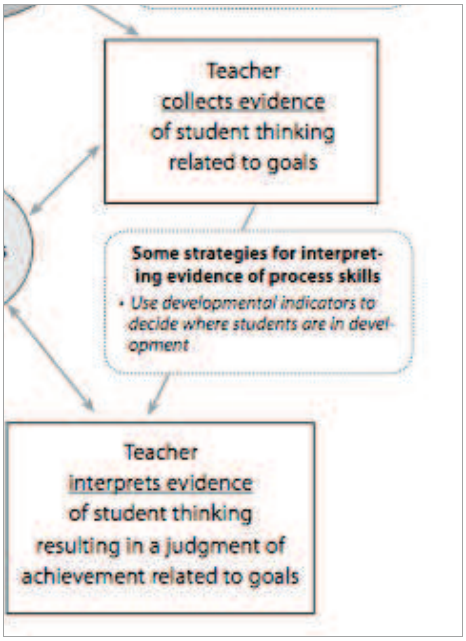
Here, four kinds of knowledge for scientific achievement are recognized: Knowledge referring to scientific facts and concepts or 'knowing that', called *declarative knowledge* and corresponding reasoning; step-by-step knowledge or condition-action or 'knowing how', called *procedural knowledge* and its corresponding reasoning; knowledge using mental models or 'knowing why', called *schematic knowledge* and its corresponding reasoning; and knowledge that enables knowing when and where to apply knowledge, and check if the application of this knowledge is reasonable, called *strategic knowledge*. These kinds of knowledge are seen as linked, and these different dimensions are recognized as being involved in the achievement of a task.

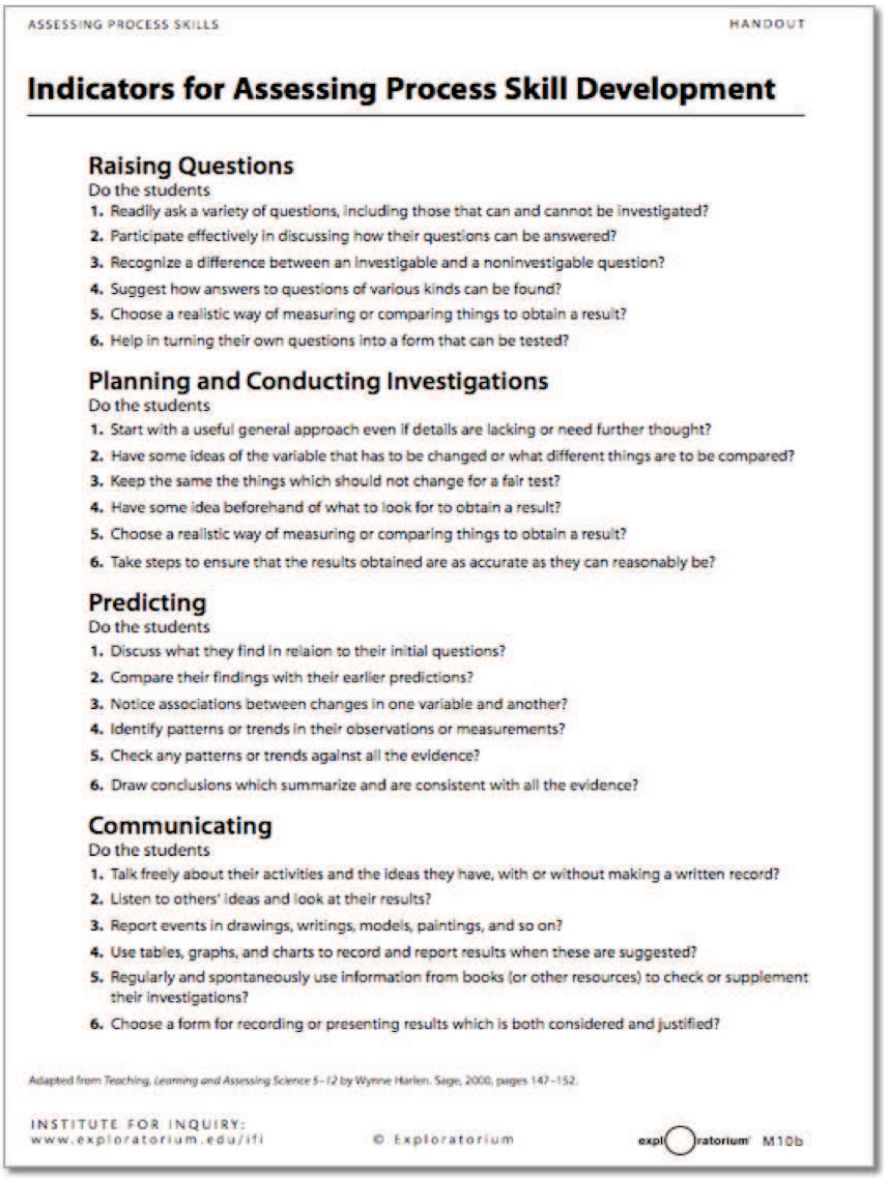
In order to assess student's ideas, some indictors are constructed and presented as questions that will guide the exploration of his/her responses.

Picture Nº 48

Indicators

Workshop II, Harlen, 2006, p. 73, p. 63, Website Pollen and Inquiry institute, Europe and USA





ASSESSING PROCESS SKILLS HANDOUT

Indicators for Assessing Process Skill Development

Raising Questions

Do the students

1. Readily ask a variety of questions, including those that can and cannot be investigated?
2. Participate effectively in discussing how their questions can be answered?
3. Recognize a difference between an investigable and a noninvestigable question?
4. Suggest how answers to questions of various kinds can be found?
5. Choose a realistic way of measuring or comparing things to obtain a result?
6. Help in turning their own questions into a form that can be tested?

Planning and Conducting Investigations

Do the students

1. Start with a useful general approach even if details are lacking or need further thought?
2. Have some ideas of the variable that has to be changed or what different things are to be compared?
3. Keep the same the things which should not change for a fair test?
4. Have some idea beforehand of what to look for to obtain a result?
5. Choose a realistic way of measuring or comparing things to obtain a result?
6. Take steps to ensure that the results obtained are as accurate as they can reasonably be?

Predicting

Do the students

1. Discuss what they find in relaion to their initial questions?
2. Compare their findings with their earlier predictions?
3. Notice associations between changes in one variable and another?
4. Identify patterns or trends in their observations or measurements?
5. Check any patterns or trends against all the evidence?
6. Draw conclusions which summarize and are consistent with all the evidence?

Communicating

Do the students

1. Talk freely about their activities and the ideas they have, with or without making a written record?
2. Listen to others' ideas and look at their results?
3. Report events in drawings, writings, models, paintings, and so on?
4. Use tables, graphs, and charts to record and report results when these are suggested?
5. Regularly and spontaneously use information from books (or other resources) to check or supplement their investigations?
6. Choose a form for recording or presenting results which is both considered and justified?

Adapted from *Teaching, Learning and Assessing Science 5–12* by Wynne Harlen. Sage, 2000, pages 147–152.

INSTITUTE FOR INQUIRY:
www.exploratorium.edu/ifi © Exploratorium explOratorium M10b

Four groups of *assessment indicators* for process skills development are identified: Raising questions, Planning and conducting investigations, Predicting and Communicating. Some questions are proposed for each skill, in order to look at the students' responses.

There are also indicators given for interpreting students' ideas. Some indicators are also recognized by Harlen (2006d, p. 50) to assess student's ideas. Various generic indicators are presented and translated into specific indicators. The table shows how one student's explanation or prediction can be interpreted in the light of some indicators. Indicators are presented as questions that will allow for interpretations. For instance, the second generic question "use their own preconceived ideas, rather than scientific ones", is translated into a specific one "use preconceived ideas about sound, rather than scientific ideas".

ASSESSING SCIENCE IDEAS — CHART OR OVERHEAD & HANDOUT

Comparing Generic and Specific Indicators of Ideas

Generic indicators of development can be "translated" into specific indicators, as shown here.

Generic Indicators *When giving an explanation or making a prediction, do the students:*	**Specific Indicators** *When giving an explanation or making a prediction, did the students:*
1. Do no more than describe the situation, rather than explaining it?	1. Simply describe what happened when the drum was hit?
2. Use their own preconceived ideas, rather than scientific ones?	2. Use preconceived ideas about sound, rather than scientific ideas?
3. Refer to relevant ideas without showing how they apply?	3. Mention the relevant ideas: that sound is caused by vibration; that we hear sound when it travels to our ears?
4. Apply the relevant ideas only in situations similar to those already encountered?	4. Apply ideas about sound correctly in this situation?
5. Apply the relevant ideas in situations different from those encountered before?	5. Use these ideas in explaining sounds made by other objects and suggest that sound travels through the air to the ear?
6. Bring several relevant ideas together to give a reasoned explanation or prediction?	6. Make a connection between vibration of objects that are sources of sound and vibrations in the air reaching the ear to create the sensation of sound?

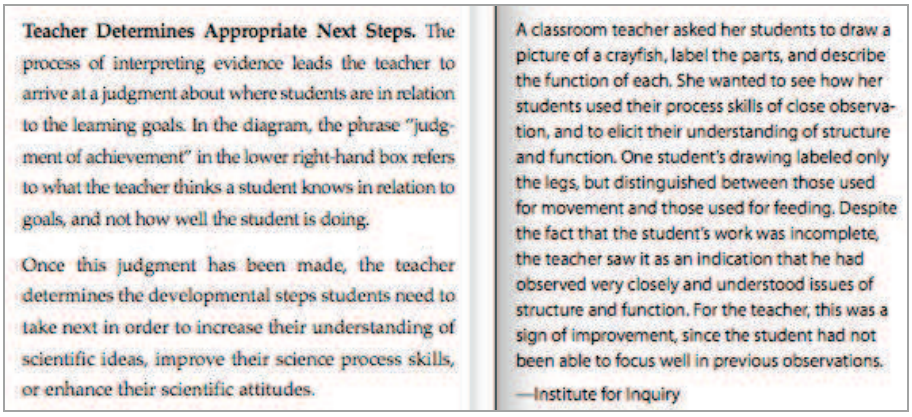
All these tools will be used to produce judgments by establishing the gap between the interpretation of responses and the goals. In assessment research, it is also relevant to have strategies to make judgments. These judgments are the basis to help students learn. Interpretations of students' responses and actions are compared with the intended goals and will result in that judgment.

The process of collecting evidence by having the students do something like writing, talking or drawing, and then comparing this to the goals is not the only aspect involved in the production of judgments. There is also the question of comparing previous student achievements with the present task.

Picture Nº 49

Evidence Interpretation

Workshop I, Harlen (2006a), p.14, Website Pollen and Inquiry institute, Europe and USA



Teacher Determines Appropriate Next Steps. The process of interpreting evidence leads the teacher to arrive at a judgment about where students are in relation to the learning goals. In the diagram, the phrase "judgment of achievement" in the lower right-hand box refers to what the teacher thinks a student knows in relation to goals, and not how well the student is doing.

Once this judgment has been made, the teacher determines the developmental steps students need to take next in order to increase their understanding of scientific ideas, improve their science process skills, or enhance their scientific attitudes.

A classroom teacher asked her students to draw a picture of a crayfish, label the parts, and describe the function of each. She wanted to see how her students used their process skills of close observation, and to elicit their understanding of structure and function. One student's drawing labeled only the legs, but distinguished between those used for movement and those used for feeding. Despite the fact that the student's work was incomplete, the teacher saw it as an indication that he had observed very closely and understood issues of structure and function. For the teacher, this was a sign of improvement, since the student had not been able to focus well in previous observations.

—Institute for Inquiry

The process of interpreting evidence is seen as leading the teacher to a judgment. The judgment of achievement refers to what the teacher thinks a student knows in relation to the goals. It is not expected that the judgment will be made in relation to how well the student is doing. This comparison allows teachers to determine the developmental steps that students need to take next in order to increase their understanding of scientific ideas, improve their science process skills, or enhance their scientific attitudes. As an example, they show how the teacher focuses on particular goals —process skills of close observation and understanding of structure and function. Then, they explain what the student did and will be interpreted and judged. To illustrate this point, the author presents an example where the teacher react to a student response —a student's drawing labelled only the leg, but distinguished between those used for movement and those used for feeding. The teacher is expected to see this production as an indication that the student had observed very closely and had understood issues

of structure and function. At the same time, the teacher produces another interpretation by looking the answer as a sign of improvement in relation to previous observations.

The connection between judgment and interpretation is most important in the process of assessment. The Standford research group developed a model that represents the complexity involved in the process (Ruiz-Primo, 2007, p. 210). It focuses on the theoretical support needed during this process in order to have reliable information about the learning process of students.

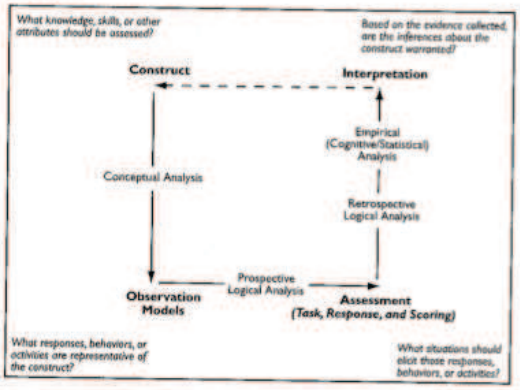
Ruiz-Primo (2007, p. 222) states that the evidence collected and the actions taken based on this evidence could have an impact on different moments of teaching. One involves everyday activities and another what will be done later. Evidence may not need a corresponding formal score. Instead, a more relevant judgment will be needed. She explains that the main purpose of classroom assessment is learning improvement. In this way, assisted performance by the students is permitted.

Picture N° 50

Assessment square

Book chapter, Ruiz-Primo (2007), p.222, USA

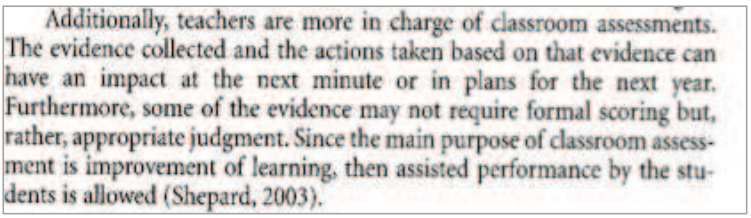
Figure 1. The assessment square (adapted from Shavelson, Ruiz-Primo, Li, and Ayala, 2002).



The assessment square begins with a working definition of what we are attempting to measure, the *construct*. At SEAL, we preferred the term construct, rather than cognition (Pellegrino, Chudowsky, and Glaser, 2001). A construct can be part of a theoretical model of a person's cognition (e.g., development of understanding of certain concepts in a domain), but does not limit assessment to an underlying cognitive model (Shavelson, Ruiz-Primo, Li, and Ayala, 2002; Shavelson and Ruiz-Primo, 1999).

Picture Nº 51

Evidence and judgments
Ruiz-Primo (2007), book chapter, p.222, USA



Additionally, teachers are more in charge of classroom assessments. The evidence collected and the actions taken based on that evidence can have an impact at the next minute or in plans for the next year. Furthermore, some of the evidence may not require formal scoring but, rather, appropriate judgment. Since the main purpose of classroom assessment is improvement of learning, then assisted performance by the students is allowed (Shepard, 2003).

Summarizing, it seems that in IBSE and assessment discourses there are certain central, crucial aspects. On the one hand, it is assumed that children arrive at school with experiences taken from the natural and made worlds and with knowledge, misconceptions and their own ideas, as illustrated above. These misconceptions are rooted in their minds and are difficult to change, so during the science lessons through inquiry, something must be done to change them. Children's ideas are seen as independent of the culture where they live or their age. Assessment for learning mechanisms and strategies are focalized on helping students to change these ideas. The ultimate assessment goal is to support mental changes and thus allowing the child to have new theories about the phenomena. The purpose of assessment is to make visible these ideas and misconceptions, to support changes during the child's new experiences in the classroom. It is relevant then, to have information about each child's thinking during all the inquiry steps (questioning the natural and made worlds, establishing hypothesis, predicting, making experimentations, concluding and communicating). The design and use of effective prompts so that misconceptions can emerge and the teacher can identify them is an important mechanism for the functioning of assessment for learning in every day teaching practice.

3. CHILDREN AND EXPERIMENTS

Another point that is common to both discourses is that, in order to learn, children must do experiments or investigations. Children are not expected to follow a particular protocol to do the experiments or investigations. They are expected to do an experiment on their own, which will provide evidence to test their own ideas or to answer their questions about the natural or made worlds. They have to ask themselves about what they notice and wonder about the natural or made worlds first of all. It is not only an experimental activity with material, objects or events from the surroundings. Experiments and

investigations may also be a library based research project, or they may involve asking questions to a scientist.

This view of inquiry is clearly stated in the second principle of the Pollen methodological guide for teachers, as "the need for individual experimentation".

Picture Nº 52

Meaning for experimentation in IBSE
Project Pollen, Saltiel (2006), p.6, Europe

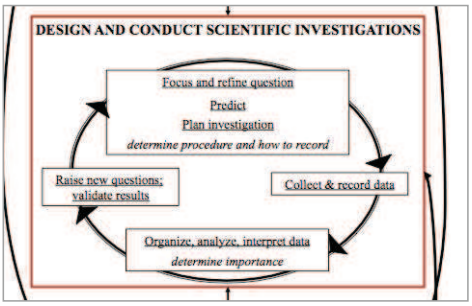
2. The need for individual experimentation

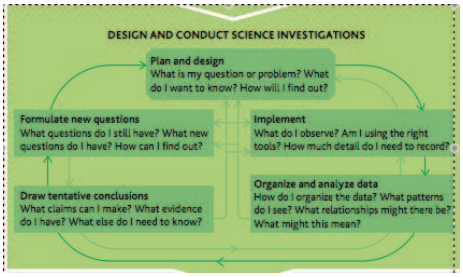
Experimentation here does not mean complicated experiments involving sophisticated and costly equipment. The reader will see that the experiments listed are in fact very simple and require nothing more than ordinary, inexpensive equipment. The sample activities listed on the Pollen site are a good example of what can be done by children.

Children have very good recollection of the experiments they conduct themselves. In addition, very early on, they have ideas about a number of phenomena. Most often, it is not enough to tell them that a given experiment will yield a given outcome (without doing the experiment or just showing it to them), or to tell them that what they think is full of mistakes. They need to reach this realisation themselves, hence the need to let them test the experiments they have come up with themselves (provided that this can be done in a classroom setting) and let them substantiate their methods amongst themselves. Here are two examples:

Children must conduct experiments by themselves. Experiments are not complicated and can be done with simple materials. No sophisticated equipment is needed. Children will be able to change their ideas if they test them and use their methods. It is not enough to give them an outcome of an experiment or show them that what they think is a mistake.

In Insight, this is expressed in the second activity represented in the framework. After the children are aware of something and start to ask questions about what they are looking at, it is expected that they will be able to focus their attention. This means that they will be able to plan an investigation based on their predictions. After that, they collect and record data. With this information, they proceed to organize, analyze and interpret data connected to their questions. The arrows show that this is not a linear procedure. This process will engage children in a single focus investigation, raising new questions, validating results, and starting the process again if it is needed. By doing this, each one will answer their own questions and express their own ideas about the phenomenon each one is exploring.





In the Pollen guide to teachers, they explain the same idea in a different way. The complexity of the process is evident.

The child states a question, or a problem to be investigated, making clear what he/she want to know or find out. Then, he/she focuses the observation, using tools and recording information. After that, the child organizes information, tries to find relationships that might be in what is observed and looks for meaning. He/she makes claims, presents evidence and sees what more is needed to be known, and continues if necessary, to produce questions and go deeper in into what is being researched in the natural and made worlds.

The same can be found in the NSRC approach. Children are expected to "explore": "students engage in hands-on exploration that builds upon their previous knowledge" (NSRC website). In order to understand the phenomenon, students ask a question and try to find an answer through the use of concrete materials or specific information.

Picture Nº 53

Hands-on explorations
Human Body Module[60],p. 10, Chile

Exploración

Momento en que niñas y niños trabajan en grupo, con materiales concretos o información específica, con el objetivo de buscar una respuesta a la pregunta inicial y así poder entender el fenómeno.

Durante esta fase es muy importante que los estudiantes cuenten con el tiempo adecuado para completar su trabajo y repetir sus procedimientos si es necesario, de manera que puedan establecer cómo sus ideas se comprueban o no en la realidad. El trabajo en grupos pequeños (de 3 a 4 integrantes) posibilita el compartir y discutir ideas con sus pares, aspecto que es fundamental en el proceso de aprendizaje.

[60] Exploration

Moment in which girls and boys work in group, with specific materials or specific information with the object of finding an answer to the initial question, thus being able to understand the phenomenon.

During this phase, it is very important that the students have enough time to complete their work and repeat their procedures if necessary, so that they may establish how their ideas are proven or not in reality. Working in small groups (between 2 and 4 members) enables sharing and discussing ideas with peers, which is fundamental in the learning process.

Children must work in groups with concrete materials or specific information with the aim of finding answers to an initial question that helps them understanding the phenomenon. It is important that children have time to repeat procedures in order to find out whether their ideas coincide with reality or not. It is stated that group work allows children to share and discuss their ideas. This is a fundamental part of the learning processes.

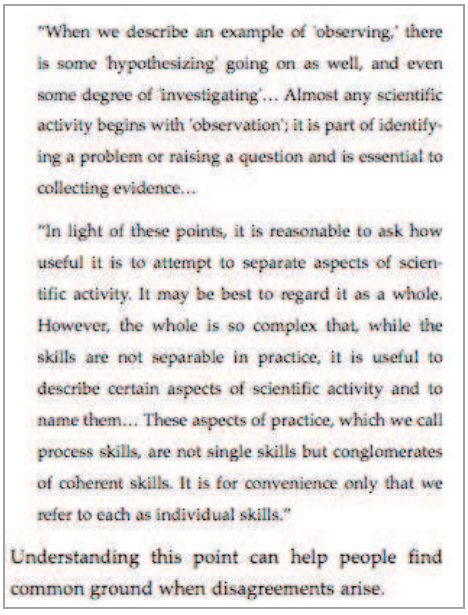
What is reported in the teachers' Pollen guide is that observation will not occur on its own. Students will not necessarily notice what the teacher expects them to notice. This is explained in the principle "You can see only what you strive to see" (Saltiel, 2006, p. 8) "In other words, in order to "see" something, you need to know what you are trying to look at. Many studies have shown this very effectively" (Saltiel, 2006, p.8).

In assessment documents, experimentation is also relevant, and it is recognized as a whole process that must be theorized in some way in order to lead to assessment practice. For instance, in the Inquiry assessment workshops:

Picture Nº 54

Investigation as a whole

Workshop II, Harlen 2006, p. 20, website Pollen and Inquiry Institute, Europe and USA



"When we describe an example of 'observing,' there is some 'hypothesizing' going on as well, and even some degree of 'investigating'... Almost any scientific activity begins with 'observation'; it is part of identifying a problem or raising a question and is essential to collecting evidence...

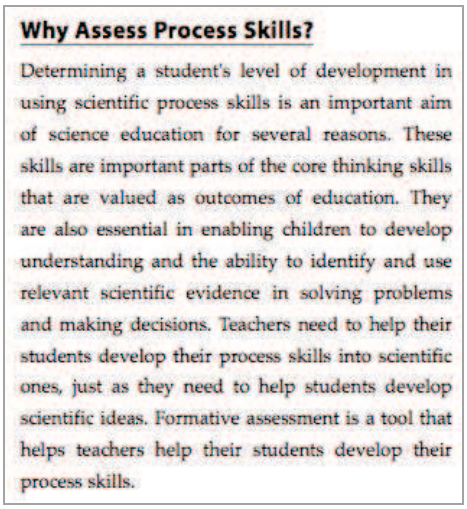
"In light of these points, it is reasonable to ask how useful it is to attempt to separate aspects of scientific activity. It may be best to regard it as a whole. However, the whole is so complex that, while the skills are not separable in practice, it is useful to describe certain aspects of scientific activity and to name them... These aspects of practice, which we call process skills, are not single skills but conglomerates of coherent skills. It is for convenience only that we refer to each as individual skills."

Understanding this point can help people find common ground when disagreements arise.

For assessment purposes, it is necessary to have a framework related to scientific activity. It is said that it must be seen as a whole activity, but that it can be related to a set of skills. Harlen (2006b) explains why it is important to assess children's skills.

Picture Nº 55

Why to assess skills?
Workshop II, Harlen (2006b), p.20, website Pollen and Inquiry Institute, Europe and England



Why Assess Process Skills?

Determining a student's level of development in using scientific process skills is an important aim of science education for several reasons. These skills are important parts of the core thinking skills that are valued as outcomes of education. They are also essential in enabling children to develop understanding and the ability to identify and use relevant scientific evidence in solving problems and making decisions. Teachers need to help their students develop their process skills into scientific ones, just as they need to help students develop scientific ideas. Formative assessment is a tool that helps teachers help their students develop their process skills.

Thinking skills are valued as an outcome of education and they also enable children to develop understanding, identify evidence in solving problems and making decisions. The teacher's assessment role is to help students develop these process skills into scientific ones, as well as developing scientific ideas. Formative assessment is viewed as a tool to support changes. As presented above, for the other line of assessment research it is also important to make visible procedural knowledge, or to know how to do things through experimentation (See Picture Nº 17).

In summary, a focus on the relationship between the child, the material and experimentation can be seen in IBSE and assessment discourses. The child must develop skills, which allow him or her to question the nature and test if his/her ideas can be supported with evidence. Assessment is viewed as a way of supporting change in skills and procedural knowledge.

4. CHILDREN AND INTERACTION WITH OTHERS

Up to now I have focused on the aspects of learning and teaching through inquiry exclusively related to individual learning. Now I will address those that

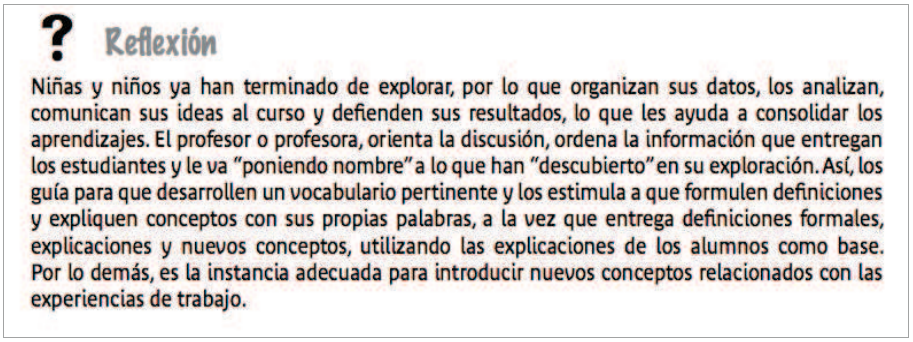
are relevant for learning in the interactional dimensions. IBSE is presented as a learning environment where students are individually engaged in an inquiry process around phenomena, supported by others and by physical materials. The child interacts with others and with the environment.

The relevance of group work and discussions for the learning process in IBSE environments is acknowledged. Students' ideas and knowledge about phenomena are at the core of these interactional moments. Teachers must ensure quality in students' group discussions as well as in all class discussions. It is recognized that by collaboration, sharing their own ideas, debating, and discussing, every phase of the inquiry process will be more efficient for the individual learning process. However, the focus of assessment is found in the individual cognitive process.

In the NSRC tradition, there is a similar moment called *reflexion*. Students are expected to carry out personal evidence-based reflections that allow them to systematize their learning. In addition, it is assumed that children will make a conceptual integration helped by the teacher's mediation.

Picture Nº 56

Consolidation of learning experiences
Project ECBI Chile, MEN Chile, Human Body Module[61], p. 11, Chile

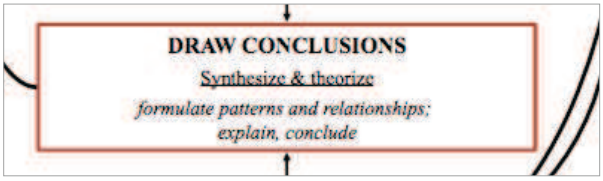


[61] Reflection

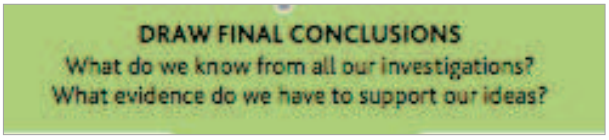
Girls and boys have already finished exploring, so they organize their data, analyze it and communicate their ideas to the entire class and defend their results, which helps them to consolidate what they have learned. The teacher guides the discussion, organizes the information that the students deliver and "gives name" to what they have "discovered" in their exploration. Thus, the teacher orients them to develop a pertinent vocabulary and stimulates them to formulate definitions and explain concepts in their own words, while providing formal definitions, explanations and new concepts, using the students' explanations as a basis. Furthermore, this is the proper moment to introduce new concepts related to the work experiences.

After the exploration, girls and boys organize and analyse their data, communicate their ideas to others, and support their findings. This is seen as strengthening their learning. The teacher interacts with them during discussions, labelling their findings; organizing the information; helping children to formulate definitions and concepts; and presenting formal definitions.

This is also present in the Insight framework: children communicate their conclusions to their peers in the classroom. These different activities happen all the time; children are working in groups, interacting, constructing explanations and arguments together, based on the experience they have had when manipulating different materials in groups activities. In *Graph N°1*, the Worth and Dyan's diagram shows these ideas. The elements presented guide the way in which all classroom activities are constructed and developed.



The fourth activity (Insight framework) is conceived to engage each child in the process of drawing conclusions, where the central aim of the inquiry process is developed: building explanations based on the evidence collected and arguments that support their own ideas about the phenomena. Children are expected to formulate patterns and relationships as they explain and draw conclusions based on their experiment or investigation. After the investigation, children reflect and ask themselves what they learned from the experience. Evidence constructed during experiements is what supports or does not support the child's ideas.



An essential element of IBSE is found in IAP documents and presentations. According to Harlen (2007) the main characteristics of the IBSE are that the students' ideas are at the core of classroom interactions, and the teacher's role consists in collecting students' ideas about a phenomenon or event, and organizing them in groups with activities that allow them to observe events and discuss possible explanations (hypotheses), share ideas and observations with the whole class, make predictions based on their own ideas,

plan in groups how to test predictions, collect evidence and interpret it, select the best explanations and link the new ideas with other phenomena and ideas.

It is said that IBSE provides a framework in which teachers and students are involved in well-defined actions, differing from those found in current classroom practices. These individuals do not act in an isolated way. Indeed, a relevant point to produce learning experiences as expected is a particular kind of interactions among students and between students and teacher. The teacher plays a key role in that. This is why teachers need to understand the changes and expectations for learning experiences, in order to give the student opportunities to learn in the intended way. Nonetheless, it is also stated that different factors may influence the learning experiences of students. In order to produce the intended learning experiences in students, teachers ought to be in permanent professional development and use classroom materials for learning, as is suggested in the NSRC principles.

Picture Nº 57

Interactions among students and between students and teacher
IAP, Harlen (2004) inquiry learning[62], p.2,Europe

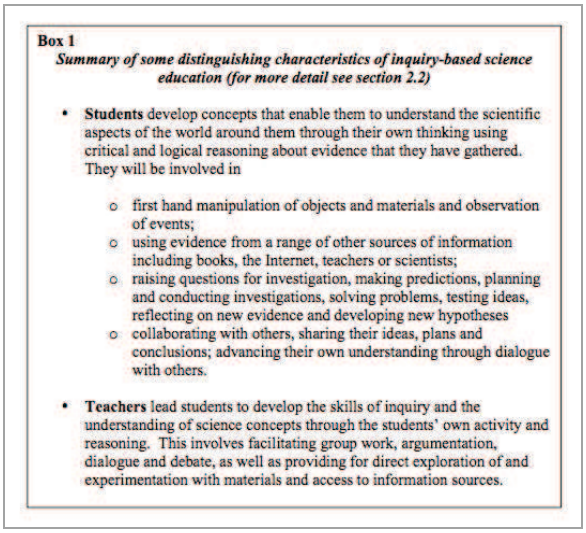
When inquiry-based teaching is practiced, teachers and students are involved in well-defined actions, which differ in several respects from current classroom practice. This paper argues that interactions among students and between students and teachers are needed for inquiry-based learning, with the teacher having a key role. Thus bringing about the required change in students' experiences is a two-step process, in which teachers' understanding of the changes needed is the first step and the provision of opportunities for students' learning is the second. The main avenues for bringing about change are through the professional development (PD) of teachers, or the provision of classroom materials, or a combination of these. When change is attempted through these inputs, there are numerous other factors that impact on teachers, on teaching and on students, that act to dilute – and in some cases cancel- their effect. Thus there is a danger that when inquiry-based inputs are evaluated, the students' experiences may not be as intended.

IBSE promotes an environment that is rich in interactions between students, teacher and materials. Each student will learn supported by others.

Picture Nº 58

Individual development of scientific concepts and activities
IAP report on evaluation, Website Pollen[63], p. 10, Europe

[62] http://www7.nationalacademies.org/BOSE/WHarlen_Inquiry_Mtg_Paper.pdf



Box 1

Summary of some distinguishing characteristics of inquiry-based science education (for more detail see section 2.2)

- **Students** develop concepts that enable them to understand the scientific aspects of the world around them through their own thinking using critical and logical reasoning about evidence that they have gathered. They will be involved in
  - first hand manipulation of objects and materials and observation of events;
  - using evidence from a range of other sources of information including books, the Internet, teachers or scientists;
  - raising questions for investigation, making predictions, planning and conducting investigations, solving problems, testing ideas, reflecting on new evidence and developing new hypotheses
  - collaborating with others, sharing their ideas, plans and conclusions; advancing their own understanding through dialogue with others.
- **Teachers** lead students to develop the skills of inquiry and the understanding of science concepts through the students' own activity and reasoning. This involves facilitating group work, argumentation, dialogue and debate, as well as providing for direct exploration of and experimentation with materials and access to information sources.

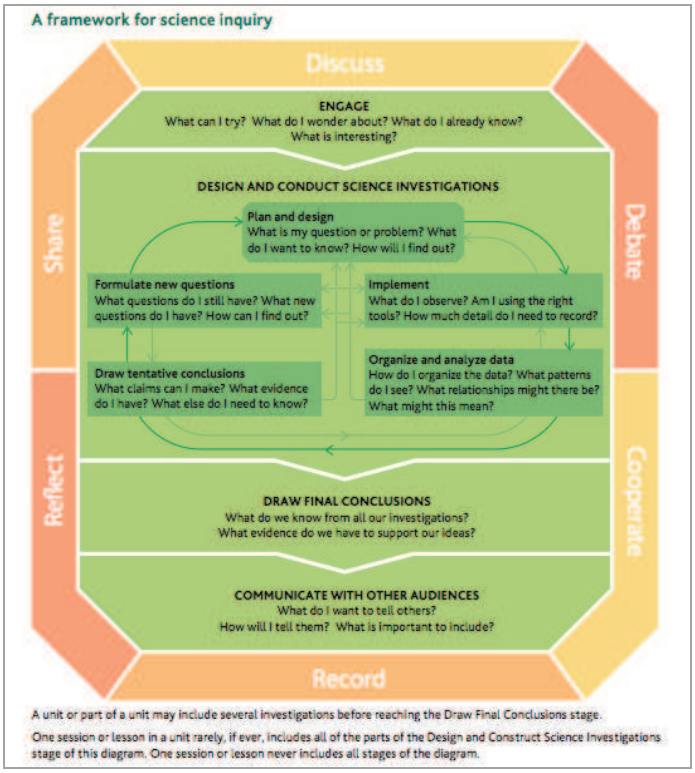
Each student will develop concepts in order to understand scientific aspects of the world around them. They will do this through their thinking. Every learner is expected to use critical and logical reasoning about evidence. In order to do so, every student must be involved in some activities. As it has been explained, one of these activities is that in which each student is engaged in a process of collaboration. Each learner is expected to collaborate with others by sharing ideas, planning and concluding, and to advance in their own understanding in the dialogue with others. As regards the teacher's role, it is said that it is relevant that they should help each student to understand scientific concepts through the students' own activity and reasoning. On the other hand, they must facilitate group work, argumentation, debate and dialogue. It is also important to provide opportunities for directing exploration and experimentation with materials and by providing access to information sources.

Each network approach recognizes the relevance of collaboration between learners to support individual learning. The original Insight framework did not include those dimensions. However, Karen Worth (author), Mauricio Duque (Pequeños Científicos, Colombia) and Edith Saltiel (La main à la pâte, France) redefined the framework as follows:

Picture Nº 59

Pollen framework including interaction
Pollen website, Worth, Duque and Saltiel,(2009), p.10, Europe

[63] http://www.pollen-europa.net/?page=AsiqsHZTASM%3D



In order to learn, children need to reflect on what they did and why they did it, share their ideas with others, discuss each other's views, debate, record and cooperate during all inquiry activities. These activities are seen as needing to be extended in time, which means that one session will rarely be sufficient for all phases and process of inquiry cycle.

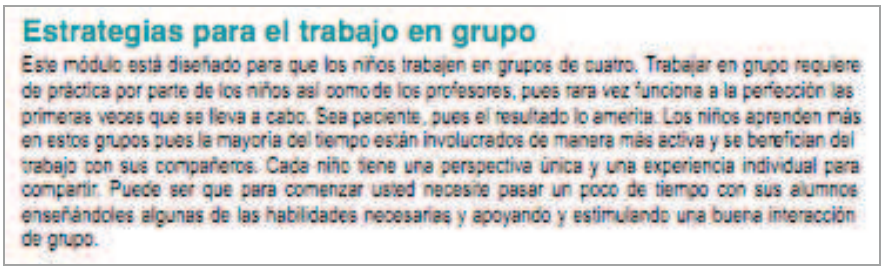
Group work is one of the strategies used in IBSE environments to encourage this expected collaboration. Both collections of curricular materials involve this kind of strategy.

Picture Nº 60

Strategies for group work in Insight tendency
Project Pequeños Científicos, Insight booklet Structures[64], p.12, Colombia

[64] Strategies for group work

This module is designed so that the children work by groups of four. Working in group requires practice by the children as well as teachers, since very seldom it works perfectly the first times that it is done. Be patient, since the result is worth it. Kids learn more in these groups



Estrategias para el trabajo en grupo

Este módulo está diseñado para que los niños trabajen en grupos de cuatro. Trabajar en grupo requiere de práctica por parte de los niños así como de los profesores, pues rara vez funciona a la perfección las primeras veces que se lleva a cabo. Sea paciente, pues el resultado lo amerita. Los niños aprenden más en estos grupos pues la mayoría del tiempo están involucrados de manera más activa y se benefician del trabajo con sus compañeros. Cada niño tiene una perspectiva única y una experiencia individual para compartir. Puede ser que para comenzar usted necesite pasar un poco de tiempo con sus alumnos enseñándoles algunas de las habilidades necesarias y apoyando y estimulando una buena interacción de grupo.

As mentioned above, the booklet is designed in such a way that children will work in groups of four. It is also recognized that children need time to do this properly. Teachers need to be aware of this and be patient while children learn to do it. It is said that children will learn more in these kinds of groups because they will be more active during the activities and they will benefit the work of their peers. Each child has a unique perspective and an individual experience to share. It is assumed that the first time, the teacher needs to spend time with the students in order to teach them some skills needed and to stimulate a good group interaction.

The teacher is recognized as an important guide for discussions. In particular, the role of the teacher is to allow children's own ideas to be part of classroom discussions. All kinds of strategies are presented to teachers in order to achieve this.

The teacher is supposed to go round to each group while they are working. The teacher is also expected to stimulate their investigation. It is also assumed that the teacher will give a particular task to each member of the group. This is said to be important to stimulate the productivity of the group.

Picture Nº 61

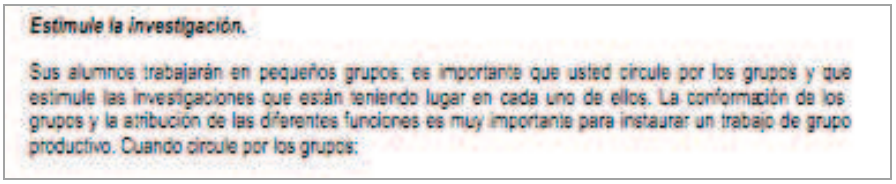
Groups' investigations in Insight tendency
Project Pequeños Científicos, Insight booklet Structures[65], p15, Colombia

---

because most of the time they are involved in a more active way and they take advantage of working with their mates. Each child has a unique perspective and an individual experience to share. It is possible that to start you will need to spend some time with your students, teaching them some of the necessary skills and supporting and stimulating a good group interaction.

[65] Stimulate research

Your students will work in small groups; it is important that you walk around the groups and foster the research that is taking place in each of them. The formation of groups and the attribution of the different functions are very important to establish a productive group work. When you walk around the groups:



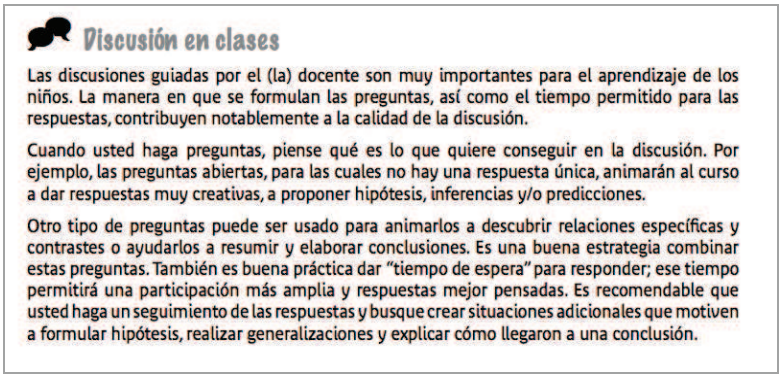
Estimule la investigación.

Sus alumnos trabajarán en pequeños grupos; es importante que usted circule por los grupos y que estimule las investigaciones que están teniendo lugar en cada uno de ellos. La conformación de los grupos y la atribución de las diferentes funciones es muy importante para instaurar un trabajo de grupo productivo. Cuando circule por los grupos:

Discussions are also important and relevant for IBSE. It is not only those that occur while children are working in groups. General discussions involving all the groups and children are also a central part of the IBSE methodology.

Picture Nº 62

Discussions in NSRC tendency
Project ECBI Chile, MEN Chile, Human Body booklet[66], p.12, Chile



Discusión en clases

Las discusiones guiadas por el (la) docente son muy importantes para el aprendizaje de los niños. La manera en que se formulan las preguntas, así como el tiempo permitido para las respuestas, contribuyen notablemente a la calidad de la discusión.

Cuando usted haga preguntas, piense qué es lo que quiere conseguir en la discusión. Por ejemplo, las preguntas abiertas, para las cuales no hay una respuesta única, animarán al curso a dar respuestas muy creativas, a proponer hipótesis, inferencias y/o predicciones.

Otro tipo de preguntas puede ser usado para animarlos a descubrir relaciones específicas y contrastes o ayudarlos a resumir y elaborar conclusiones. Es una buena estrategia combinar estas preguntas. También es buena práctica dar "tiempo de espera" para responder; ese tiempo permitirá una participación más amplia y respuestas mejor pensadas. Es recomendable que usted haga un seguimiento de las respuestas y busque crear situaciones adicionales que motiven a formular hipótesis, realizar generalizaciones y explicar cómo llegaron a una conclusión.

Here what is explained is that discusions guided by the teacher are very important for children's learning. Two aspects are recognized as a contribution to the quality of discusions: The way questions are constructed and the time

---

[66] Class discussion

Discussions guided by the teacher are very important for the children to learn. The way in which questions are asked, as well as the time allowed for the answers contribute enormously to the quality of the discussion.

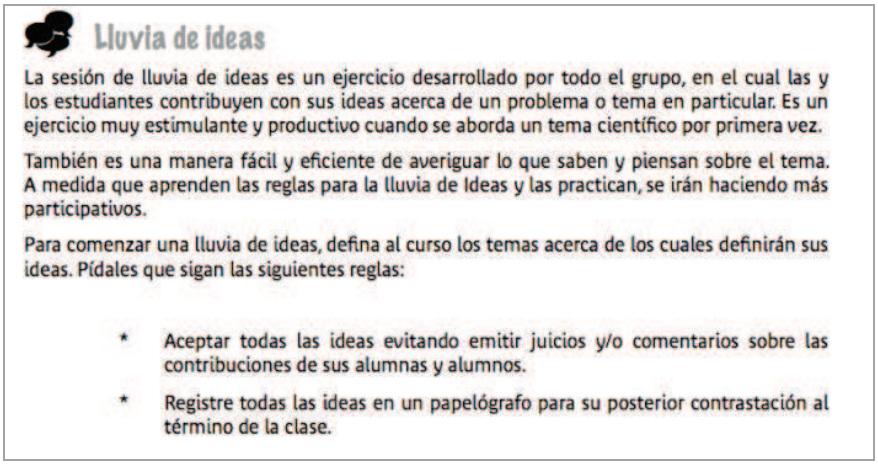
When you make questions, think of what you want to achieve in the discussion. For example, open questions for which there are different answers will encourage the group to give very creative responses, propose hypotheses, inferences and/or predictions.

Other type of questions may be used to encourage them to discover specific relations and contrasts or to help them to summarize and draw conclusions. It is a good strategy to combine these questions. It is also a good practice to "give waiting time" to answer; this time will allow greater participation and well-thought answers. It is advisable that you follow-up the answers and look to create additional situations that motivate the formulation of hypotheses, generalize and explain how they arrived to one conclusion.

given to answer them. In that sense, the teachers need to connect the questions they will ask, thinking about what they want from the discussion. Some examples are presented. Open questions with multiple posible answers are sugested as a way to stimulate creativity, to propose hypothesis, inferences or predictions. It is said that another kind of questions can be used to encourage children to discover relations and contrast or synthetize and come to conclusions. It is expected that when children have time to think about their answers, these will be more developed. Teachers are recommended to follow the answers and to create additional situations that motivate the formulation of hypotheses, generalizations and explanations about the way they arrived at their conclusions.

Picture Nº 63

Strategies to stimulate cooperation in NSRC tendency
Project ECBI Chile, MEN Chile, Human Body booklet[67], p.12, Chile



[67] Brainstorming

The brainstorming session is an exercise developed by the whole group, in which the students contribute with their ideas about a particular problem or topic. It is a very motivating and productive exercise when a scientific matter is addressed for the first time.

It is also an easy and efficient way to find out what they know and think about the subject. As they learn the rules for the brainstorming and they practice them, they will become more participative.

To start a brainstorming session, tell the group about the topics about they will be giving their ideas. Ask them to follow these rules:

- Accept all the ideas, avoiding making judgments and/or comments about the contributions of your students.
- Record all the ideas on a paper wall for their later comparison at the end of the class.

During a brainstorming ("*lluvia de ideas*") session, it is predicted that each child will contribute with their own ideas about the problem or subject of the session that all students are discussing. This kind of exercises is expected to be particularly productive when a subject is introduced for the first time. Likewise, it is envisaged that the teacher will inquire in that way about what the children know and think about the subject. Thus, little by little, the children will learn to be more participative and active. Some practical advice is given to teachers: to accept all kinds of ideas without judgments or comments, and to record all their contributions in order to contrast them when the session is finished.

Other moments when the teacher can establish a discussion are also identified: in smaller groups different from the whole class. It is suggested that discussions allow children to reflect about what they already know, use their assumptions and convictions, learn from the others and improve the art of communication. It is also said that those moments facilitate the teacher's assessment of the student's knowledge, determine what they know and what they have learned. Some suggestions are given about how to achieve what is expected. Discussions are seen as moments of dialogue, an interchange of ideas between students and also with the teacher.

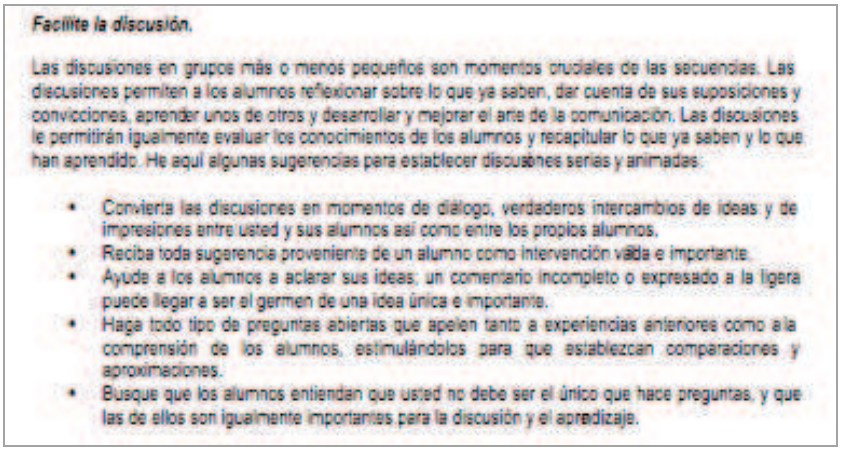
Picture Nº 64

Strategies to stimulate cooperation
Project Pequeños Científicos, Insight booklet Structures[68], p. 15, Colombia

[68] Facilitate Discussions. Discussions in relatively small groups are crucial moments of the sequences. Discussions allow the students to reflect on what they already know, account for their assumptions and convictions, learn ones from others, and develop and improve the art of communication. Likewise, discussions will enable evaluating the students' knowledge and retake what they already know and what they have learned. Here are some suggestions to establish serious and exciting discussions:

- Make discussions moments of dialogue, actual interchanges of ideas and impressions between you and your students, as well as between the students themselves.
- Receive all suggestions from the students as a valid and important intervention.
- Help the students to clarify their ideas; an incomplete comment or lightly expressed may be the origin of a unique and important idea.
- Make all kinds of open questions that refer both to previous experiences and to the understanding of the students, motivating them to make comparisons and approximations.

Try to make the students understand that you must not be the only one who asks questions and that their questions are equally important for discussion and learning.



Facilite la discusión.

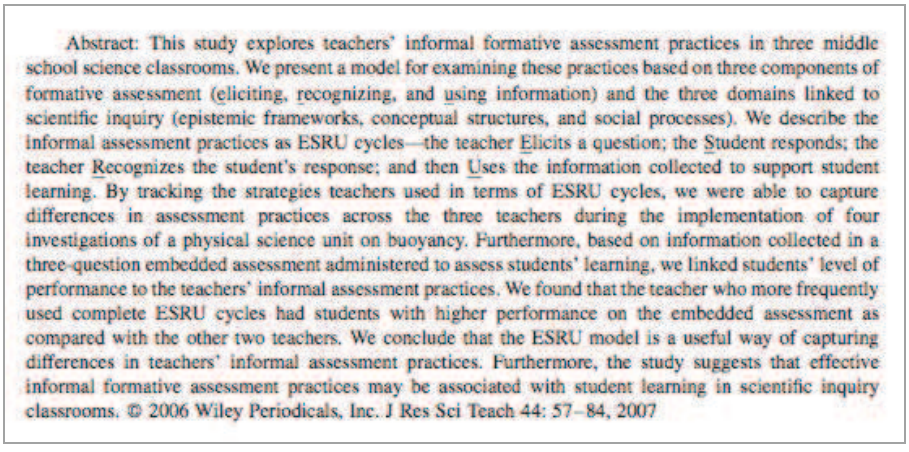
Las discusiones en grupos más o menos pequeños son momentos cruciales de las secuencias. Las discusiones permiten a los alumnos reflexionar sobre lo que ya saben, dar cuenta de sus suposiciones y convicciones, aprender unos de otros y desarrollar y mejorar el arte de la comunicación. Las discusiones le permitirán igualmente evaluar los conocimientos de los alumnos y recapitular lo que ya saben y lo que han aprendido. He aquí algunas sugerencias para establecer discusiones serias y animadas:

- Convierta las discusiones en momentos de diálogo, verdaderos intercambios de ideas y de impresiones entre usted y sus alumnos así como entre los propios alumnos.
- Reciba toda sugerencia proveniente de un alumno como intervención válida e importante.
- Ayude a los alumnos a aclarar sus ideas: un comentario incompleto o expresado a la ligera puede llegar a ser el germen de una idea única e importante.
- Haga todo tipo de preguntas abiertas que apelen tanto a experiencias anteriores como a la comprensión de los alumnos, estimulándolos para que establezcan comparaciones y aproximaciones.
- Busque que los alumnos entiendan que usted no debe ser el único que hace preguntas, y que las de ellos son igualmente importantes para la discusión y el aprendizaje.

All the students' suggestions should be taken into consideration and treated as an important contribution. Teachers are also supposed to help the students to clarify their ideas: one incomplete idea or comment can be the source of an important and unique idea. It is also relevant to make open questions that appeal to their previous experiences and comprehension. Children are supposed to ask questions during the discussions.

Picture Nº 65

Informal assessment and interactions
Research article, Ruiz-Primo and Furtak (2006), p.57, USA



Abstract: This study explores teachers' informal formative assessment practices in three middle school science classrooms. We present a model for examining these practices based on three components of formative assessment (eliciting, recognizing, and using information) and the three domains linked to scientific inquiry (epistemic frameworks, conceptual structures, and social processes). We describe the informal assessment practices as ESRU cycles—the teacher Elicits a question; the Student responds; the teacher Recognizes the student's response; and then Uses the information collected to support student learning. By tracking the strategies teachers used in terms of ESRU cycles, we were able to capture differences in assessment practices across the three teachers during the implementation of four investigations of a physical science unit on buoyancy. Furthermore, based on information collected in a three-question embedded assessment administered to assess students' learning, we linked students' level of performance to the teachers' informal assessment practices. We found that the teacher who more frequently used complete ESRU cycles had students with higher performance on the embedded assessment as compared with the other two teachers. We conclude that the ESRU model is a useful way of capturing differences in teachers' informal assessment practices. Furthermore, the study suggests that effective informal formative assessment practices may be associated with student learning in scientific inquiry classrooms. © 2006 Wiley Periodicals, Inc. J Res Sci Teach 44: 57–84, 2007

Assessment for learning research recognizes the relevance of interaction for individual learning. In the USA line of research, Ruiz-Primo and Furtak (2006)

have explored this issue further. Some components of informal assessment during class discussions are identified. Teacher asks questions (elicit), children answer and he/she recognizes the student response, and he/she uses the information collected to support learning – ESRU Cycle. They also identify three inquiry domains that the teacher needs to be aware of: epistemic frameworks, conceptual structures, and social processes. The first is related to the norms and ways that knowledge is validated and evaluated during the inquiry process, how this or another answer, argument or idea is supported by empirical evidence. The second refers to the conceptual structure that is part of scientific knowledge, and the last is connected to the social mechanisms used to communicate knowledge. The combination of ESRU Cycle and the three dimensions were identified as a way to support learning.

For Ruiz-Primo and Furtak (2006) conversation is an important part of the IBSE assessment environment. The aim is to close the gap in individual learning with the intended goals.

Picture Nº 66

Strategies to stimulate cooperation
Research article, Ruiz-Primo and Furtak (2006), p.60, USA

Informal Formative Assessment and Classroom Talk: Assessment Conversations

Ongoing formative assessment occurs in a classroom learning environment that helps teachers acquire information on a continuing and informal basis, such as within the course of daily classroom talk. This type of classroom talk has been termed an *assessment conversation* (Duschl, 2003; Duschl & Gitomer, 1997), or an instructional dialogue that embeds assessment into an activity already occurring in the classroom. Assessment conversations permit teachers to recognize students' conceptions, mental models, strategies, language use, or communication skills, and allow them to use this information to guide instruction. In classroom learning environments in which assessment conversations take place, the boundaries of curriculum, instruction, and assessment should blur (Duschl & Gitomer, 1997). For example, an instructional activity suggested by a curriculum, such as discussion of the results of an investigation, can be viewed by the teachers as an assessment conversation to find out about how students evaluate the quality of evidence and how they use evidence in explanations.

Summarizing, assessment conversations during daily activities are conceived as the way to recognize students' conceptions, mental models, strategies, language used, or communications skills. Teachers are recommended to use talk information to guide instruction. Particular attention is paid to the quality of the investigations and particularly to the way children evaluate the knowledge coming from the experiences in classroom. For instance it is relevant to see by means of assessment strategies whether students are using evidence to support their explanations.

ACTION 4: IBSE AND ASSESSMENT FOR LEARNING INDIVIDUALISTIC CULTURAL SENSIBILITY

The final analysis in this chapter, identified as an action in Leontyev's terms, is the most important for my process of critically reviewing my assumptions, and also identifying the collective assumptions. The goal of the analysis was to make a link between these ideas and reasoning and the group of theoretical assumptions on children's learning and development discussed in Chapter four. During the process I became aware of the way the assumptions became part of my awareness because of my participation in the social praxis. The language used in the artefacts are supported by those assumptions, but are not explained. Only by doing this analysis did I start to become critical of my own assumptions.

I have demonstrated that when IBSE designers plan an inquiry teaching-learning sequence and researchers envision assessment tools and models, a phenomenon is chosen as the object around which the child conducts his or her inquiry activities. Researchers and curricular designers have some learning expectations or goals in relation to the knowledge that will be learnt by the child through this inquiry process. Assessment for learning research provides designers with theoretical tools that they use in the construction of teaching-learning sequences.

If assessment is conceived to help the learning process, what counts as evidence of learning? How are the expressions and actions of the child considered as evidence of learning? In which conditions is the evidence constructed? Which assumptions support the interpretation and judgments? Which role is it assigned to the interactions in the assessment process? How do assessment researchers and designers include this aspect in the construction of learning evidences? How is that evidence judged? These questions guided my inquiry about dominant discourse and the construction of this chapter. I assumed that the evidence of learning was focused on the individual child and the individualistic cognitive perspective was dominant. The relation of the child with the situation and social activity was not part of dominant discourse.

Some elements are central in the dominant discourse: enhancing learner knowledge by prompts, evaluations, notebook, and talks; to recollect information about each learner as *evidence of learning*; the *interpretations* of evidence based on theoretical constructs such skills to characterize individual process of learning through criteria and indicators; and *feedback* to each child based on *judgments* comparing the evidence of his or her process with intended goals.

The child is confronted with a sequence of facts such objects floating and sinking. During learning activity, the child will express his or her own

explanations and thinking connected to those facts. Teacher assessment responsibility is to enhance these learner's ideas, and judge them making a contrast with expected learning goals. The judgments are produced when learner's ideas and actions are compared to those that are accepted by a scientific community or learning goals, considering the child's developmental levels. The teacher modifies his or her teaching activities based on the gap that he or she has found and provides feedback to support changes in the child's ideas. The learning goals and the way to reach them are discussed, shared and changed in an explicit way by teacher and learners.

The interpretation of the information and the judgment is supported by constructivist assumptions on learning. The goals are focused on the child's process skills, uses of scientific content and attitudes towards science. Process skills involve the capacity of the individual to make observations, create hypotheses, predictions, experiments or investigations, communicates results and conclusions. This is related to the idea that child own ideas will only change when they are challenged by experiential evidence: The child needs to experience by him/herself why his/her own theory does not work. The concepts expressed in the goals are needed to support the inquiry process (possible because of skills), this will not happen without them: a hypothesis involves concepts and connections between them.

The analysis in this chapter allows me to affirm that the dominant discourse in IBSE Network is supported by various individualistic assumptions about development, learning, knowledge and thinking. My hypothesis is that socio-constructivist assumptions shape the dominant discourse. I found that the dominant discourse uses expressions and ideas that resonate with Piaget's genetics approach to development and learning, as well as with particular interpretations of Vygotsky's Zone of Proximal Development – ZPD, mediation discourses, and individual cognition. Although some socio-cultural language is used, the interpretations seem to be individualistic in the end.

For instance, learning evidence for researchers are changes in the ideas and actions of each learner interpreted as conceptions, alternative frameworks, misconceptions or naïve conceptions as well as mental models, according to the individualistic perspective. The child has in mind ideas, theories and explanations, as well as inquiry reasoning expressed in his/her own language. This is coherent with assumptions about the existence of a hypothesis that the child does not communicate and mathematical and scientific reasoning following a natural line of development independent from learning. Inquiry thinking could be conceived as a process, which aims at adapting to the environment. The evidence collected will be the environmental feedback that is needed by the individual to develop the natural developmental laws of thinking, according to Piaget.

Learning occurs when these innate ideas change in the light of inquiry thinking: based on evidence from experiences and experimentation that do not support his/her existing ideas, when a conceptual change is observed: ideas about natural and made worlds change towards more accurate approximations which are similar to ideas expressed in the scientific community. Somehow, the child experiences the world following his or her internally culturally detached thinking. The child's ideas are seen as independent of social and cultural forces. The interpretations are supported by the assumption of the existence of internal inquiry thinking following the natural line of development independent of cultural language and ways of reasoning: Speaking and producing are reduced to the individual, subjective intention of the child, externalizing ideas previously formed on the inside. Knowledge is viewed as independent of the situation. The child has ideas that are used in different situations independently of the social activity in which he/she is acting, Knowledge is independent of culture and historical forces.

Another important assumption originating from constructivism that makes operational the dominant discourse is the need of mediation in order to learn. Based on Vygotsky's ideas, it is clamed that the learner learns while he or she interacts with other learners and with the teacher. Thus, for purposes of assessment, the conversations in class are relevant in order to achieve individual's conceptual change. The purpose of assessment conversations is to support each learner in the process of changing his or her ideas. This is expressed as the necessity to share goals with students, to decide with them the steps to change and reach the goals. In other words, to make visible to each learner the indicators and process of judging whether the learner is learning what is expected to be learnt.

The interaction with phenomena, peers and teacher can be interpreted as feedback from the social and physical environment to accommodate and re-equilibrate the mental structures. Interaction can be also viewed as the opposition of individuals engaged in an inter-mental or inter-psychological exchange, and the child constructing knowledge by him or her self on an inter-mental level, as Roth and Radford (2010) described as part of the individualistic perspective of ZPD.

Another characteristic of IBSE Network dominant discourse is that the learner constructs his/her own knowledge based on his or her previous ideas, as constructivism claims. The fundamental idea is to support learners in this process of de-construction and construction of their own ideas. The aim is to follow each learner in his or her conceptual change: it is expected that their own ideas or explanations about natural and made worlds will evolve into more accurate ones. That means: learner's new ideas will fit with evidence presented and will be analyzed by him/herself. By examining the evidence of particular events, the learner will support his or her own ideas or re-construct them. The

learner's ideas are connected with events and facts that happen within natural and made worlds. Assessment will be the tool to support the child's construction of big ideas in connection with the phenomenon. In this approach, it seems that the cultural and social forces involved in the learning process are not considered. A dominance of the innate and natural laws of development can be assumed. The child's ideas are considered independent from culture; all children from different parts of the world have the same kind of ideas. The historicity of thinking and knowledge is not considered at all, nor the connection of the individual with the social activity in which he or she is involved.

Another important element in dominant discourse is the constructivist model operating when inquiry processes of learning are in place. Learning through Inquiry means that the child will be able through an hypothesis or idea about a phenomenon; plan, design and develop an investigation to provide evidence to support the hypothesis; contrast his or her ideas and hypothesis with evidence; conclude and change his/her ideas when they does not fit with evidence or, on the other hand, strengthen their ideas.

What is postulated is that an individual learns when the conceptual structure that the learner has is questioned by the learner him or herself and in the case where it does not work anymore, is seen as having to change. The role of interactions in the assessment activity maybe interpreted as a possibility to generate the environmental feedback for adaptation and to argue his/her own position to see the reaction of the environment. The role of socio-cultural context and situation in which the child is involved is not considered in the model nor are the different meanings and interpretations that the individuals can develop in relation to the activity in which they are involved. In the Pollen Guide for teachers there is a principle stating that not every body sees the same. This could be interpreted as being based on socio-cultural assumption. How ever, the focus of learning is on a change of the child's own ideas that he or she has in mind. Knowledge can be interpreted as detached from situations following the fact that the ideas are in the mind and not produced in the context.

UNDERSTANDING THE PROBLEMATIQUE

I have analyzed researcher's texts with three aims in relation to the problematique. First, I aimed at understand how researchers used the assumptions and ideas that I found in Chapter four, and that I named as cultural sensibilities. I found a tendency of researchers and curricular designers to built their research objects with languages that are in resonance with individualistic cultural sensibility. It is what I called the dominant discourse. Second, I aimed at identify my own ideas and forms of thinking in researchers and designers texts. I

have identified my cultural sensibility as individualistic. Third, I aimed at understand how classroom activities were conceived by researchers when adopting the individualistic cultural sensibility. I described different elements that researchers use to imagine assessment for learning activities.

In this chapter I have organized some text-pictures in order to constitute the dominant discourse Assessment for learning and IBSE. I have used some categories that allow me to follow specific line of thinking. On the one hand, to focus attention on aspects present in the language —expressions, words and assertions— that are problematic when some philosophical ideas and socio-cultural perspectives are adopted —a view connecting human beings, perception, experience, phenomena, experimentation, and reality, natural and made worlds. On the other hand, there are some typical activities expected in assessment research discourse that allow me to see an individualistic tendency in discourse. I have shown how the way evidence of learning is constituted and the theoretical constructs to support the interpretation and judgments can be based on an individualistic perspective even though the meditational character of teacher and peers are strongly present in the discourse. In the end, what is relevant is the conceptual change interpreted as changes in mental structures. The situated characteristics of cognition, the cultural and historical accounts of knowledge, the role of institutions and power relations, and the mediation of cultural tools are not at the center.

These two dimensions of my analysis will be used in the following chapters. In Chapter six, I de-naturalize the "common sense language" of IBSE and assessment for learning. In Chapter seven I give meaning to the context showing what is possible and what is not in particular time and space, and in Chapter eight I present several tensions which arise when the individualistic perspective is assumed and the socio-cultural perspective is used to analyze classroom situations. These analyses constitute the basis to proposing the Socio-cultural perspective for Assessment for learning and IBSE discourse.

I selected text-pictures from documents (principles, curricular material, frameworks, and research documents) on inquiry-based teaching and learning. In order for a teaching practice to be considered inquiry-based, some elements must be present: children are expected to be in contact with the natural and made worlds by directly perceiving phenomena and using materials for this; different kind of children's experiences, ideas about the world, conceptions and theories are part of the teaching and learning; experiments to test child ideas are expected to take place; and interaction of the child with peers and teacher are part of every day activities in the classroom.

Assessment for learning discourse builds on these elements in an inquiry-based practice: The learning goals to be the guide of assessment are stated as individual process of learning (e.g., skills, conceptual knowledge, procedural knowledge, schematic knowledge, strategic knowledge). Child explanations,

theories and ideas of phenomena are at the core of information and learning evidence that is examined by assessment strategies. Experimental skills must be also followed by assessment; and interactions are an essential part of the assessment strategies in order to close the gap in mental models, language and skills.

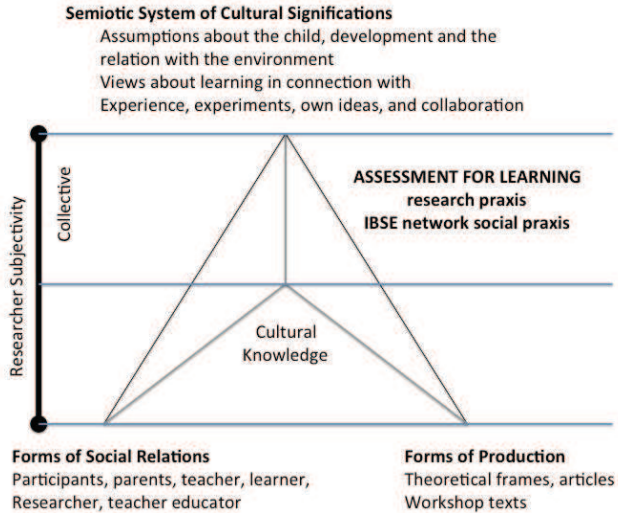
The dominant discourse is constituted by these ideas and reasoning: The child perceiving the natural and made worlds, and phenomena; the child constructing and having ideas and theories about natural and made worlds and phenomena; the child changing his/her ideas by making experiments; and the child changing ideas and supporting his/her ideas by interacting with others. The goal of assessment activity is to ensure a change in the child's ideas about the natural and made worlds and phenomena and his/her inquiry skills.

In the previous sections of this chapter I presented some pictures in order to introduce the IBSE Network practice, some characteristics of IBSE Network discourse in relation to inquiry-based teaching and learning, and assessment for learning research discourse. I used text-pictures from different kinds of documents that circulate in the IBSE Network. I expected that the selected documents be used to support and guarantee the practice of inquiry at schools, and at the same time, to help teacher educators and teachers consolidate their configurations of inquiry-based classroom activities. To conclude this chapter and in relation to my investigation, I present a selection of elements of the discourse that seem to be naturalized as part of the discourse of IBSE and assessment for learning. By saying this I mean that in my subjectivity, those elements had become my "natural language" or "common sense". In the languages, ideas and reasoning presented, there is no explanation, and the variety of interpretations, based on previous experiences, is not considered.

In the next illustration I organize my observations around Radford and Empey's (2007) representation of social praxis. In the illustration I recognised that my own subjectivity was shaped by the ideas and reasoning which emerged from the analysis. This was possible because all those activities shared in the social praxis of the network with different actors and forms of relationships, as well as theoretical frameworks, articles and workshop texts that are shared. I also represented in the left part of the picture the link between my subjectivity and the subjectivity of the assessment for learning and IBSR researchers and designers. I used the word collective to present this point.

I identified under Semiotic System of Cultural Significations the assumptions about the child, development and child interactions with the environment, as well as views about learning in connection with the words experience, experiments, own ideas and collaboration. During the analysis in the next chapters I will question some of the statements that make part of the Semiotic System of Cultural Significations, and that I described previously. My relation with participants of the IBSE Network is what I represented as Forms of

Social Relations that were described during the analysis. I learned my individualistic sensibility in interaction with them. The frames, the articles and other artefacts circulating in the IBSE Network, and that were use for the analysis in this chapter, were identified as Forms of Production. Finally, I consider that in the network we shared a cultural knowledge that has been produced by researchers and designers, as well as practitioners in the IBSE Network.



Graph Nº 2. Representation of the researcher subjectivity immersed in the collective social praxis of the IBSE Network

The ideas and reasoning were selected because they resonate with assumptions about the child and his or her development as well as the relationship with the environment. This view of learning included words such as experience, experiment, own ideas, and collaboration. These were the elements that guided my analysis. After that, I developed the hypothesis that dominant discourses of assessment for learning and IBSE are supported by an individualistic view although some elements of socio-cultural tendencies can be recognized. This is what is called socio-constructivist. In Chapter ten I will develop this idea.

6. Sensibility Space Three: De-naturalizing

Imagine two human beings talking about a particular event somewhere on Earth. The event relates to something that can be perceived by their senses. One of the human beings has a round object in his hand while he walks. Then, he removes another object, a little red cylinder from the inside of the round object, and points towards it. The other human touches the first one's head. Two humans are experiencing an activity.

If the cartoon above[69] represented that situation, we can imagine this experience produced feelings, emotions and interest. We can see that reflected in their gestures. They are expressing something. The boy looks at the man in the eye enthusiastically. The man is looking at the boy with interest. The man touches the head of the child and smiles. Then he puts his hand on his chest: this shows affection. Something strongly emotional is happening between these two bodies. We can also have a feeling that there is particular relation between those bodies. We may as well attribute a cultural meaning to the objects in the situation: there is a clock, a battery, a newspaper and a chair. What are they talking about?

[69] Cartoon published in the Colombian news paper, El Tiempo (Quino, 2006). In this picture I have removed the captions in each frame.

We can imagine many possibilities of dialogue around the objects present in that situation. Even though their bodies are surrounded by sensations, the words they can use and the way their body moves make particular sense of facts and events perceived by their senses. Let us see the words that Quino, the cartoonist, imagined for the sequence:

QUINO's cartoon from EL TIEMPO

tomado del Periódico EL TIEMPO.

2

Box 1:[70] LOOK DADDY, I WILL SHOW YOU AN EXPERIMENT

Box 2: WE TAKE OUT THE BATTERY FROM THE CLOCK AND...

Box 3: THE CLOCK STOPS COUNTING THE TIME!

Box 4: WE PUT THE BATTERY BACK AND...

Box 5: ...UPS! THE CLOCK CONTINUES COUNTING THE TIME! WHAT DOES THIS CLEARLY SHOW US?

Box 6: THAT TIME IS NOT IN THE CLOCK, AS ONE BELIEVES; TIME IS INSIDE THE BATTERY, AND THE CLOCK ABSORBS IT FROM THERE!!

Box 7: WOW! HOW ADMIRABLE! DID YOU DISCOVER THIS BY YOUR SELF?

Box 8: NO, THE TRUTH IS THE PHYSICS TEACHER TAUGHT IT TO US TODAY AT SCHOOL.

Box 9: AS FUTURE IS GETTING DIFFICULT... WHAT A RELIEF IS IT TO KNOW THAT I AM PAYING THE BEST LEVEL EDUCATION FOR MY SON!!

From multiple choices of languages, the son uses one that directs us towards a rational thinking, which is found in scientific culture. However, something is not

[70] Taken from the newspaper EL TIEMPO, Saturday October 18, 2006 QUINO (2006)

coherent in his argumentation. Why does this cartoon strike our thinking? Why is it funny? Where are the contradictions that make the son's thinking incompatible with ours? Different reasons are making each one of us smile. He is talking about his experience in relation to real objects or artifacts built by humans. He makes specific sense of the situation and communicates it. He also says that he learned about the experiment at school with the physics teacher, and also mentions his thoughts based on his experiences outside school. He uses a rational thinking supporting his arguments on evidences; he makes experimentation to test his own ideas. He uses cultural thinking available in everyday language, and he is showing a phenomenon. However, the argumentation is bizarre because we know that time is an abstract concept and it is not "contained" in a battery.

Imagine a world without human beings. How would the world look like? Will it be the same, as we human beings perceive it? These simple questions seem easy to answer: Of course! The world can exist without humans. Animals, plants, water, and sun will be there. When humans are on that world something appears between the world and humans. Humans' desire to know the world: Humans producing knowledge about the world. Knowledge is based on the way humans perceive the world, how they experience it, and the language they use to build their own reality.

By looking at the sequence presented in the cartoon without words, we can see a representation of events happening in the world. We can describe what we see differently from the first description we did, by using our cultural knowledge and the language used by Quino: a little person walking with a clock in his hand, an adult sitting on a chair with a newspaper in his hand, something happening with the clock and between those people. We can imagine other things from the world happening there although they are not represented in the picture: the sound of the voices, steps, paper, light, smells, diversity of textures, etc. At the same time, we can perceive changes in the bodies: open eyes and mouth, different body positions and facial gestures. We can also interpret those changes as an expression of feelings. The interpretation we made of a situation is supported by our cultural way of perceiving.

In the cartoon containing words something different appears. Those humans are experiencing something that is particular to them. They are interacting with the elements of the made world and talking about them. Those elements of the world are presented in the situation in a specific way by language. Language generated by voices and by their body gestures, showing an affective dimension of humans: bodies engage in making events happen. Language produced by voices. Those new elements give a particular meaning to the situation for those two human beings, and for the readers of the cartoon. Language expresses something about the made world: the clock, the battery; and from the social world, time. Another dimension is evocated through the words: school, teacher, physics and education. A social world becomes strongly present. Humans interacting within organizations: school, family. The two humans became a son and a father. The father expressed his trust in what paying for a high level education can do for his son. Values and norms also appeared there.

When I was analyzing the texts of the IBSE Network, I noticed some words that were part of the language used in the texts that I had never questioned, as if those words had an intrinsic clear meaning for everybody: experience, phenomena, and experiment. The analysis of Quino's cartoon shows how I was trying to make sense of the 'social' in relationship with the child, his everyday experience, experiment and phenomena. I wanted to think as a socio-cultural scholar. When I was reading socio-cultural scholars' texts in science education, I became aware that the role of language in learning and the relation with knowledge was crucial to understanding the differences between the individualistic perspective and the socio-cultural one. This sensibility space was built to allow me to explore the differences, and to adopt some socio-cultural assumptions to think about my world. I have called the process of gaining a new sensibility *de-naturalizing*. That is, taking a distance to what seemed natural to me in order to 'strange' and question what I had taken for granted before. De-naturalizing core elements of the dominant discourse of IBSE, and assessment for learning, means to begin a movement of my subjectivity towards the socio-cultural sensibility.

In order to delimit some problems and tensions emerging when the socio-cultural perspective is adopted, I analyze words and sentences that are taken to be natural in the dominant discourse of assessment for learning and IBSE. In the first part of the chapter, I present some methodological considerations about the analysis carried out in this chapter. In the second part, I focus on the relation between the child, perception, reality, experience, experiments, phenomena and observation, as part of the dominant discourse. It is what I call naturalizing the dominant discourse. At the same time, I state possible assumptions behind those ideas, posing a problem question in the light of socio-cultural assumptions. Those possibilities are what I called the process of de-naturalizing. To close, I summarize problems and tensions arising from the analysis.

THEORETICAL AND METHODOLOGICAL CONSIDERATIONS

This sensibility space represents a third dimension of my analytical process. It is a space to question my 'natural' ideas and reasoning guiding my individualistic sensibility, and also, to question the collectivity's ideas of IBSE scholars. I saw that the theoretical constructions in assessment for learning gave great importance to getting evidence about the changes of the child's own ideas. In other terms, assessment supported conceptual change in the individual mind. The expression 'the child's own ideas' started to become unclear to me: What were researchers talking about? What does it mean to have my own ideas? Particularly, this analytical process represents the first disturbing moment of my change processes. Until now, I presented my awareness of socio-cultural assumptions and the differentiation of the individualistic. However, I did not have those socio-cultural assumptions in me.

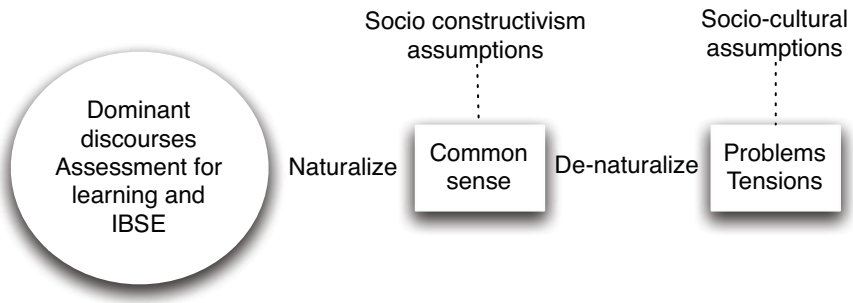
Indeed, what I believed 'to be' appears not to be! It was then a difficult moment, since my own certitudes as a teacher educator were moved! My workshops, my way of teaching, and my perception of the truth started to be really uncomfortable. In terms of Radford and Empey's (2007) representation of cultural knowledge, this is a moment of disturbance of my subjectivity in the dimension of Semiotic System of Cultural Significations: a change in my beliefs about learning, the child and the relation with the natural world. I recreate in this sensibility space part some the considerations of my everyday activity researching assessment for learning in IBSE, directing my attention towards words that will be inquired and questioned.

In Chapter five I shaped the dominant discourse in assessment for learning and IBSE. I found that one of the foundations of that discourse is the idea that children experience the world and possess natural ideas about it. In

other words, the child produces reasoning about natural phenomena. It is also relevant to mention that the way in which IBSE-science teaching expects to change those ideas into more scientifically accurate ones is by allowing children to experience and experiment with phenomena in the classroom. I started to question myself about the possible interpretation of those aspects that characterize dominant discourse. The first question is about the assumption behind experiences shaping children's ideas. I also wanted to explore the relation between children's perception and the natural and made worlds. Then, I analyzed the notion of phenomena, and I looked at the child's explorations of phenomena in their daily life, assumed to be the source of children's scientific knowledge and ideas.

This analysis is represented in the Graph Nº 1. In the left corner there is the dominant discourse. The process to find those core ideas of the discourse and the assumptions behind them is what I called 'naturalization' and action process number one. I argue that the core ideas and assumptions constitute a common sense of the individualistic view. In other words, those ideas are part of the cultural sensibility of scholars in the field of assessment for learning and IBSE. It is a set of core ideas that have been naturalized and taken for granted as being the central building blocks for the whole theoretical apparatus and the deriving practices of assessment for learning in IBSE. Such set of ideas is built mainly on socio-constructivist assumptions of learning.

If a set of core ideas is taken for granted, it is also possible to question such core. The process of 'de-naturalization' refers to using socio-cultural assumptions to look at the naturalized core ideas of the common sense. This is the action number two. The process of de-naturalization stands on the adoption of a different theoretical foundation, namely socio-cultural assumptions on learning.



Graph Nº 1. Representation of the Methodological process

No discourse has all its core ideas made explicit in one single declaration document. It has been my analysis as a critical researcher, and the identification of my own ideas as practitioner, that guided the analysis. In this process, teasing out different reflections on the Quino cartoon discussed before was a concrete strategy that helped me formulate questions about what discourses are taking for granted. Words as experiences and phenomena appeared to be clear and delimitated in meaning. I asked some questions: What is the phenomenon that the son is looking at and how is the process of looking at the phenomenon? How do the experience and experimental process happen? What is the role of language in the experiences and constitution of phenomena? I turned to philosophy and socio-cultural theories to try to answer those questions. I also interviewed a physicist to discuss her perspective on those issues. By doing that, I started to see problems and tensions arising when a particular set of assumptions is used.

ACTION 1: NATURALIZING

In Chapter five I presented what I found in artifacts of the IBSE Network. In this part of the chapter I continue the analysis by making the link between the observed ideas and my ideas that will be questioned. During my inquiry, the action —naturalizing— had the goal to find evidences in IBSE scholars' texts about my certitude that assessment for learning and IBSE was guided by knowledge coming from research on misconceptions, naïve theories and child's everyday ideas about natural phenomena. I found evidences to support my claim that those fields of research were guided by the individualistic cultural sensibility. I also found my own assumption and ideas in the collective of practitioners. Here I focalized some aspects of my ideas that will be questioned in the following analysis.

My first truth that I was looking for evidence in IBSE artifacts was my idea that 'children reason about phenomena in everyday life, and that this truth supports inquiry-based teaching'. Indeed, I always started my workshops by looking for information showing me the ideas of phenomena in the teachers' own mind —I also expected adults to have their own ideas about phenomena when science education fail to change them— and I found them. I bring to this text sentences from the Pollen guide supporting primary teachers teaching trough inquiry, as evidences of the existence of such truth —children reason about phenomena in everyday life— and also in the scholars' texts.

THE CHILD REASONING ABOUT PHENOMENA BASED ON EVIDENCES —OWN IDEAS—

> Many children see the eye as a receptor, rather than an active medium and, in order to see an

> Likewise, in electricity, a number of children can be seen to believe that putting a light bulb on a battery pole

object, they think that they need something to move from the eye to the object. They, like our ancestors, have a lot of trouble accepting that, in order to see an object, light (which is invisible) must move from the object and enter the eye. The children base their reasoning on the fact that, when light is shone directly in the eye, it is blinding. It takes some time until they can distinguish between looking (to see an object, one obviously needs to look at it) and the light from the object that enters the eye. (Saltiel, 2006, p. 15)	is enough to light it up. There is nothing quite like letting them experience the phenomena on their own, so that they see the lamp will not shine. Later, many of them think that electricity comes out of the poles, to enter the circuit (some specify that, when the two come together, this is what makes the light shine). It is important to ensure that the children can clearly state that viewpoint and ask them to later explain why, when there are three light bulbs in a row, all three shine. (Saltiel, 2006, p. 15)

Table Nº 1. Scholars' texts evidencing my same own idea that 'children reason about phenomena in everyday life, and that this truth supports inquiry-based teaching'

It appears in those two paragraphs that children have reasoning or ideas about phenomena. This kind of reasoning is based on evidences and facts, as scientists built their reasoning: "The children base their reasoning on the fact that, when light is shone directly in the eye, it is blinding", "they, like our ancestors, have a lot of trouble accepting that, in order to see an object, light (which is invisible) must move from the object and enter the eye", and "The children base their reasoning on the fact that, when light is shone directly in the eye, it is blinding". I could draw a parallel between this reasoning and the son's statements in Quino's cartoon: For the son, the fact that the clock stopped when the battery was out, supported his new reasoning. In those examples I see reflected my truth and belief that children reasoning is based on facts and evidence, and that children can modify such reasoning when they collect new evidence.

The second idea that I had in my 'mind' was that children do experiments to test their own theories. Somehow they were collectors of facts and evidences and constructers of theories. I found this kind of reasoning to be as truth in curricula material for supporting teachers training workshops to introduce assessment for learning principles, and in the Pollen guide for teachers.

THE CHILD MAKING EXPERIMENTS AND HAVING INQUIRY EXPERIENCES

Children have very good recollection of the experiments they conduct themselves. In addition, very early on, they have ideas about a number of phenomena. Most often, it is not enough to tell them that a given experiment will yield a given outcome (without doing the	In order to help students have productive inquiry experiences in which they express and test ideas that can lead to new scientific understanding, teachers need to check in and offer guidance in every phase of the process. To do their investigations, students must be able

experiment or just showing it to them), or to tell them that what they think is full of mistakes. They need to reach this realization themselves, hence the need to let them test the experiments they have come up with themselves (provided that this can be done in a classroom setting) and let them substantiate their methods amongst themselves. (Saltiel, 2006, p. 6)	to ask questions that can be investigated. And in order for students to draw conclusions based on evidence, they need to be able to plan systematic investigations to gather that evidence. The teacher's role in this process is to find out how the student is doing in each phase, and help them make progress. (Harlen, 2006a, p. 10)

Table Nº 2. Scholars' texts evidencing my same own idea that 'children do experiments to test their own theories which is somehow as if children were collectors of facts and evidences and constructers of theories

As it is stated, "children have very good recollection of experiments", and "they have ideas about a number of phenomena". It is as if the child very naturally acted as a scientist. Indeed, it is also said that they "need to reach this realization themselves, hence the need to let them test the experiments they have come up with themselves". The thinking of the boy in the cartoon is an illustration of this child reasoning by supporting his thinking with evidence. The boy is presenting his experiment and evidence to support the change of his initial belief 'the time was in the clock' for the new one 'the time is in the battery'. Assessment is viewed as how the teachers "help students have productive inquiry experiences in which they express and test ideas that can lead to new scientific understanding". For assessment purposes, it is also important to help students "ask questions that can be investigated", and also, "in order for students to draw conclusions based on evidence, they need to be able to plan systematic investigations to gather that evidence". The assessment activity in classroom should bring ideas such those presented by the boy in the cartoon and plan how to help the boy to review his new idea.

Another own idea that I had was that that children explanations about phenomena were not in concordance with those of scientists. The next text is an illustration of my own idea shared by the collective of scholars.

CHILD EXPLANATIONS AND PHENOMENA

Quite often (but not always) such ideas are in contradiction with the scientific explanations of the phenomena being studied. It is important to allow a new and more coherent explication to emerge, through a process that will be all the more enthusiastically embarked upon as the students realize that their ideas are inaccurate, incomplete or in contradiction with those of others, by helping students express their ideas and encouraging them to express them orally or in writing; taking those ideas into account, without judging them; not discarding them from the outset, even if they are considered "incorrect" by the teacher; taking

> them all into consideration, without making value judgments. Then, the inquiry process begins, during which most of the ideas will be able to change. (Saltiel, 2006, p. 16)

New elements appear in this kind of reasoning that as practitioner I shared. First, those ideas are sometimes in agreement with those produced in science, but quite often they are in contradiction "with the scientific explanations of the phenomena being studied". Second, there are phenomena that can be explained scientifically and studied. During my everyday researching activity I started to find the phenomenon difficult to apprehend. I had problems, because I couldn't find such object clearly delimited. And third, others ideas are a source of modification of the own ideas: "the students realize that their ideas are inaccurate, incomplete or in contradiction with those of others". Somehow, I hold the idea that by sharing ideas and reasoning with others finally we produced the good reasoning. What is relevant at the end is that the process of inquiry is the learning mechanism by which those ideas will change. This is, the child adapts his cognitive reasoning by feedback of the environment.

These three strong certitudes that I clearly had are stated in documents in the IBSE Network. My common sense, and my 'natural' way of thinking and reasoning were not my own ideas. My 'own ideas' were mine as I belonged to the community of practitioners of IBSE, at list with those that write the texts circulating in the network.

ACTION 2: DE-NATURALIZING

Once I could convince me that my own ideas were shared ideas, I started to link them with the group of assumptions that I had identified as a result of my analysis in Chapter five. The goal of this action became to de-naturalize my natural way of thinking, my common sense. The analytical process was to question my own assumptions and ways of making sense. I made a link between my own ideas, IBSE and assessment for learning scholars' thoughts, and the group of assumptions delimitating the individualistic cultural sensibility (see first column). This link allowed me to raise many questions to be investigated (some examples in second column).

LINKING IBSE WITH INDIVIDUALISTIC ASSUMPTIONS	QUESTIONING IBSE WITH SOCIO-CULTURAL
The ideas and reasoning circulating in the network are based on the recognition of individual cognition and mental activity (looking for own ideas, explanations of phenomena) and is analyzed separately from the	Then, what happens if those assertions and truths are removed? And what if it is truth (moving towards another set of cultural truth) that:

social activity (the child cognition is not explained in terms of being in a classroom activity which is particular kind of social activity, in a school, educational system).

The mind, psychological process, thinking, and consciousness are conceived as entities lodged in an individual interior space (ideas are in mind and accumulated from the every day activities).

Learning and cognitive processes are focused in what happens in mental activity (the inquiry process as a learning and cognitive process, are focus in how those ideas in the interior mind change).

- Individual cognition is tied to the social and cultural environment. Learning and cognition are social phenomena. Individual cognition can be traced when looking at the individual participation in social activities. Socio-cultural conditions support individuals' modes of life.
- Learning is constructed around the individual appropriation of cultural tools while is participating in a social activity.

There is not reference to differences of the child's own ideas in relation to the child's culture. In Chapter five In documents it is stated that "whatever their culture and age, students generally have ideas…" It follows that the individualistic tendency is looking for the child's naive conceptions about the world independently from culture, but as a result of a natural developmental line of all human individuals. What is relevant for inquiry-based teaching strategies (assessment for instance) is to support the conceptual change in the individual's mind. Learning is conceived as a conceptual change or as changes in the explanations.

Those changes in the explanation are expected to happen by interaction with the others' ideas. The role of society and culture is reduced to an environmental feedback supporting the individual conceptual change.

What happens then if there are not those ideas about phenomena produced by everyday experiences? Rather:

- Individual's conceptions are socially and cultural built. Individual's interpretations and meanings emergent from the social activity in which he/she is involved. Individual's meanings about the world vary from one activity to another. The nature of physical tools and intellectual or discursive tools vary from one social setting to another.
- The role of society and culture is seen as determining the learning process. The activity determines the individual learning.

Knowledge is viewed as detached from social activities. There is an a-historical and a-cultural account of knowledge. Knowledge is made up of

How could knowledge be conceived in the context of IBSE? When:

- Knowledge is not separable from

personal viable constructs. Naïve ideas are unstructured knowledge or a collection of unstable misconceptions that need to be re-emplaced.	the activity, and it is situated and dependent of cultural meanings constructed by the community. Knowledge is tied to the historical moment and culture where individuals are acting. • Contextual features of knowledge, the relevance of where, when, with who and other elements from a situated action.

Table Nº 2. Naturalizing and questioning with assumptions

By asking myself those questions, I started to think with the new set of assumptions. I 'borrowed' socio-cultural assumptions and started to assert that the way humans experience, perceive and experiment phenomena in the natural, made and social worlds depend on the cultural artifacts available —I use cultural artifact to say that the artifacts have different meanings depending on the culture—, the activities they engage in, and the social relations with others. In that sense, the 'own ideas' of children depend on the social activity in which they are engaged, on the relations with others, and on language with specific interpretations. It implies that children's own ideas are not stable and change depending on the activity in which they are involved. Every situation allows the child to produce argumentations in the way he/she is expected to by the surroundings.

Quino's cartoon allowed me to introduce some problematic issues that arise when children's ideas about the natural and made worlds are in focus. What the son is saying is possible because of the existence of the clock, the batteries and everyday notions of time. If the assumption that human ideas emerge in the cultural and historical conditions is adopted, neither a child nor an adult could have expressed the same idea one thousand years ago, because that type of non-mechanical clock did not exist to measure time, the meaning of time was different, the clock did not have batteries and the social and cultural meaning shared today, neither did he have the batteries or the connotations given today to artifacts in the historical circumstances of the son.

It also shows that there are many possible languages that can shape human activity within the natural and made worlds. Indeed, each human's activity is shaped by language configurations. This statement is one of my new 'own ideas', maybe the first one I could adapt to myself, but I will show that for me grasping its meaning and making sense of it was a process full with difficulties. I gave meaning to this sentence when making sense to Bakhtin's term heteroglossia described by Mäkitalo, Jakobsson, and Säljö (2009)

> This exotic term captures something that is, we argue, not so cryptic. In fact, it is close to our everyday experiences. What the term alludes to is the observation that there are diverse ways of communicating and knowing about objects and events. In other words, and to continue in Bakhtinian parlance, in the complex society there are many "speech genres" that reflect how different social groups or institutions communicate about what they do.

My analysis of Quino's cartoon was guided by the claim that "there are diverse ways of communicating and knowing about objects and events". By making the analysis, I was trying to convince myself that when humans are looking, touching and seeing objects and movements close to everyday experiences, there are several possible talks and knowledge in connection to the activity. I imagined different talks around those events in the cartoon, for instance the son words could be different:

LOOK DADY, NOW I KNOW HOW A CLOCK WORKS...
THIS IS THE BATTERY THAT MAKES THE POINTERS MOVE.
THE BIG POINTER INDICATES THE HOUR AND THE LITTLE ONE THE MINUTES.
THE BATTERY IS ADJUSTED IN THIS LITTLE BOX.
IT IS SEVEN HOURS AND FORTY MINUTES, NOW I KNOW HOW TIME IS MEASURED.
I AM SO IMPRESSED THAT THIS LITTLE OBJECT MAKES MY CLOCK MEASURE TIME.

This is an example of different languages that I imagined around the son and father events. I got inspiration from the example given by Mäkitalo, et al. (2009) to illustrate that in "the complex society, there are many "speech genres" that reflect how different social groups or institutions communicate about what they do":

> If we take a simple object as, let us say, an orange, it can be discussed, analyzed, and thought about in many different ways and in many different genres. The satisfied consumer may speak of its delicious taste and its juicyness, the dietician will speak of it in terms of nutritional value and richness in vitamin C, and the artist may attend to it in terms of its colour, shape and texture in the context of what is to be a still life. At more abstract levels, we can think of the importer of oranges, the transport companies shipping oranges from their sites of production to consumers all over the world, and the economist, in her role as advisor to a multinational company, analyzing the supply and demand in the market for oranges, as thinking and communicating about oranges in very diverse manners. In the latter cases, the terms and concepts that are productive are very different from those that characterize the consumer enjoying his morning fruit or the shop owner trying to persuade customers to purchase fresh oranges. Thus, the orange as a physical object is embedded in

> diverse social practices where very different "speech genres" and conceptual frameworks are relevant.

Reviewing these words today, and the different speech sequences I imagined in Quino's cartoon, I realized that I did not see, at that time, the institutional dimension, neither the diversity of social activities that moved possibilities of speeches about objects. Indeed, the examples above illustrate different possibilities of talk produced by individuals belonging to particular institutions: the individual as an economist from a firm, or as a housewife, or, in the case of the son in Quino's cartoon, as a son. I realized today that, when making the exercise of imagining different captions for the cartoon, I always imagined the son's speech detached from a social activity. The exercise was still made from my individualistic perspective.

Furthermore, Mäkitalo, et al. (2009) presented those theoretical explanations to claim that:

> Learning, in the sense of mastering what Vygotsky (1986) refers to as scientific concepts, implies being able to contextualize phenomena in discourses that are often at odds with those that are used in everyday settings. Furthermore, in many situations there will be multiple, sometimes rivaling, scientific discourses that are relevant. (Mäkitalo, et al., 2009, p. 7)

Then, my individualistic 'own idea' stating that the child has theories about phenomena, was disturbed. Something was bizarre. Indeed, I had this idea that learning was happening independently of the social activity, as if learning was at another level, not embedded and dependent on the activity. If mastering scientific concepts "implies being able to contextualize phenomena in discourses that are often at odds with those that are used in everyday settings", then how can it be that children have theories about phenomena coming from their everyday experiences?

The difficulties to change my individualistic perspective can be perceived in my analysis. In the previous version of this text (Carulla, 2011) I wrote that "children's experiences are embedded in a social world with the languages and meanings in cultures", and " the ideas that children express and the teacher takes as evidence of learning for assessing in the context of an IBSE classroom cannot be taken as independent from the artifacts and language within a culture". The institutional dimension was lost. I was analyzing with my individualistic sensibility. I presented those ideas to show how disturbing the process of changing my theoretical perspective has been. The result of such movement is that I had different questions and problems to solve. What follows is an example of such a search of understanding and recognizing another cultural way of looking at learning and knowledge as well as human cognition.

I wondered how the relation between objects and phenomena and children is. How do humans observe things? Then I became aware that I needed to explore the fact that children will observe an object or a phenomenon through their *perception*. This simple statement became complex when I tried to make sense of it. Exploring some philosophical texts (Law, 2008) I found a vast universe considering this apparently 'simple' connection between perception and the natural and made worlds. This question has been an important area of discussion in philosophy. My thesis is not a thesis in philosophy and I did not intend to become a philosopher.

However, I had to make a novice incursion into some of these texts and ideas in order to address the following questions: How do humans perceive the natural and made worlds? Do all humans perceive them in the same way? In this section I will explore this relation between humans and the natural and made worlds. I also asked myself about the relation between humans and phenomena. As it is stated, children arrive to the classroom setting with a history of experiences where they have had contact with phenomena. I will expose some thoughts that highlight the complexity behind the word *phenomenon*. What is a phenomenon? How do humans perceive a phenomenon? I also see that *experimentation* is connected with phenomenon. It is the way in which the scientist constitutes it. I explore these notions in what follows. I am aware that what I did is not a literature review about those words. The analysis is an attempt to make sense out of different ideas that started to move my perception of reality, experience, phenomena and human activity.

REALITY, EXPERIENCE AND PHENOMENA

Let us make some considerations about those apparently simple questions. My intention is to highlight the complexity and not to dig into it. Realizing such complexity, the extension and diversity of literature on this issue, and my lack of knowledge on it were important elements of my de-naturalization process. I became aware that the exploration of those 'simple' words and questions could explode as three complete thesis on their own. My intention here is to show how I started to make sense of them in a different way, and not to present an exhaustive discussion of these ideas and questions.

Guided by my common sense, I can say that we all agree that there are things that can be touched, seen, smelled, heard and tasted by humans. There is water in the sea, a tree, a cat, a big boat, a piece of chocolate, etc. We have names and words that point those objects and that evoke them when they are not in our presence. At the same time, we agree that we can feel changes in that world; the leaves of a tree moving, a big boat moving on water, a dog running, a

piece of chocolate that 'disappears' from our view while we chew it, etc. We have words to communicate those issues and we do things in relation to that. Those words design the world outside of us.

Many words can be found to point this: reality, real, biological reality, material reality or natural and made worlds. In the introduction of the thesis I chose to call it the *natural world* and the *made world*. The natural and made worlds, or what is commonly referred to as *reality*, are a clock, a battery, a chair, human bodies, movements, changes in things, etc.: It is what is obviously there.

> La réalité est ce qui semble aller de soi, ce que nous croyons toujours bien connaître. Elle alimente les certitudes les plus tenaces de la conscience[71]. (Boillot, 2004, p. 22)

As Boillot (2004) says, reality (natural and made worlds) is what seems obvious to us. Reality is what we believe to know very well. It is a presented as certainty.

In the IBSE discourse, it is clearly stated that children must observe objects and phenomena from the *real* world. Children will observe using their senses: tasting, hearing, touching, smelling and sighting. To observe also involves being able to categorize and to distinguish qualities in the objects observed. It is related to an intellectual process by which the individual will process the information that came from the environment around him/her. Perception is a human process that captures information from the surroundings through senses and processes it with the intellect (Boillot, 2004). How do humans perceive the external world (made and natural worlds)? Exploring the concept of perception a complexity emerges: human perception is guided by representations. What a human sees is, somehow, a distortion of what there is outside.

> The word perception indicates a *direction* rather than a primitive function. It is known that the uniformity of apparent size of objects at different distances, or of their color in different lights, is more perfect in children than in adults. It follows that perception is more strictly bound up with the local stimulus in its developed than in its undeveloped state. (Merleau-Ponty, 2002, p. 13)

This brings some problematic aspects when one considers the relation between human perception and the natural and made worlds. Assuming that children have knowledge about the natural and made worlds based on their perception, how does this knowledge look like then? How does a scientist come to a body of

[71] The reality is that it seems obvious, those things that we still believe well known. It supplies the most stubborn certainty of consciousness.

knowledge that reflects the way the natural and made worlds function? How do they manage this complexity?

Different perspectives about the relation of humans, perception and reality can be found. A first view assumes that humans perceive the world in a way that mirrors the way the world is (e.g. Lagemaat, 2006). I see, I hear, I touch, I smell or I taste things, and the things 'are' as I perceive them. This is called a *common-sense realism* or *naïve realism*. Skovsmose (2009) explains this type of realism as the idea that "Reality is more or less as we experience it to be, and this realism becomes the starting point for common sense-based certainty." (p. 38). The natural and made worlds (or reality) are more or less as humans experience and perceive them. This is the base of human common sense certainty: I know the world; the world is as I perceive it.

Scientific knowledge is constructed by scientists with the aim of understanding and dominating the natural and made worlds. Scientific knowledge allows us to make predictions about the future. This is why common sense or the idea that the world is as we perceive it has been questioned by scientists. Klein (1994), a French physicist, wrote that the development of modern physics has shown the ineffectiveness of common sense in the construction of theories and understanding of some experimental results. It seems then that human common sense is not what guides the scientific way of approaching the natural and made worlds.

Taking this into account, I found a second view about the relation between human perception and the natural and made worlds. It is to separate the natural and made worlds from human perception. According to *scientific realism*,

> the world exists as an independent reality, but it is different from the way we perceive it [...] **Reality** is the state of things, as they actually exist, rather than as they may appear or may be thought to be. In its widest definition, reality includes everything that is and has been, whether or not it is observable or comprehensible. (http://en.wikipedia.org/wiki/Reality).

In this approach, natural and made worlds or "Reality" are what they are. That means that it is there, independently from human thoughts and perception. The objects belonging to the natural and made worlds are there, or were there, whether a human is observing or not. However, what grants things the status of real is the fact that they are part by scientific statements. For scientific realism:

> [T]here exists a common core of ideas, typified by an epistemically positive attitude towards the outputs of scientific investigation, regarding both observable and unobservable aspects of the world. The distinction here between the observable and the unobservable reflects human sensory

> capabilities: the observable is that which can, under favourable conditions, be perceived using the unaided senses (for example, planets and platypuses); the unobservable is that which cannot be detected this way (for example, proteins and protons). (Stanford Encyclopedia of Philosophy, http://plato.stanford.edu/entries/scientific-realism/)

The output of scientific investigations is divided in those aspects of the world that can be perceived with the senses and other devices, and others 'things', such as proteins, that are detected differently. To illustrate this point and differentiate it from the first idea presented, let us look at the following example:

> If a tree falls in a forest and there is no one there to hear it, does it make sound? The common-sense answer is to say that of course it makes a sound. Falling trees are noisy things. But if you think that sound is nothing more than the effect of air vibrations on our ears, then it would seem to follow that if there are no ears in the neighborhood, then the tree does not make a sound (Lagemaat, 2006, p. 98)

When humans are not present in a particular place of the natural and made worlds, things happen independently from their perception. What happens can be described in two different ways. One is by using words used in activities of everyday social life that refer to the way humans perceive it. The other one is by using words used in scientific social activity that reflects what it "really" is, according to the scientific theories. A tree falling in the forest produces air vibrations. Those vibrations are not a sound themselves. They become a sound when a human perceives them with his or her ears.

This approach is similar to what Skovsmose (2009) describes as *Modern realism*:

> This realism is based on a distinction between appearance and reality: There is a significant difference between what we experience in a simple and immediate way and reality as constituted independently of anyone's experiences. In other words, reality only presents itself to us in a disguised way. It becomes dressed up in the fancy clothes of sense experiences, but to obtain insight into reality, we must look behind appearance. (p. 38)

In this approach a distinction is made between appearance and reality. From this perspective, the natural and made worlds will be considered differently from what humans perceive of them. Through experience, humans will have access only to an appearance of the natural and made worlds. It is said that only by

looking behind appearances humans will obtain insight into the natural and made worlds.

Modern realism is the philosophical position behind the way in which a scientist produces knowledge about the natural and made worlds. All kinds of theoretical tools are used to present knowledge that describes these humans' independent natural and made worlds. It is accepted that people who are not members of a scientific practice have different ways to approach the natural and made worlds.

> Surtout, la science et tout particulièrement la physique contemporaine nous posent aujourd'hui une question brutale, celle qu'à sa manière, la philosophie depuis très long temps à un niveau métaphysique [...] quand nous parlons de réalité, de quoi parlons-nous? L'homme de la rue postule en fait de l'existence de corps de dimension moyenne; le physicien, lui, postule l'existence de particules élémentaires. Mais la différence d'un réel à l'autre n'est pas seulement une différence d'échelle; il ne s'agit pas des mêmes choses. Bien plus, dans le premier cas, la réalité se présente comme un univers d'objets, des choses matérielles; pas dans le second[72]. (Boillot, 2004, p. 32)

It is recognized that there are different ways to talk about reality. Common people talk about existing objects, the natural and made worlds constituted by material objects. Physicists postulate the existence of elementary particles. The two ways of approaching reality or natural and made worlds are completely different. They do not have the same nature. Following the socio-cultural assumption, there are different social activities in which people use languages to refer natural and made worlds —for instance, the object 'orange' can be perceived differently according to which language is adopted and in which social activity such language emerge.

There is yet a third view to address this relation between human perception and natural and made worlds or reality: the *phenomenological view*. This position is based on an empiricist philosophy:

> According to this view, matter is simply the permanent possibility of sensation, and it makes no sense to say that the

[72] Especially science and particularly contemporary physics ask us today a brutal question that, in his own way, the philosophy explored for a very long time to a metaphysical level [...] when we talk about reality, what are we talking about? The man in the street postulates that the existence of medium-sized body, the physicist, he postulates the existence of elementary particles. But unlike a real one is not only a difference of scale, it is not the same thing. Moreover, in the first case, the reality is as a universe of objects, material things, not in the second.

> world exists independently from our experience of it (Lagemaat, 2006, p. 100)

In order for an object or reality to exist, it is necessary that it be perceived. The world does not exist independently from human experience. Connected to that, this line of thinking follows the idea that knowledge about the world is produced based on human senses. Humans know through their experiences.

Looking at these philosophical views, and connecting them to the core ideas of the dominant discourse, it seems difficult to follow the assumption that the child may have some innate hypotheses and scientific ideas about the natural and made worlds. The assumption that the child has his or her own scientific way to see nature is problematic. For instance, if we assume that scientific reasoning is different from the common sense realism, it is impossible to have those theories and hypotheses that seem to be the fundamental pillar for the dominant discourse. Scientific reasoning is a construction based on existing cultural tools. It is not a natural or innate way of thinking.

We can also take the last idea and assume that in the dominant discourse the existence of the world is connected with the senses, and reality is as we experience it. The question then asks how the child experiences the world. Did a child two thousand years ago experience the world in the same way as a child would do today? Going back to Quino's cartoon, we can argue that this statement becomes problematic. Two thousand years ago the conception of time was culturally different. At that time human beings did not have the tools that the son is manipulating in the cartoon. The other problematic aspect in this approach is that scientific reasoning is based on evidence: measuring, comparing, and using different cultural tools to construct this evidence. That is, perception is not a good tool to support evidence. We must learn to use particular scientific strategies to support perception.

EXPERIENCE AND EXPERIMENTATION

Looking at the dominant discourses, one of the central ideas is that children's experiences are central to the learning process. It is assumed that children arrive to the classroom with experiences in the natural and made worlds that have given them some kind of knowledge about reality. According to this, every child will construct knowledge about reality or the natural and made worlds by experience. They will use their senses and the information given by them to know it. Apparently there is the basic assumption that children have the possibility to construct theories and knowledge to explain the natural and made worlds and to constitute it on their own, by themselves. It also seems that those theories are evidence-based, as scientists' reason and do. So, I ask the following

questions: How do humans experience the natural and made worlds? What does experience mean?

Different meanings are given to the word *experience*. A first one, which is the most frequently or commonly used by people is the "…ensemble des connaissances que l'on acquière par le temps et l'usage" (Russ, 2004, p. 102). It is the set of knowledge that is acquired during time and use. This refers to all kinds of knowledge connected to the individual acting and living in a social world.

Another meaning attributed to the word experience is a philosophical definition, which emphasizes a connection between human senses, knowledge and the world. Experience is the "connaissance acquise par les sens, due à la sensibilité: impression sensible non élaborée: synthèse des sensations" (Russ, 2004, p. 102). Experience refers also to a body of knowledge acquired by the senses, coming from or related to sensibility. It also means a sensible impression that has not been elaborated. It is a synthesis of the sensations. Somehow, knowledge, experience and senses are connected.

From a philosophical point of view, according to Compte-Sponville (2001), experience is our door to access the real world. It is those things that come to us from the outside. This can be referred to as an external experience. However, it is also recognized that experience involves all those things that came from the inside and are referred to as internal experience. Both experiences are considered important because both make us learn something. Experience and learning are tied.

There is yet another meaning attributable to the word experience. A meaning that is used in epistemology. Experience is the "action d'observer les faits en vue de vérifier une hypothèse. Souvent synonyme d'expérimentation" (Russ, 2004, p. 102). From the epistemological point of view, experience means the action of observing facts in order to verify hypotheses. It can be a synonym of experimentation.

Thus, experience and experimentation are seen as connected:

> Expérimentation: Une expérience active et délibérée: c'est interroger le réel, au lieu de se contenter de l'entendre (expérience) et même de l'écouter (observation). Se dit spécialement de l'expérimentation scientifique, qui vise ordinairement a tester une hypothèse en la soutenant a des conditions inédites, artificiellement obtenues (le plus souvent en laboratoire) et reproductibles[73]. (Compte-Sponville, 2001, p. 233)

[73] Experiment: An experiment active and deliberate: it is the real question, instead of just hear (experience) and even listen (observation). Refers specifically to scientific

Experimentation is explained as a particular kind of experience, in which some purpose is assigned to the experience, for example, to test a hypothesis. In fact, it is also associated to a question that is asked to reality. It is not only a matter of experience capturing information with all senses and processing that information by observing. Furthermore, it is done to test a theory or explanation. In order to do that, a particular setting is used: specific conditions that can be reproduced.

Experience is a word that is used in two different ways in the dominant discourse. One refers to the historical experiences of the child before coming to the classroom. The second refers to the historical experiences in the science classroom. In the first case, it is expected that the contact of the child with the natural and made worlds will provide a body of knowledge that then he or she will bring to school. One possible assumption behind this is that those experiences take place regardless of the culture where the child lives. In this way, there is no connection between those experiences and the social activities in which the child is involved. No references to the cultural language are made. It is also said that these experiences will generate theories, hypotheses and explanations about the natural and made worlds. It is also assumed that those theories have some characteristics that can be found in children coming from different cultures and in different historical moments. A possible assumption supporting this idea is that those hypotheses and theories are part of the natural development of the child and the environment supports this internal process of maturation. It is recognized that experience is the way to know and to adapt to the surroundings. Hence, everyday experiences in the natural and made worlds result in a body of knowledge and this knowledge and way to experience are similar to the scientific way to question the natural and made worlds. Following this line of thinking, the dominant discourse can be related to the individualistic discourses presented on Chapter four.

These ideas seem problematic when some of the socio-cultural assumptions are used. As argued in Chapter four, the child cannot be seen as isolated from the social activities in which he or she is involved. Each contextual occasion makes the child adapt to the situation. Children's theories and ideas about the world emerge because of the thinking possibilities brought by the social activity in which children participate. In that sense, they are not stable; one way of thinking can be useful in one situation and not in another.

The purpose of an IBSE teaching setting is to produce contextual situations that allow children to have another kind of experiences: experimental ones. Children will make experimentations to test theories and ideas that came from the other kind of experiences. A possible assumption is that the natural way

---

experimentation which typically aims to test a hypothesis supporting the new conditions has artificially obtained (usually in the laboratory) and reproducibility.

to know is by experimenting, and children's natural way of knowing is similar. This may be problematic if the interpretation of experimentation is used. It is different from experience. There are different processes that must happen in reasoning. For instance, if we return to the son's argumentation in Quino's cartoon, in which the child uses the scientific language and provides evidences that support his claims, it is clear that his arguments are not scientific. They look as if they were, because he did an experiment showing with facts that his theory did not worked and that a new one can be state based on what is observed, as someone expects to be done by a scientist. The problem is that he did not use all the cultural tools to support the claim, as it is stated in the definition of experimentation. There are some rules and ways to argue that must be learnt.

According to Säljö (1997), experience must be regarded as connected with the languages that are available in the culture where the individual lives. If it is assumed that language is what gives sense to the experience, and the culture where the individual is embedded is the source of experiencing the world, then there is a problem with the assumptions behind the dominant discourse. To experience the world as a scientist, one must be embedded in the scientific culture, and experiencing the world is shaped by the language and possibilities brought by the environment where the individual lives. Then, the individual cannot be isolated from the social activities in which he/she participates. On the one hand, the cultural context gives the tools to think and experience the world. On the other hand, the social activity gives the possibilities of making sense while the individual is participating.

PHENOMENA AND OBSERVATION

As it is often said in the dominant discourse, the purpose of IBSE is to enable pupils to gain understanding of the objects and phenomena around them. Children will observe an object or a phenomenon from the real world close to them that can be observed by their senses. It is then clear that they will acquire a body of knowledge through their senses, by using them and on present time: by experience.

Phenomenon is a word that is commonly used to refer to facts and events that happen in the natural and made worlds. It is assumed that scientists studied and developed theories and models connected to each phenomenon. In the IBSE context, I used to talk about it frequently, and nobody asked me what I meant by that word. Neither did I. I found in different IBSE texts, and also in science education research texts, that the word phenomenon is used as if there existed a unified, transparent and clear meaning for it.

I got into trouble when I was trying to understand which phenomenon was behind the son's argumentation in the cartoon. I began to wonder about the process of constituting a phenomenon or what such 'thing' is. Looking at the

etymology of the word in non-specialized literature —I used sources that are addressed to common people to track common sense uses—, a phenomenon is "what appears to us" (Godin, 2007). Furthermore:

> [...] is any observable occurrence [...] In scientific usage, a phenomenon is any event that is observable, however commonplace it might be, even if it requires the use of instrumentation to observe, record, or compile data concerning it. Furthermore, Kant makes a distinction between phenomena and noumena. For him, noumena, in contrast to phenomena, are not directly accessible to observation[74].

A phenomenon seems to be what we observe, something that is happening in the world around us. We can observe it by using instruments and recording information. Two different aspects are highlighted in this text: one is *noumena*, which is what we can use to theorize but that is not accessible with the senses, in contrast to phenomenon, which is observable.

Furthermore, phenomenon is connected to what reality is considered to be:

> La notion de phénomène prend tout son sens dans le contexte du problème philosophique de la réalité. [...] Avons nous accès a la réalité en soi, aux choses elle mémés? (Boillot, 2004, p. 35)

In this text, an important question is asked: Do we really have access to reality? The assumption behind scientific realism is used. It is with theories and assumptions that we constitute a phenomenon:

> Pour autant, le phénomène n'est pas une simple apparence trompeuse. Objet de la connaissance scientifique, il est apparence conduite à sa vérité par la théorisation et l'explication scientifiques. (Boillot, 2004, p.35)

It is recognized that a phenomenon is an object belonging to the scientific knowledge. It is not an appearance itself. One has access to a veritable phenomenon by theorization and scientific explanations. Yet, another kind of phenomenon is recognized: those that are built by sociologists like the growing number of people that do not have a fixed place to live:

> Lorsqu'en médecine, on parle du phénomène de rejet greffé, ou lorsque le sociologue étudie le phénomène de l'augmentation du nombre des "sans domicile fixe" il ne s'agit pas de réalités superficielles ou étonnantes, mais de cet ordre de réalités que la

[74] http://en.wikipedia.org/wiki/Phenomenon

> science observe ou établie. Il s'agit donc de faits; non de faits bruts, mais de "faits constatés qui constituent la matière des sciences" (A. Lalande). Ces faits, pour être scientifiques, sont les objets d'un protocole d'observation et de description rigoureuse." (Boillot, 2004, p.36)

Two kinds of phenomena can be recognized here: those that belong to the field of natural science, and others that belong to the social sciences. Once a phenomenon is identified —"rejet grefée" in the case of medical research or "sans domicile fixe" in the case of sociologists— it is pointed that they are not "superficial" or "astonishing" realities. It is clarified that they are realities that science observes or establishes. They are described as facts. But those facts are not all kinds of facts: They are facts that can be proven and that are at the base of science. In order to give those facts the adjective *scientific*, they are object of an observational protocol and a rigorous description. This means that there are some kinds of facts that are not what a human being perceives with a naked eye. Those facts need a particular treatment that turn them into evidence of this more 'deep reality' in contrast to 'superficial reality'.

I highlighted that in the dominant discourse in the IBSE-Net it is considered that children arrive to the classroom with several ideas and theories connected to scientific phenomena. Teaching through inquiry helps students test their existing ideas about scientific phenomena, consider alternative ideas, and gradually develop an understanding that is more consistent with evidence and with the scientific view of how things work.

> Most students have rich experiences and personal theories or mental models for explaining […] Unfortunately, many of their theories are either misconceptions or conceptions that are only valid under certain circumstances…Those conceptions are so deeply rooted in students' minds that it is difficult for students to change them, even after students have been intensively exposed to scientific conceptions (Yin, et al., 2008, p. 338) (Shavelson, et al., 2008)

It is said that those theories do not change only by presenting scientific concepts in relation to the phenomenon. In order to change those ideas, children must experience the phenomenon in a new way, by following this rigorous line of experimentation. Those theories are supposed to work under certain circumstances, as if a kid had the possibility to 'naturally' follow some kind of scientific reasoning ending in a theory that works for many observable facts. What kind of experiences did children have that allow them to access those facts that scientists have observed or established? Do children observe and establish similar facts?

EXPERIENCES IN A SOCIAL WORLD

By looking at the diversity of approaches and languages that shape in different ways the core elements of the dominant discourse, I present some reflections based on my interpretation of the socio-cultural approach. I explored some relations between human beings, experiences, the natural and made worlds, and phenomena. I realized that something is missing in all those explorations. If a human being stopped being viewed as an isolated individual experiencing alone the natural and made world, but was immersed in a social world —a social world that some how also constitute this human reality—, then the question emerges of what happens with his/her experience of the natural world —the world or reality constituted by natural, made and social world. Can we experience the world independently from culture? Or independently from the social setting where we live in? Does the experience of the natural and made worlds change when the social and cultural nature of human beings is taken into account? How do social and cultural dimensions affect experiences? Have humans always had the same kind of experience in the natural and made worlds? The central issue is to take a position in relation to a fundamental question: Does the individual mind think in a way that does not depend on the social and cultural dimensions of beings? Another possible way to ask the question would be: What kind of relation exists between individuals' thinking about the natural and made worlds and the social world where they live?

Those questions have been addressed by researchers that assume that the social world indeed plays a central role in the way humans experience the natural and made worlds. As Säljö (1997) recognized, there are many current attempts to establish a research approach that studies human thinking and possible acting "from a non dualist stance, i.e. from a position in which the internal (thinking) and the external (the world out there) are not posited as isolated entities" (p. 173).

This discussion appears relevant when looking at the way Descartes's thought about the relation between human mind and actions. He looked at them as separated and analyzed the mind functioning isolated from the social world. This is viewed as a separation between mind (thinking), an individual matter, and actions, which are essentially social (Säljö, 1997).

> Cartesian dualism starting out with a prior commitment to separating mind and action, reality and our awareness of it, results in an impoverished and abstract understanding of significant psychological phenomena such as human development, learning and experience. It separates the world and human action in a manner that leaves the fundamentally social and material nature of human actions and activities inexplicable. (Säljö, 1997, p. 173)

Isolating thinking from actions and reality from the human perception or awareness of it does not consider the complexity involved in the human process of development, learning and experiences while participating in social activities. Humans get to know the natural and made worlds while they participate in activities of social nature. Human experiences will occur during that participation. The idea that Cartesian mind is an entity that can be studied per se and outside human practices has been recognized as a challenge faced by social science in the research arena (Säljö, 1997). Researchers whose gaze studies social activity also criticize Piaget's assumptions: the autonomous cognitive child-scientist constructing a Kantian epistemology from direct experience (Lemke, 2001). It is recognized that research in social science must "attempt to provide a perspective in which the person perceiving and his/her conceptions of the world are reintegrated. Thus, potentially, there is a striving towards studying mindful action and meaning" (Säljö, 1997, p. 173). In that sense, human thinking about the world must be analyzed and studied by connecting activity and thoughts.

By introducing the human being in an environment where not only the natural and made worlds 'are there', but also social activities in which that human being participates —a social and cultural world— appeal to a new approach to consider humans, reality, experience and phenomena. Until now, I presented those issues as isolated matters from the social world. But as children that will learn through inquiry are immersed in a particular kind of social activity, schooling, and also participate in other kinds of activities outside school, it seems relevant to consider this.

FINAL REMARKS: PROBLEMS AND TENSIONS

Moreover, in the IBSE discourses it is said that children have experiences outside their school in which they will learn about the natural and made worlds, as well as experiences in the classroom. It is also recognized that 'the other', a kid or a teacher, helps this individual know the natural and made worlds. To me, there is a tension between the Cartesian isolated way of seeing thinking and cognition and this idea of the need of others to know the natural and made worlds. It is also said that each learner must experience alone. Can those experiences be focused on a mind independent from the social dimension? Or does the experience have a social component that needs to be considered? How does it work?

Let us think about phenomena, experience, experimentation and inquiry thinking with these tensions in mind. A first question that arises is: Where is the phenomenon? A problem appears when we look at the world independently from

language, which is a cultural and social artifact. Is a phenomenon what we see? Or do we see it with language? A second problem can be delimited when we talk about experience: How does the child experience the world? Does the child experience the world with his/her internal cognitive process and language, as Piaget argues, or with the artifacts available in the culture, following Vygotsky's thinking? And finally, a third problem can be posed when experimentation and inquiry thinking are looked at from the language perspective: If language is a cultural artifact and, experimentation and inquiry thinking are driven by language then how it is possible to do it in an isolated way? Without collective assumptions and meanings?

WHERE IS A PHENOMENON?

When looking at the cartoon, I observed the battery, the clock, the pointers of the clock, the son with the clock in his hand, the father looking at the situation. Where is the phenomenon? Is it the movement of the pointers in the clock? Is it the color of the clock? Is it the weight or the shape of the battery? How do energy and time play in the situation? I began to understand the complexity behind the apparently simple word *phenomenon*. How could it be possible for any of us to encounter phenomena in every day lives? Do we at all meet phenomena? How can it be possible to say that children in an IBSE classroom are experiencing a phenomenon and they have ideas about it because they have experienced it outside school? Which is the nature of the phenomenon encountered outside school and in the science classroom? If children are assessed in relation to their explanations, concepts and ideas behind a specific phenomenon, it is necessary to analyze the connection between explanations, concepts and ideas with a phenomenon and furthermore with the facts that are observed.

From the definition presented previously, we can say that a phenomenon involves a person that is observing and facts or events to be observed. It seems impossible to separate the facts from the observer; the phenomenon involves the person that is looking at it, with particular theoretical tools and possible with instruments. Kant opposes the phenomenon to "the thing in itself". The thing in itself is the thing in a way that it has no relation with our thinking. According to Kant, only the phenomenon is knowable. The things per se only can be thought of (Godin, 2007, p. 316).

It appears then that a phenomenon does not exist independently from a process of knowing and the knower. Let us return to the cartoon scenario. Which phenomenon is present? What kind of knowledge can be used? How does a person construct a phenomenon? How would a community of scientists constitute a phenomenon? I am not educated as a scientist, so the meaning that I give to the term phenomenon was shaped by my self-meaning, this is, the sense

that people of my educational background would attribute to such term. In my naïve way of thinking, I used to think a phenomenon as something that I can observe in the made and natural worlds. It is "out there".

The clock and the battery are there, the pointers move when the battery is in the clock, and stop moving when the battery is out. This is what the son and the father can see, hear, smell, touch, and eventually taste. However, when the son speaks, something different emerges: A relation between the clock, the battery and time. We have the physical objects and facts on the one hand —the clock, the pointers in the clock, the battery. On the other hand, we distinguish concepts —time, time movement, time occupying a space—; and we also have the connections between the facts and the concepts in the expression of statements —the pointers movement shows the passing of time, time is in the clock or time is in the battery.

What we 'know' by our collective experiences is that the battery will make our radio sound, our toy move, etc. We believe that the battery has a special power and that this power generates changes in what we observe. I shared the cartoon with a physicist colleague, Carola Hernandez, and asked her about the phenomenon that the son is looking at. She said that the phenomenon connected to the facts could be that there is a device —the battery— that can give energy to another device —the clock— and produce a movement in the pointers. Somehow, the phenomenon is constituted by several experiences that result in an abstract artifact related to those facts that we are looking at. Besides that, we 'know' that time is something that we can measure with a clock, or with other tools. For example, you look at your watch and know that 'it is' 12 hours and 5 minutes, or you use a chronometer to measure 'how much time' a swimmer takes to arrive to the other side of the pool; or you know that a day has 24 hours, a minute has 60 seconds. We could also look at the position of the sun in the sky and have an idea of the time. So when we see the clock, the battery, the clock moving with the battery and not moving with the battery out, where is the phenomenon? How do we constitute it? What is the relationship between the clock, time, movement and the battery?

In those reflections, complexity becomes evident: Our reality and the way we perceive the natural and made worlds are connected with our thoughts, concepts, and beliefs. On the one hand, those ideas are individual since it is one person who seems to enunciate one idea. But on the other hand, they are also collective since the possibilities for a particular individual enunciation are always rooted in the historical, social and cultural practices an individual is a part of. In that sense, we start to understand why the cartoon surprises us: We have 'learnt' and we 'know' by collective experiences within our different social activities, that time is not in the clock and neither in the battery. However, the reasoning of the son seems so logic that we could actually trust what he is saying. Indeed, in some languages like French (also in Spanish), people say that

time is 'running' like a river, as if it was tangible and it occupied a space (Klein, 1994). In that sense, the language that we normally use helps us give particular perspectives to the concept of time, as the son in the cartoon did. This is why the logic in the son's argumentation is not so far out from our collective experience with time in the everyday life.

In order to answer the question of knowing where the phenomenon is, we can say that it is not in front of our senses but rather that we perceive things with the senses of language used in the institutional culture or activities —such as the economist talking about the orange, or a scientist talking about the same orange, or the housewife referring to the same orange. In order to find the phenomenon we must learn a language with a specific, culturally determined reasoning. Around the observed facts we can imagine different languages expressing different phenomena, as the son presented the facts and constructed evidence to support his idea and theory. Thus, a phenomenon does not exist independently from the culture and language available in a particular historical time. The statement that a child has innate theories and hypotheses about phenomena must be questioned from a socio-cultural point of view.

HOW DOES THE CHILD EXPERIENCE?

When the son and his father were 'experiencing' those facts, the clock with the battery, the pointers moving or not, each one was giving a particular meaning to the situation and making a particular sense out of it. For example, the son expressed his first belief: the clock shows the movement of time, time is in the clock. He seemed surprised by his own thoughts: time was not in the clock, as he previously believed, but in the battery, the clock just absorbs time from it.

The father's remarks make us think that he was experiencing the experiment in another way and that he was surprised about the son's findings and wanted to know if he found it by himself. After the son told him that the physics teacher had taught him that, he expressed how satisfied he was by knowing that he was paying a good education for his son. The experience was lived in a different way by the son and by the father. The 'facts' were the same but the way each one experienced them was different. The father was not

assessing if the reasoning of the child was right or wrong. A reader of a cartoon with a scientific education assesses the reasoning from a scientific perspective. Yet, a reader working in education may assess the reasoning from a different perspective. The son was talking about his social activity in the classroom, activity that is not lived by the father. In that sense they could not see the same, or talking in the same register.

If we assume that children experience the world with an internal and innate cognitive configuration detached from the tools and language available in the culture, and that there is an internal language that is not socially constituted and which allows the individual to express the individual ideas about the world —as Piaget formulated—, we experience a problem when other theoretical perspective is assumed. For instance, we don't know how the son's experience was at school, and why he ended up with his theory and conclusions, nor the way he reasoned. We suppose that in his past experiences in social activities like schooling, he learned to argue based on evidence, but that he does not yet know how to constitute scientific evidence that can be consistent with other facts. We are sure that he can learn to argue in another way, but his experiences are not like the scientists' experiences, because he does not have the language to experience in that way.

HOW DO EXPERIMENTING AND INQUIRY THINKING COME ABOUT?

The son expressed that he was making an 'experiment'. He did it by making some actions in the 'reality' and by producing a particular kind of thinking about it. Accompanying the actions with the objects, the son makes a reasoning that gave meaning to his experiment; each one of his sentences and actions gave a sense to the situation:

> **Son:** Look daddy, I will show you an experiment. We extract the battery from this clock and… The clock stops marking the passing of time… We put the battery in the clock, and hop! The clock starts showing time passing. That proves us clearly, what? That time is not in the clocks, as we believe; time is inside the battery, and the clock takes it from there!

The son was making different assumptions from those that we normally do. Time moves, time occupies space, time can be transported from the battery to the clock. For him, the movement of the clock pointers is the evidence of the passing of time, and the absence of movement, when the battery is out, is evidence that the time occupies space in the battery. What gave sense to the experiment are the assumptions that the son was making during the actions and when the consequences of it were presented.

When an experiment is going on, there are assumptions and thoughts that are not expressed explicitly. Those assumptions are shared by a collectivity and transmitted through culture. If we assume that the child adapts his/her thought to

the social activity in which he/she is involved, he/she will have assumptions that can work in one kind of situation and not in another. Following the idea of Shouldz and Säljö (2001), the contextual features push the child to think differently and make sense of the situation in a different way. The same occurs with the example of Magnuson, Templin et al. (1997) when it is recognized that a scientist uses different assumptions and conceptions according to the social activity in which he/she is involved. Our way to experiment is also shaped by socially accepted and transmitted assumptions.

UNDERSTANDING THE PROBLEMATIQUE

The analysis in this chapter contributes to the problematique by showing some tensions when questioning some central ideas of the dominant discourse. The personal questioning of my ideas could be used to question the ideas that circulate in the IBSE Network. The reflection presented in this sensibility space reflects my personal way of de-naturalizing my own ideas. I did that by visiting texts from different fields that where not constructed to give a deep understanding on the matter. It was not my goal. I was just looking for ideas that transformed my ways of thinking. With all these reflections I identified some problems and tensions for myself when the core ideas of the dominant discourse are highlighted. The essential problem becomes evident when the child is considered as isolated from the language and culture in which he or she lives in. The language, artifacts, concepts and the activities in which all those artifacts make sense, make our way to experience the world completely different than from humans from other historical times. We experience with a particular way of thinking and reasoning as well as with different concepts. It is not possible to make experiments without being engaged in that kind of practices, as Roth (2006a) mentioned. Teachers and students may not see the same when they are manipulating material and making experiments.

Views of reality, experiences and phenomena shape the theoretical perspective of Inquiry Based Science Education. However, the meaning given to these terms are not explicit in documents and written text. It is said that children learn science trough experience, as if experience is a word with one possible interpretation. As I presented, they are a view of experience that does not consider the role of language, social activity and culture when a child is experiencing, and another view that assumes experience is inseparable from language, social activity and culture.

In IBSE texts, the words phenomena or phenomenon are also frequently used as an object that is present in the classroom activities. I showed that this is possible only if a specific kind of language is available in the classroom

activities and if children use it. On one hand, it is possible to assume that the phenomenon can be observed with every day language, and on the other hand, that a different language is necessary to see it. The observer and his/her language constitute phenomena, as well as the collective thinking emerging during the activity.

Finally, another word called my attention: reality. During my analysis of IBSE texts, I assumed that a central element behind the didactical proposal was reality. I assumed reality in IBSE texts when children were invited to observe at the natural and made world. This is also a complex matter, since reality has several ways to be constituted. Natural and made worlds can be analyzed from a perspective isolating facts from the human thinking or connecting with. Scientific realism assumes a world out there is independent from the observer, but it is made real through science; while other perspectives assume the natural and made worlds are in relation with the observer. In the case of children in a science lesson, natural and made worlds must be thought in relation to the observer as well as to the collectivity. In a science lesson, children are involved in a social activity with the language available and used. Children interpret the facts within this social and culturally determined situation.

7. SENSIBILITY SPACE FOUR: DISTURBING IDEALS

> Ce que je voulais comprendre, c'est ce qu'elles avaient éprouvé. Peut-être n'était-ce pas la vérité, la réalité des faits, mais ce qu'elles reconstruisaient de cette réalité. Mais peu m'importait: ce que je désirais connaître, c'était "leur" histoire. Qu'elle soit vraie ou non. Si vous avez eu une grande frayeur dans une rue déserte une nuit, vous risquez de décrire l'individu qui vous a attaqué comme un homme fort, menaçant. En réalité, c'était peut-être un petit mec insignifiant. Mais vous l'avez "vu" grand et menaçant : c'est "votre" histoire. Et c'est celle que je veux entendre[75]. (Murakami interview by Pons (2011))

I would like to appropriate the words of Haruki Murakami, contemporary Japanese writer, to express the reflection that will guide this writing. His last novel, 1Q84, is based on stories of people who experienced through some social realities that greatly impacted their lives. In an interview for Le Monde Magazine, Murakami explains that he was interested in understanding what people had felt: "Maybe this was not the truth, the real facts, but rather what these people re-built from that reality. I was looking for each one's story." Although he mentions that concrete facts may be identified, his interest was in the people who experienced the facts and the way in which they felt this experience. Memories are pervaded with sensations and personal interpretations of what was experienced. The core is the experience.

---

[75] What I wanted to understand is what they had experienced. Maybe it was not the truth, the facts, but they rebuilt this reality. But I did not care: I wanted to know what it was "their" story. Whether true or not. If you have had a great fear in a deserted street one night, you might describe the individual who attacked you as a strong man, threatening. In reality, it was perhaps a little guy insignificant. But you have "seen" large and menacing it is "your" story. And this is what I want to hear.

This sensibility space is about my travel to the world of concrete human activity materialized in the everyday life of a classroom. It is a space where my individualistic sensibility was challenged by changing my assumptions about an everyday school activity. This analytical work was different from the work in the other sensibility spaces since it was based on my experience, by participating two times per week in science lessons and school activity with a teacher. I focused my attention in the assessment activity in inquiry-based lessons and I explored the socio-cultural perspective, having in mind the assessment of group work.

I present some events preparing my work in the field —I refer to finding a school, a teacher and students to work with— and in the design and development of science lessons at school. With these events, I illustrate how I started to notice a different reality from the naturalized, usual idealistic perspective that I held when being member of the IBSE network in my practice as teacher educator. It is a story about my landing in the world of socio-cultural assumptions, and a starting point to understand this new culture. As in the words of Murakami, my intention is to tell how I experienced the events. That is, I am making my process the object of my research and systematic reflection. My intention here is not present empirical material on what happens in a classroom for building a grounded theory of teacher's or children's perspectives. This space is looking again at my subjectivity transformation.

In the first part of the chapter I address theoretical and methodological aspects, and I tell about the process through which I chose the events. In the second part, I showed my experience planning my work in the field. I chose events that made me aware of the flow and constantly changing character of everyday life. In the third part, I focused on some facts that enabled me to highlight the distance between the interpretations from the perspective of research, the IBSE network ideals, and those that operate in everyday school life. The chapter ends with the illustration of some problems and tensions that arise when the mentioned distances are considered.

THEORETICAL AND METHODOLOGICAL CONSIDERATIONS

With the purpose of exploring socio-cultural theories in assessment for learning in the context of the IBSE Network, I generated a research situation in which I could interact and be part of a classroom activity during four months (February to May 2009). The original main idea was to have a place where I could inquire about possible changes in the learning assessment, looking at the different typical interaction settings of inquiry-based classrooms. The experience moved

my individualistic view in two senses. First, during my planning and organization of the work field, I faced several problems that called my attention towards the flow and changing characteristics of the daily life. Second, I started to notice the diversity of interpretations that arise when people in their daily life encounter artifacts, such as those proposed by the IBSE network.

As a sensibility space the original idea can be reformulated in new terms. I performed two actions, each one of which has a purpose in changing my sensibility about the significance of the 'context' of activity, and on connecting and resignifying some of the elements of assessment for learning in a particular classroom context.

ACTION 1: DISTURBING MY IDEAS ABOUT 'THE CONTEXT'

This action had the goal to challenge my assumption behind my view and interpretation of the word 'context'. From my individualistic cultural sensibility, and my own educational culture, I learned to ignore, when looking at classroom activities, that the individuals experienced the cognitive learning process in a classroom at school, and in particular cultural-historical moment. I used to think that the socio-cultural 'context', where the individuals lived the classroom activity, was something static and equal for all schools of a neighborhood: children with the same social level, children sharing the same kind of family life, schools with the same kind of administrative organization, and teachers sharing the same background.

By recounting some events, I gave a meaning to the theoretical assumption connecting individuals with society found in socio-cultural theories. For Lemke (2001), to take a socio-cultural perspective on science education means viewing science, science education, and research on science education as human social activities conducted within institutional and cultural frameworks. My purpose was to make sense of such a statement. Particularly, Lemke made explicit his view that research assuming a socio-cultural perspective must inquire about social activities in such way that gives a substantial theoretical weight to the role of social interaction. For him, interpersonal social interaction is only the smallest scale of the social. He explain interactions between people as one part of more complex phenomena:

> Sociocultural theory proposes that such cooperative human activity is only possible because we all grow up and live within larger-scale social organizations, or institutions: family, school, church, community center, research lab, university, corporation, and (depending on your particular theory) perhaps also city, state, global economy, and even a potentially globe-spanning Internet chatroom or listserv group. Our lives within these institutions and their associated communities give us tools for

> making sense of and to those around us: languages, pictorial conventions, belief systems, value systems, and specialized discourses and practices. Collectively such tools for living our social semiotic resource systems and our socially meaningful ways of using them constitute the culture of a community. Taking an ecological view of communities, we should also include as parts of such an ecosocial system all the artifacts and natural species and materials people employ in making use of these tools.
>
> Finally, sociocultural theory emphasizes that all human activity functions on multiple scales, from the physiological to the interactional to the organizational to the ecological, and so also on the corresponding time scales from the momentary to the biographical, historical, and evolutionary (pp. 296-297).

There are different messages behind those words that I could not see despite reading this quotation several times. Firstly, the idea that individuals and interactions in daily life are connected to large-scale social organizations did not make sense to me in connection with activity of assessment for learning. Secondly, the relationship of the communities and their diversity of tools leading individuals to make particular sense of social activity were far beyond my possibilities of thought. The goal of this analytical process was therefore to use my experience to make sense of these statements.

When I started the research, I had difficulties making sense of the role of the 'socio-cultural context' in the assessment process, since I had my static idea of it. At that time, I was trying to find social and cultural factors that would have an influence on the student-teacher-group relations in the classroom. I identified the 'socio-cultural context' as possible practices in certain regions —for instance a description of the context as location or economical background of individuals of a school— as if the context was something static that could be described by factors as I illustrated in the first representation of my research work in Chapter two, where I wanted to explore the role of teacher, students and my own social background in the configuration of classroom activity. I thought of assessments of teaching and learning science cultures and the way in which these cultures influenced formative assessment. The following excerpts of my research notes show that particular way of thinking.

Empirical Material N°1
Field notes, Carulla, 2008

[…]

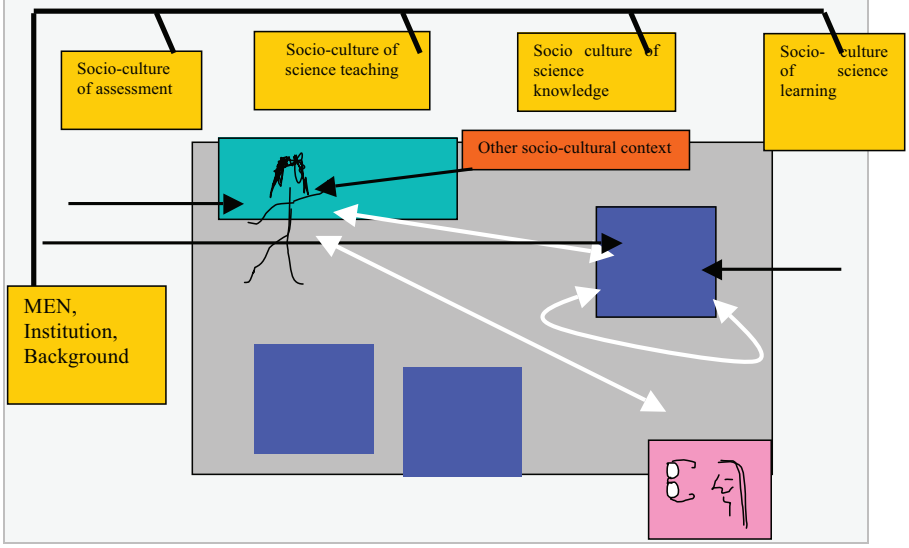
Which are the contextual factors that are part of people's different points of view?

[…]

The white arrows represent the relations that I will explore, characterize and describe. The black arrows represent the possible tensions and distances between the points of view of teachers, students and researcher, and which will be my object of study.

[…]

I am interested in understanding the problems that both teachers and students find when they confront their own point of view with: that of the Colombian Education Ministry, the evaluation policies of the educational institution and the collective building of knowledge within the context of inquiry-based learning.



I wrote: "Which are the factors of the context that are part of people's points of view?" By stating 'factors of the context', I wanted to say those social and cultural variables that could affect teaching and learning. I was assuming there was a uniform context that would determine the way of thinking of the individuals that act and live in it. I represented the socio-cultural dimension as a diversity of existing cultures in relation to teaching, learning and assessment. Likewise, I imagined the classroom assessment activity as a possible source of tension for the teachers or each student, if their work or their way of seeing the assessment was in conflict with the requirements of the state or of the institution: "I am interested in understanding the problems that both teachers and students find when they confront their own point of view with: that of the Colombian Education Ministry, the evaluation policies of the educational institution and the collective building of knowledge within the context of inquiry-based learning." Looking at my words, my individualistic tendency to understand the classroom assessment activity is evident. I was talking about individuals' cognitive representations or their points of view. I was unable to notice the individual and the social activity as a unit to be analyzed.

In regards to what I wanted to research, I wrote that the white arrows in the graph represented the relations that I was going to explore, characterize and describe. I saw assessment for learning as a process of interaction between individuals. In particular, I wanted to see what happened if the individual was replaced by the group of individuals. What kind of interactions would appear then? I did not establish a particular relation between black and white arrows, as if the static socio-cultural context did not affect inter-subjective relations. My view gave importance to the social and cultural dimensions of the individuals, as stable entities that would act in one way or another according to their view.

I realized that the term 'socio-cultural' was likely to have a different meaning from the one I had given it. This was not simply a set of social variables that affects or not what happens in the classroom. As I showed in Chapter four, the social and cultural contexts from a socio-cultural perspective is not static, they change in time and under local circumstances (Engeström, 1996; Lave, 1996). For my analysis, I considered the context as constituted by relations among people within an institutional frame as I interpreted Lemke (2001). However, again, I had an individualistic tendency to perceive the institutional frame. In my understanding based on my interpretation of Radford and Empey's cultural-historical view, I see today that what was relevant to analyze was the social activity in which the individuals were immersed as a complexity including Cultural knowledge, Forms of production, Forms of Social Relations, and Semiotic System of Cultural Significations. I adopted a view that views the interactions of children and teacher as a social activity mediated by language, artifacts, tools and shared meanings as well as relationships, norms and values possible only in that concrete historical moment. Thus, I changed the word 'context' to a 'social praxis', constantly changing and configured by individuals' engagement in the activity.

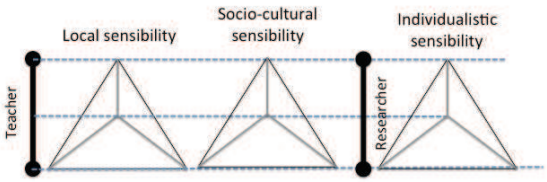
I used some elements of my experience to give meaning to the idea that social interactions among individuals cannot be separated from the institutions in which they occur. Cooperation and interaction between individuals make sense thanks to the community in which they act. The sense we give to what we do is given by languages, conventions, beliefs and principles, as well as specialized languages, conventions and practices (Lemke, 2001). Similarly, I will consider the idea that the contexts are linked to specific historical situations and that interactions and human activities happen according to what is possible to think and do within that particular historical moment (Radford, 2008; Roth, 2007; Roth & Radford, 2010). Thus, contexts are not static entities or factors that we can collect; human situations and activities are modified through time, in the same place where personal interactions occur. Quoting Radford (2008),

> [T]hinking is a dialectic movement between the constituted historical reality and the individuals who refract that reality according to their own subjective interpretations, actions and

> feelings. Individuals do not think in an isolated manner; they appropriate historically and culturally determined manners and at the same time act according to their own subjectivity. (p. 219).

ACTION 2: LANDING

My simplistic view of a context was difficult to 'remove' from my subjectivity. I used cultural-historical activity theory to understand the problem I was facing. The situation of my encounter with everyday life at the school can be described with Radford and Empey's (2007) triangle of social praxis and cultural knowledge.



Graph Nº 1. Representation of the interaction of individuals with diversity of cultural sensibilities

I faced, in my visit to the field, the diversity of the social praxis in which the teacher and I were involved, and the differences of my ideal of classroom praxis with my IBSE interpretations. Graph Nº 1 represents the complex situation: a teacher immersed in her own 'Local cultural sensibility' —I used the term Local to give an account of the social praxis of the teacher—, myself immersed in my own social praxis of IBSE and assessment for learning, and the socio-cultural research used as a source of inspiration to imagine a new assessment activity. I identified three different assumptions present in my experience in the field: teacher's group of assumptions, socio-cultural assumptions, and my IBSE assumptions.

I started my research on assessment for learning, based on a laboratory[76] approach to shaping the classroom reality, in which there was no place for the 'socio-cultural context', beyond the assumption that the classes took place in a static context, and the instructional materials were translated and adapted to it.

I gradually built this reality during 9 years of work in inquiry-based teacher training projects. My everyday practice —reading of modules and class sequences, evaluations, training workshops, detailed observation of class videos, direct observation of classes and reading of research articles— generated a common sense and an ideal image of a class: the laboratory class. I say 'laboratory' reality, since I had removed all the elements that happen in a current activity class: dominant teaching forms, characteristics of teacher-student personal interactions, students that do not want to do the activity because they are hungry, noise and laughs because of what happened during the school break, management decisions that affect the possibilities of what is done or the planning of a school journey that makes it impossible to carry out the designed class. None of that existed in my way of visualizing that reality that I considered 'real' and possible although I had not lived it. This was what I was trying to make apparent to teachers in my workshops: I wanted to share my individualistic cultural sensibility with them.

When I first designed the research cooperation with a teacher in her classroom, I built on the critical research methodological triangle presented by Skovsmose and Borba (2004), as discussed in Chapter three. At that time, I had planned that the teacher and I would be engaged in a cooperation imagining an assessment for learning activity, considering the interactions between subjects and the physical world. We planned classes together; each one contributed with her ideas before each class. We had weekly conversations, not only about what we did, but also about our previous experiences with assessment and education. We looked at the reactions of the students and considered them in the light of what we planned. I considered as the *Current assessment situation* the classroom assessment activity without my intervention. That is, the assessment activity as the teacher used to do it. When the teacher and I planned together our weekly session, I called the assessment activity, the *Imagined assessment situation*. And finally, I called the *Arranged assessment situation*, the implementation of what we thought, as interpreted and realized in practice by the teacher. We carried out

[76] I used the word 'laboratory' to represent Ole Skovsmose's (2010) idea presented by him in a speech at Aalborg University. He made a difference between the way as research discourses constitute the 'reality' of a classroom, where the complexity is reduced to those aspects that want to be showed, and the 'reality' of a classroom with all the complexity emerging in a classroom located in a social setting, with specific institutional culture, values, norms and relationships.

the process of *pedagogical imagination* and of analysis of the current situation with its problems so as to formulate the imagined situation.

I documented that process with audio recordings of our conversations before class and videos of the two weekly sessions with the students. Likewise, I wrote diaries and e-mails to my PhD supervisor, as well as work reports that I carried out to support the design of the classes. The latter were about my findings on the context in which I was and they provided my view of the moment about the learning and teaching processes based on inquiry. As I grappled with the recordings, transcripts and documentation, I came to realize that the 'empirical material' I had collected could be explored in different ways. I could have provided a description and analysis of the process of pedagogical imagination to document the practice of the assessment practice of teacher and the students' engagement with her activities. But such an analysis would have kept me operating with my naturalized individualistic concepts.

It became evident that the documentation allowed me the opportunity of seeing how my entering into the school, gaining access to collaboration with the teacher, and the very same dialogues with the teacher were important part of my questioning. They were important events of sensibility. I decided then to examine the material from this point of view. The first action in this space revolves around my selection from this material to re-create some of the events, to tell my story: My story of my subjective change. This experience in the field enabled me to understand the research process in a different way. In my analysis I will include some considerations related to my appropriation of socio-cultural research and learning theories. I intend to show how some of the aspects of socio-cultural theories made sense when I looked at my experience in the school.

The second action is focalized directly on the assessment activity. The goal was to show events looking for the diversity of interpretations that the teacher praxis allowed her to do, and my own, that were shaped by my experience as a teacher educator of IBSE network. Although I landed in a class in an institution, in a particular historical moment, I also travelled to another theoretical world: from a view centered on the individual and his/her conceptions, to one in which language and different ways of reasoning in different cultures were evident. While I was trying to understand the way in which learning is observed in the group work, and how each student is assisted to learn, I found new approaches and ways of constituting the universe of the classroom. Then I learned that there are other possible ways to shape the classroom reality that are as well documented and supported. I could also see that that new way of shaping reality implied a series of actions and activities that were different from the ones in the other theoretical approach. In terms of my first angle of the *problematique*, I could explore the difficulties faced by individuals when their experiences are different from the classroom activity ideals of the IBSE and assessment for learning pedagogies. I faced here the

impact of the differences between the teacher expectations and interpretations of curricular material, based on her Local cultural sensibility, and my interpretations and expectations of classroom activities based on the same curricular material and my IBSE and assessment for learning knowledge. Our individual forms of constituting classroom reality were different. At the same time, I experience difficulties by making sense to the socio-cultural ideas.

For instance, in the new approach, the learning goals were stated in terms of appropriation of language and discursive types that help the students give sense to the world (Leach & Scoth, 2003; Mercer, et al., 2004). The theorization on the way the students learn was different. They would not speak about skills or concepts but about cultural ways of reasoning that had to be appropriated by the student. The centre of interest was language: Scientific education seen as a discursive process (Mercer, et al., 2004, p. 359). Social interactions were considered the core of the learning process: students must be aided by their science teacher to give sense to the conversations around them, and while doing this, relate them to the ideas they have and to diverse ways of thinking (Leach & Scoth, 2003). Emphasis is on the conversations that are of inter-subjective character. The individual and his/her thinking, what is intra, become conversations with his/herself, using the inter-subjectivity language (Mercer, et al., 2004).

Gipps (1999) explains how scholars researching assessment for learning with a socio-cultural perspective inquire about assessment and relationships:

> In newer forms of assessment, such as negotiated assessment and self-assessment, the student has a role in discussing and negotiating the terms and outcomes of the assessment, although in reality such a practice may be rare. The thesis behind such a non traditional approach (critical-theoretic in Habermas's framework) is that students need to become involved in the assessment process so that they are encouraged to monitor and reflect on their own performance in order to become self-monitoring and self-regulating learners (Broadfoot, 1996; Wittrock & Baker, 1991; Wolf et al., 1991). A key element of the interpretive paradigm is the need to understand a learner's response. In relation to informal assessment, this includes the learner's expectations, assumptions, and interpretations of the classroom culture, task demands, and criteria for success (Aikenhead, 1997). (p. 379)

I needed also to understand the socio-cultural perspective about interaction. I had the idea that interaction was important for the individual process of learning. In that sense, my experience in the school was shaped by this approach and by the possible interpretation of ideas such as those exposed by Gipps. For instance, we explored with the teacher the idea of negotiation of meanings with learners,

and also to share with them the objectives of the activities. We involved as much we could the students in the assessment process, but it was not easy to make sense of the idea of including learners' expectations and assumptions. During my visit to the school, I decided not to consider the learners' perspectives, since I was not comfortable with that, I had difficulties in finding ways to approach to the students.

Through weekly dialogues, the teacher and I re-shaped the classroom reality: reality from her perspective, reality from my perspective. Likewise, we thought about what was going to take place during next class or week or month. The goal guiding my actions at school was my questions about the way in which the learning during group work could be assessed. How to get closer to what was expected from the inquiry learning theory —by generating debates, sharing ideas, asking questions and answering them through experimentation, etc. The teacher's activity in classroom was guided by her interpretation of our conversations, her knowledge of the school —she had worked there for 9 years—, and her knowledge of the children and their possibilities.

In this chapter I present a re-construction of the experience. It will be a new story, based on my sensations and interpretations in the light of my new socio-cultural theoretical framework. I do not intend to tell a sequence of events. Instead, I want to find dialogues, and situations that enable me to give sense to some dimensions of socio-cultural theories. By doing this, I will generate some categories to illustrate my new views. I intend to show how I gradually went from a fancy, laboratory image of the classroom reality, possible for every classroom activity in the world, to one in which the social praxis and the individual became part of my perception of the assessment reality of the classroom. In this new way, the existence of an assessment for learning within de-contextualized practices of the IBSE Network got re-configured.

Maybe the research stories tell us about the experiences of those who have reflected about assessment for learning. But the classroom reality is not as they represent it. The everyday activities, in the flow of life, as cultural-historical research perspective tries to capture, and modifies that fancy, laboratory reality. I will write about my fancy research-based world meeting the world of a teacher and the children. I divided my analysis in two sections. The first is an attempt to materialize the first action with the goal of giving meaning to the assumption linking individuals with large-scale social organizations. For this, I chose some events when I was organizing my visit to the field. The second section is built around some events illustrating the process of following the socio-cultural assumptions and the interactional everyday life of a classroom.

LINKING INDIVIDUALS WITH SOCIAL ORGANIZATIONS

I presented in Chapter six some theoretical approaches to the term 'reality'. In this chapter, I use the psychoanalytic perspective recognizing the intrapsychic reality of each individual (Rojas-Urrego, 2009a), associated to an individual way to construct reality, and the inter-subjective reality as a relation developed by those individuals. Green (2002), quoted by Rojas-Urrego, wrote that during the analysis of a person, the inter-subjectivity becomes the mediation in order to be conscious about the intra-psychism constituted by the meeting between the internal world and the external. This perspective and the cultural-historical constitution of all individual psyche with the 'I' and the 'Ego', inspired me to create a category to analyze some events. I say that two persons develop a relationship and interact according to their intra-psychic reality, and at the same time the social activity in which those persons are involved mediate what is possible in the inter-subjective relation (e.g., it is not the same to a person to be in a relation with a psychoanalyst than to be with others in a work situation, or a personal relationship).

I observed that for an individual the inter-subjectivity varies according to whom this person relates, the role adopted in interaction moment, and historical background. I characterized this observation as unstable inter-subjective relation. In line with this idea, I will give sense to the unstable inter-subjective relation according to the institutions to which individuals belong, and to the changes that take place in time and in historical moments. I illustrate how inter-subjective relation changes in time within the same place. With this, I want to capture the flow of life (based on a cultural-historical perspective) while individuals are engaged in social activities within social organizations (following Lemke's statement of socio-cultural perspective). I wanted to move from my static view of the context.

When I began organizing the empirical research and searching for access to a school and a teacher to collaborate with, I had to face some difficulties. I started realizing that Cristina was not simply Cristina. From a feeling of being an individual that did a research in a school, I became a representative of a particular community. This community determined my relations and interactions at that moment, the possibilities to do something or not. Although I was in study leave from my previous job at the University of Los Andes, my interaction in this particular context was determined by my belonging to the institution that I worked for. We were inseparable. What was happening, the relations that I was establishing, all were determined by the history of previous interactions with individuals of the educational institutions and the particular context in which the research was being developed. The activities that I had done as part of that

institution and my belonging to it were linked not only to the image that I have of myself but also to the image that the others had of me.

When a bond is made between an individual and the society, inter-subjective relations may be established in terms of the possible interactions of each individual involved in the relation and the circumstances of the moment of interaction. The same person may have different relations with others. When changing from one context to another, from one activity to another, there are possibilities that become real and others that do not. According to my analysis, the inter-subjectivity of a person is variable in terms of the way in which the relations with the others are established and the roles that we socially adopt in one case or another. These cannot be dissociated.

Teachers are part of a school. This implies there are things they may do and others they may not, but additionally that their belonging to the institution makes them act in a particular way. In the search for a teacher who was willing to generate knowledge with me and be my research partner, I found stories with facts that I related to that connection between an individual and the society. The role that we adopt in a particular social praxis or that is attributed to us determines what we may or not do. It is an essential part of the social activity. According to Radford and Empey's (2007), forms of labor and social relationships are tied to the social praxis. I explain these ideas with the following events.

EVENT 1

My interview with Clara —a science teacher educated to use inquiry teaching by a Colombian inquiry-based project— for instance, allowed me to see how her individuality and her possibilities were tied to the context in which she worked and performed. Her students seemed very enthusiastic with the way they were learning science. I had great faith in her. We had a particular connection. She had expressed several times that she wanted to work with me. Clara was Clara, but she was not Clara at the same time. She was bounded to the relation that we had established before when I was her teacher educator: our inter-subjective relation.

Empirical material N°2
Extract of my thoughts while I was looking for a teacher collaborator in my research
(Selection/teacher, p.1)

Clara: She has been outstanding in the different training sessions in the project "Pequeños Científicos". She has a good performance during the design and development of workshops for teachers. She has been involved in different activities of the team without charging, out of her own motivation. She has participated in special workshops with Karen Worth. A video was made

interviewing her students and they showed a particular ability to speak; their reasoning regarding scientific knowledge was pertinent, as the ones related to the learning process. We have, just as with Juana, established a very close relation of mutual trust. She has scientific formation: a Biology Master's from a respected Colombian University. Thanks to her participation in the project, she got a scholarship to do a Masters in education at a public university. She is currently in that process. She is the only teacher that I have heard has explored the creation of new modules of learning sequences through inquiry for high school students in areas different from the existing modules. She is critical and has good working relations. I feel good working with her. Her participation in my research depends on her involvement not conflicting with her studies.

These were my reflections on Clara and why she could be the ideal collaborator. In my activity as teacher educator, I built a relationship with Clara: I was a teacher and she was a student to my teaching. As teacher educator I had a very positive image of her, as teacher and as learner, not only because she was good in her teaching, but also because of her commitment to her own process of learning. I found in her an ideal teacher to work with, since she knew very well how to apply inquiry in her teaching. Observing my reflections at that moment, I isolated her from the institution, I did not consider that she was a teacher in a school and that this dimension was important to my visit to her classroom. However, when I got to speak to Clara about the possibility to work together, some obstacles arose and made such a project impossible. Her relations with the institution became evident.

Empirical material Nº 3
(E-mail to Paola 1/26/09)

On Thursday I will interview a wonderful teacher from a public school. She was among the first teachers I described... I would love it to be her, since she is very good, reflective, etc. But she is doing a Masters and I don't know if this will be too much work for her. If this does not work out, I will continue hunting...

Empirical material Nº 4
(E-mail to Paola 1/30/09)

The meeting today didn't go well. This teacher can't either, not because she doesn't want to, but because the conditions of the school are terrible. They are changing the headmaster and there is not much interest on inquiry...
I am a bit down with this situation. I don't know if maybe I'm dreaming with a research that is too complicated... I need to speak to you urgently.

The school administration where Clara worked had changed. The new leadership did not support inquiry-based science teaching. They were not interested in it. Clara had devoted several years to develop a fully inquiry-based science curriculum at the school. I personally had several meetings with the Board of Directors and teachers at the school, and teachers seemed to do teaching based on inquiry. The school had even been acknowledged publicly for their work in developing IBSE —in the ceremony of a specific teacher education program within a Colombian inquiry-based project in 2007. Clara had received support to do her Masters studies thanks to this acknowledgement. However, the conditions had changed. It was no longer possible for her to work with inquiry, although she recognized the value of it. She described many tensions and problems in this regard.

At that particular time, Clara was not only her, but also part of the institution she worked in. As such, she could not do what she wanted. She had to follow particular rules. Her work had to be adapted to the administrative situation of the moment. This was evident in different dimensions in her everyday activity. As she explained to me, her class planning had to follow other parameters now. The context had changed in some way, so had our relationship. We were not part of a common inter-institutional project that could support our work. The type of relationship we had established in the past was no longer possible. The situation of the moment changed our inter-subjective possibilities to work together.

Our roles and relations within an organization are limited by what is allowed or not to do in that organization. Establishing a place to develop my research was revealing issues that I was not aware of, although I already knew of them. In other words, I thought that teachers would want to work with me out of the blue and that there would not be other forces that would hinder the fieldwork. But it did happen; the context 'turned against me' and showed me its ways of operating. There the context was showing us something that cannot be separated from our individualities and possibilities in a particular moment and place. The cultural-historical research perspective about studying the everyday life of individuals started to make sense to me, and I noticed something that I had learned to avoid before.

EVENT 2

I made the decision to carry out my fieldwork at an educational organization. I will call it "United Organization", to refer to the fact that several primary and secondary education schools comprise it. The United Organization has links with the University that I worked for and thanks to this I had done several tasks for them: My first contact with inquiry was when I supported a team of teachers of this organization in the interpretation and adaptation of the sequences of inquiry-

based learning. I had also conducted workshops in mathematics education for their teachers, and was part of the team that designed the mathematics curriculum. I did my Masters thesis using empirical material from this organization.

They received me very well when I asked the leaders to let me carry out my PhD fieldwork there. My feeling was that I represented a particular person, a teacher trainer that belonged to the teachers' team of a socially renowned University. We had interacted several times in the past. I had always felt they respected my work. I was Cristina, but I was also someone else. I was all the dimensions and images grouped in my self, so that they would open their doors to me. The Board of Directors gave me the chance to establish a relation with someone in the institution, just as I expected.

Empirical material Nº 5
E-mail to the board of directors, 1/15/09

Alfonso and Rebeca,

Again, thank you for your warm welcome yesterday. I present here the main agreements that we came to during our meeting. If there is any change or missing information, please let me know.

We agreed that your organization:

1. Accepts the proposal of Cristina Carulla to carry out research fieldwork in one of the 5th grade's science classes of some of the schools under your administration.

2. On Thursday 22 of January, during the institutional planning meetings time will be given so that Cristina can introduce her ideas to the five teachers of 5th grade, so that she can know with which of the five teachers she can collaborate. Appointment scheduled at 7 am in United Organization to go to Juanchito School.

3. Once we know which teacher will be participating in the fieldwork, Cristina will contact the headmaster of the corresponding school to present him the project and talk about the conditions: weekly presence of Cristina at the School, planning work moments with the teacher, changes in the assessments, recording of videos and audio, interviews with the kids, places, etc...

It was agreed that Cristina Carulla:

- Would inform about the progress of the fieldwork and possible developments within the organization.

- Would conduct a workshop for the teachers of the organization about assessment for learning or training focused on groups of students rather than in one single student.

- Would avoid making global assumptions about the work of the organization based on the class experience. It was clarified that the research neither intends to judge the pedagogical work of the Organization nor that of the teacher in particular. The work

consists in exploring possibilities and a learning experience for the teacher, the children and the researcher.

Empirical material Nº 4
E-mail from Rebeca, member of the board of directors of the organization, to Cristina, 8/12/09

Cris: You know that the doors of the United Organization will always be open for you, at least while I am here.

The Board of Directors of the United Organization gave me a 'warm' greeting, as I wrote in the summary of our meeting. They gave me permission to do my research with one of the teachers of 5th grade. They gave me a place at an institutional event so that I could speak to them and look for their support. In the summary sent, the willingness and trust of the board in relation to my work and me were evident. They did not object to my demands; they just approved my request and gave me their resources. In the case of Rebeca, she manifested her openness. Rebeca was representative of the institution and had an inter-subjective work history and relationship with me. I had shared different social activities with her, from the creation of a curriculum to the teacher training processes.

As may be perceived in the message, again I had the idea that, having stable institutional conditions —a fixed contextual variable—, I would magically have a teacher that would want to work with me. My assumption was that my inter-subjective relation with individuals I worked with in the past was continuous and out there again, regardless of circumstances of everyday changing life. As I had interacted with other teachers in the past, I felt that I had a good relation with them. For me, having the support of the Board of Directors meant that the following steps would be easy.

EVENT 3

The search for a teacher, who would be interested in what I saw as questions to study in everyday inquiry-based classroom, and at the same time would want to do research with me, became a problem. I had a series of candidates who had attended workshops with me and I had the impression that they were the perfect candidates: We could speak the same inquiry language. Similarly, I thought that they would not have any problem to work with me, since I felt there was a minimum degree of trust among us. Nevertheless, when I tried to establish the terms, the environment and the situations showed me that my assumptions were not sound enough. This was me, but it was not me at the same time. I felt that although I was approaching the institution as a researcher, I could not be

separated from the institution that I worked for, and of the image that the teachers had of me out of my workshops and work relationships in the past.

While designing the fieldwork, I had agreed to do the research with one of the 5th grade teachers of the United Organization that I knew since 2002. I admired her for the way she managed inquiry-based work and the way she encouraged the students to get actively involved in activities. I used videos of her classes to illustrate aspects of inquiry in my workshops, both on assessment and on inquiry. She had taught me many things. When I started the empirical work, I spoke to her on the telephone and I perceived distance in her voice. She told me that it was impossible for her to take part in the research. She gave me an explanation related to her personal situation. I felt upset, since 'I' was being 'me'. I felt I had a relationship beyond work with her. I was approaching her as an individual writing a research and not as a representative of an institution. I was very naive to think that she would have liked to work with me, as I had felt that the first time I told her about my intentions, she seemed to have accepted my proposal. The only thing she had asked for in exchange was that I would teach her what I knew about inquiry and I felt she was connected with the idea.

The tension between my institution and the United Organization were not only at the management level. There was also discomfort in the teachers. That tension and discomfort were not due to me as an individual, but to my belonging to the institution that I worked for. I felt this very strongly when I went to talk to the teachers as we had agreed, on the educational planning day.

Empirical material Nº 6
E-mail to Paola, 1/26/09

```
My visit to the school was a complete failure. I found nothing
but cold ice... Well, I was planning to call you but I wasn't
feeling good and time just passed by... I'm trying to find new
solutions. They offered me a teacher who is not in 5th grade and
she is the coordinator for a lot of people...
```

I remember the feeling of failure. In general, my relation and contact with the teachers that I visited was pleasant. I had never before felt rejected. But I did feel it that day. Something strange was happening. First, the rejection of one teacher to work with me. And now all of them, one by one, said no. Between the conversations and my search for explanations, I got to understand that they were very upset about a series of events that happened at the university that I worked for. They felt they were being used and they were not receiving anything in return. At least nothing that was actually important for them. In this relationship, I was me, but not really me who they were rejecting. My relation with my employer was also a burden to me. Although I was not present when those events referred to by the teachers happened, it was as if I had been. Moreover,

those events were related to some work sessions about inquiry and learning assessment with foreign experts that had pushed the participants to question in depth the knowledge related to inquiry processes. This generated discomfort in many of the participants.

I had the feeling that my role as a teacher educator in the past was also related. For the teachers, I did not only belong to the university, but I was also part of the expert team in inquiry and assessment and had international links on the matter. As teacher educator, I established a particular relationship with them. During two years I was there with the teachers week by week, while they appropriated inquiry tools. I spent a year conducting a workshop in which we discussed and worked on inquiry principles. That image was also coming to light. It was not me, but the image produced by the role played as teacher educator, with different knowledge. They saw in me a potential judge of their work in the classroom. Opening their intimate workspace to someone is difficult, but in addition opening the workspace to someone that they consider an 'authority to judge' over their work can be interpreted as dangerous. I was not aware of the power that such image produced on teachers. My knowledge became a threat in that situation. Maybe they felt they were not doing inquiry the way I had shown them from the theory so many times; maybe they were overwhelmed with other sensations. They did not see me as Cristina but as that other me who was an authority in the matter. I definitely did not want them to see me like that. I wanted to learn from them. For me, they were the authority in the classroom, in the activities with the children. I wanted to learn in that context but I already had a role that had been given to me historically in different contexts and during 9 years of interactions with the institution that they work for.

During that meeting, Inés, the coordinator of the science area in the five schools, was there. I had not met her before. She had not been in my workshops before. She was a high school teacher with a degree in chemistry. She felt the tensions and proposed to work with me. She said she had started to work in a primary school, and that she could do it to give me the chance for my research. She said she would help. For Inés, I was only me because she did not have images or ideas of me. Thus I could be myself, I could start a new relationship with her where the weight of the institutional framing was not so heavy, and instead, was free from any previous history.

Empirical material Nº 7
E-mail Paola 2/2/9

```
Well, finally I decided that I will work with Inés. The day that
I went to the United Organization and the teachers did not say a
word, and without me saying anything else, the general
coordinator of the science area —who teaches science in addition
```

to coordinating— told me that she was interested. She said she could change the group of students, since she had been given 10th grade, but that she had worked with 5th grade last year and could ask to continue with that group in 6th. Besides, she said that it was easier for her than for the teachers because her timetable was more flexible. My doubts and the reason why I wanted to look for someone else is that I do not know her work because she has not been long with the 6th grade students, so she must not be very skillful... But I think there are other advantages.

Several things seem good from the proposal:

1. On one hand, the board of directors is enthusiastic about the proposal, they felt very interested.

2. On the other hand, the institutional conditions as regards to the science curriculum, in which inquiry is a "stable" factor. I want to say this, since in my conversation with Clara, the other teacher, about what has happened in the institution and the difficulty they have to teach by inquiry, leads me to think that it will not be easy to find all these conditions of the United Organization, since they have an established curriculum guided inquiry modules or didactic units.

3. This teacher has been 9 years in the organization and has followed all the process of curriculum design. She also has a degree with emphasis in science. She has scientific formation, which enables me an interlocutor in science, in which I am not very strong and I need to learn.

4. Since I did not say anything, Inés asked Rebeca if she thought I might not be interested in working with her, which makes me think she is actually interested and she is not just doing me a favor.

5. Rebeca told me that once one of the teachers accepted, she would think that this work could count for ranking. This sounds great to me, since she would be rewarded for her work.

6. OK. I said we would talk this week and classes start today. I have thought that I prefer to be prepared to start; that this first month is to go at slow pace and start sailing in that reality.

Although I described Inés in that mail as a coordinator and mentioned all the attributes particular to the social role she was playing —coordinator and science teacher with a degree in science— I did not have an image of her. We did not have a history together that would give meaning to those particular roles that each one was carrying. Our history began with the research. 'Coordinator', 'science teacher', 'science degree' were only words and images that were separated from the person of Inés; Inés was not Inés. She became my research colleague. On the other hand, in my e-mail to Paola there is evidence of the significance to me of doing research in a context in which the key elements for an inquiry-based science class were already accepted.

MOVING MY AWARENESS

With the three events depicted above, I have tried to re-create how the everyday activity of planning my visit to the field was disturbing. The analysis gave me the possibility to grasp ideas behind the cultural-historical activity theory. During Clara's event, I focused the attention on changes that appear in a work situation. A new comer in school changed the priorities of teaching, ignoring the inquiry perspective preferred by teachers. The individuality of Clara, her personal beliefs, was not enough to allow her to continue her teaching trough inquiry. She must follow the institutional directions and act in consequence. The construction and analysis of the event allows me to notice the strong relation between the individual, the social activity and the social organizations.

I also made apparent with the second event that the possibilities of my visit to the field were also shaped by my past work relations and experiences connected with teachers' experiences and institutional possibilities. Teachers, administrators and myself acted in connection to the complexity of institutions where we belong, with specific ways of understanding meanings and resources. By showing the difficulties of finding someone to research with me, I illustrated the complexity of human activity, functioning on multiple scales —my individual and the teacher's psychological perceptions and ways to constitute reality, the specific way to interact between myself and teachers, and my relation to the school mediated by my past experiences and also by the organizational relation in the past. I tried to make sense of the multiple scales shaping human social activity: in one moment in time and place —in a neighborhood, in Bogotá, in Colombia—, with a biographical and individual experience —my history of relationships within the school as a teacher educator and Clara, Inés and other teachers' personal history—, a history of relationships and shared meanings —Clara, Inés and other teachers had a history of relationships with me as a teacher educator or no relationship at all as Inés and I—, and the evolutionary and variable characteristics of the relationships in a physical space —such as those relationships changing in the same place when new contextual changes open up other possibilities for the relationship.

INDIVIDUALS MAKING SENSE OF WORDS AND ARTIFACTS IN SOCIAL ACTIVITIES

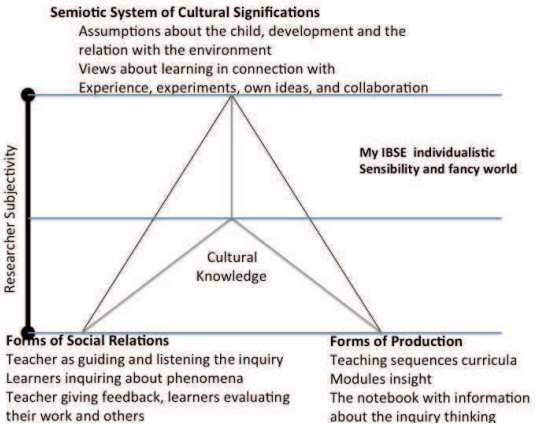
When we carefully observe the research in assessment for learning activity in inquiry-based classrooms, we travel to a 'fancy, laboratory world' —I use here the expression 'fancy world' in the sense of something that is created from the researchers' imagination, theoretical positions, as well as their practical knowledge. In that world, there are ideals that account for the interpretation of

the researchers on learning theories, knowledge and assessment. On one hand, it grounds a group of assumptions about the way scientific knowledge is generated and clarified: inquiry. On the other hand, it consolidates those ideas in the expectations for the student's education: skills, scientific concepts, explanation abilities and attitudes. The integration of knowledge promotes the generation of tools for the assessment in the classroom —criteria, indicators and ways to recover knowledge— and shapes the expected assessment activities in the classroom: the kind of conversations, exchanging ideas, feedback communication activities and problems to be solved.

As user of research for assessment for learning in the IBSE Network, I gradually built a particular way of thinking about the reality of assessment in the classroom. The supported and very well documented arguments of the researchers led me to enter that fancy world. They made sense to me. I learned to constitute a reality in the classroom that was very similar to the reality in that research. For example, I could imagine situations of assessment for learning on each student. I could see types of questions and activities that could help every student to develop a certain inquiry skill. Likewise, I was able to detect the type of comments that would help the students to gain understanding of scientific concepts. I was looking for mechanisms to identify the students' learning in terms of skills, attitudes and contents.

My adopted fancy world became concrete in my workshops with teachers, in my talks with researchers, in my careful analyses of videos of inquiry-based classes. I also observed children's notebooks and some activities of the teachers. I was always looking forward to giving sense to the theoretical tools that I had learned. I never had the chance to test myself on how this would work in the daily classroom activity. I did not know what would be teachers' reactions to my questions or comments. I did not know how I would act in such circumstances. Similarly, I did not know the everyday life of all the teachers that attended my workshops. Sometimes I had visited them, but I had never worked close to them, trying to make sense of theories in the field. From my fancy world I travelled to the world of a school in the city of Bogotá. I arrived to a context of an inquiry-based science class with children and a teacher. I was looking forward to learn about this dimension that my fancy world was lacking: I wanted to have the experience of the everyday school life.

Graph Nº 2 represents my subjectivity fully charged with the individualistic sensibility and fancy world. My subjectivity as it evolved in the everyday praxis as teacher educator within a community, while sharing artifacts, words, concepts, ways of looking at inquiry, productions of knowledge and teachers and learners relationships. I learned to interpret curricula material of the insight modules with this sensibility. I arrived to the school with my historical way of interpreting inquiry.



Graph N° 2. Representation of researcher subjectivity in terms of the IBSE individualistic sensibility and fancy world

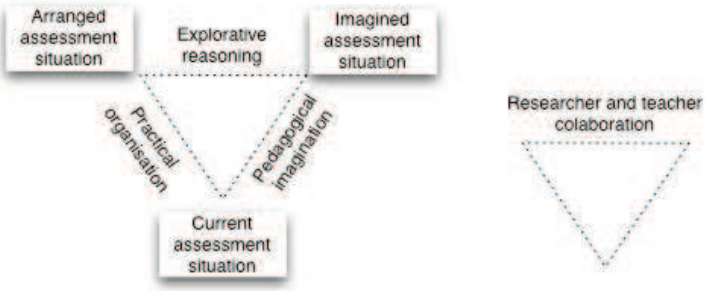
My individualistic sensibility and fancy world included the set of assumptions about the child, development and relations with the environment, and all my truths about the way in which the learning was expected to be planned. I also had a view on the relationships between the teacher and the learners, the kind of feedback about the learners' works and expectations about children's thinking. Additionally, I had a large experience interpreting the curricula material and had my own view on notebooks' characteristics as well as uses of them to assess children's evolution in inquiry thinking. When I arrived to the field I did not have the elements of the analysis presented in Chapter four, I did not have a clear differentiation between them and the socio-cultural.

When I started to analyze my experience at school, I realized that my ideals of the inquiry-based classroom were far from what happened in the everyday life of that classroom. Innate ideas and theories of children were not part of the language used by the teacher, nor of the ways of supporting what students were doing. The assessment activities varied from traditional ones —individual tests— to group work situations following inquiry guidelines. Inés interpreted the Insight modules called "Structures" and the "There is nothing to loose" —the curricula material following inquiry principles and presented in Chapter five— in a different way from what I did based on the ideal inquiry model. The interpretation of the group work and its purpose were different in the sense that for Inés the organization of the class by groups was a strategy to work pedagogically, while for me it was relevant and constituted the learning process itself. For Inés, the focus of assessment was on how well the children managed the concepts and on how complete their work was, while for me the core was the inquiry activity, including skills and concepts to develop thinking. I realized that

the way we interpreted the artifacts —such as the notebook and the activities carried out by the children— was different.

The challenge for the fieldwork was to change my individualistic IBSE sensibility and the focus of assessing learning. I had initially in mind to look at group work as the move from the individualistic perspective, focalized in gathering information about learning in the individual mind, towards one that collected information by looking at learning in the interaction of individuals. I used material collected during my stay at the school, paying attention to the varied interpretations of the process of teaching and learning that took place in the classroom and during the process of design of new assessment strategies with Inés. Also, the analysis of my experience brought elements about the flow of everyday life, constituting the classroom activity not as static but rather as changing, while Inés and I decided changes and new forms of organizing children's learning activities.

The activities that Inés and I did were organized around the methodological triangle of Skovsmose and Borba (2004) as mentioned in before (Graph Nº 3).



Graph Nº 3. Methodological triangle that supported the experience at school

During the planning of the imagined situation, following the model of Skovsmose and Borba (2004), Inés and I would talk and plan around assessment for learning and the possibility of assessing the interactions of the groups. Inés and I carried with us a personal history of assessment. In my case, it was not related to the school where we were; in Inés's case, her personal history was related to her teaching practices at the school in the United Organization.

Although we had the freedom to move in the assessment group activities that we were exploring, the dimension of summative assessment and institutional norms, as well as the history of Inés within these traditions were part of the possibilities and restrictions of our exploration. For example, every two weeks the kids would undergo an overall evaluation that covered all the institutions that

were part of the United Organization, related to the topics they were learning. Within this restriction it was important to prepare the kids for this assessment. Likewise, the topics that were being taught had to be related to those that all the teachers of the same level were teaching. These facts determined activities of evaluative nature in the classroom.

One of the characteristics of inquiry-based teaching is that children desks are organized in such way that children can do activities in groups. In some schools this was problematic since the desks were designed for the individual and not as having the possibility to be used for group work. In Inés' school this was not a problem, since the desks were tables and thus it was easy to organize the group of tables. It became a ritual for children to modify the organization of their desks. When children arrived to the class, they found their desks in lines, normally 7 desks per line and 6 lines in total. The classroom had 42 students. When the individual summative assessment was done, the kids would seat in this way. This is a classroom organization in which Inés addressed all the children, appealing to their individuality. However, what happened most of the time was that children would arrive and organize their desks so as to work in groups of four, sometimes five or three students per group. When we imagined assessment activities, we thought of those groups, as well as in the activity that would make the whole group interact. Inés addressed the groups in class, she explained what they had to do and then went group by group to support the work they were doing. The interaction in each group would be determined by the proposed activity, the sense Inés gave to it when she presented it to the class, the questions of the groups and the language that every child would bring to the shared space.

The science curriculum in the institution was based on the Insight Modules —see Chapter five for a characterization of these materials— on the learning sequences designed in the United States. The fortnightly summative evaluations in the schools of the United Organization were based on the contents of these modules. In each module, there were elements that accounted for the type of permanent and overall assessment suggested throughout the development of the activities. For this reason, some activities explicitly had the name of initial, intermediate of final evaluation. The contents to be assessed in every session were written down. Moreover, matrixes were included to collect information about the students and evaluation criteria.

Every module assessment activity is what it is, but somehow it is not what it is supposed to be. It is what it is because those who wrote it had particular intentions and made an effort to make as explicit as possible all the elements needed to give a particular meaning during its application. However, it is not what it is because what counts is the interpretation that is made of it in a particular situation, with a particular history, and in a particular moment.

Roth and Radford (2007) cultural-historic theoretical consideration help me to clarify this point:

> The difference between (cultural relative) objective, collective significations and individual sense is captured in the relation the relation of the universal (general) to the particular rather than in the contrast between the logical and psychological. Individual sense therefore is a concrete realization of collective significations, which, as a general (universal), exist only in and trough all concrete realizations and the possibilities that these enable. It is only in and through collective cultural signification that the world can become and object of individual consciousness, it self enable by those significations. (p. 11)

Scholars conceived the Insight modules, with all the signs, graphs, and words, with some collective signification: those of the individualistic cultural sensibility. Being involved in the IBSE praxis, I learned those cultural and collective significations. However, Inés did not have a history of interactions with that collectivity. She learned to read the Insight modules from her collectivity of science teachers, with a different cultural sensibility. The significations attributed to the module's words were different from mine. Following Roth and Radford's (2007) reasoning, the word is not the same "when the interlocutor is of a different social group, when he is inferior or superior in the hierarchy, according to the more or less tight social links that he might have with the speaker" (pp. 11-12). In this case, Inés and I had different relations with the designers of curricula material: she had not interacted with them as I did.

Back to the 'problematique', the situation was that Inés had her local cultural sensibility, I had my individualistic cultural sensibility, and we were trying to change the classroom assessment activities based on socio-cultural cultural sensibility. Taking distance from the understanding and learning as something attached to the mind, I could see another side, which is that social activities are the source to build meanings to the artifacts. Artifacts by themselves do not have an intrinsic, essential meaning.

Next, I will use five episodes to show the transformations of some artifacts —questions that intended to assess what a child knows or does not know about a particular subject—, into others with different meanings that give new directions to thinking possibilities in that precise moment —i.e., uses of interactions between individuals to assess; changes in the focus of the assessment centered in the individual towards one centered in the group work; radars of assessment processes from thinking structures around the construction of a phenomenon. Moreover, starting from experience, I will imagine different possibilities of shaping reality depending on the interpretation given to the described situation. I will go from looking at assessment as a way of inquiring about what an individual knows or does not know, to one that focuses on the interaction of the learners during classroom activities with the others and some facts, using the language and meanings available in that culture, communicating

and using all kind of artifacts to think. The purpose is to highlight the situated characteristics of cognition following Lave's discourse (see Chapter four) and the mediation of artifacts, teacher, and other learners in the thinking processes (with the local cultural sensibilities).

EVENT 4

We began our first planning meeting giving sense to the activity described in the module under the title 'initial assessment' of the module "Structures"[77]. From my individualistic point of view, I had always interpreted that activity present in all the modules as an activity that each child had to do. For me, the purpose was to determine those ideas, the wrong conceptions, and the naive theories that children brought in relation to the subject addressed by the module. Similarly, I thought this was the opportunity for every child to express what he or she knows and what he or she does not know. In the case of this module, the subject was "structures". Particularly, the focus was on different concepts supporting the building of structures and on their qualities. Children observe many structures around them and begin a path towards differentiating and producing structures that can support weight without falling, etc.

My interpretation of the initial assessment activity was that it had to be done by each child individually. It was a starting point to establish what the students knew and knew how to do in relation to the science topic of interest: physics concepts involved in structures. I imagined changes in the way of answering questions. In order to focalize the attention in the group interactions and assessment activity, I thought that each individual would answer with the help of another, helping each other to make sense of questions. However, in my conversations with Inés, we conceived another possibility for the development of the activity.

The following image shows the way in which the initial assessment activity was proposed in the module. The intention of this assessment is to identify what the students know or do not know or if they are confused regarding to the topic. The aim is to identify the ideas of each child about the structures that they observe and what they know from their previous experiences. It is

[77] In Chapter five I described some of the characteristics of this curricula material for primary schools. The activities for all 'modules' or booklets are structured with the inquiry model that I presented. In this module called 'Structures', what is different from others is the topic. For all topics, the learning sequences are planed in such way that in each activity the learners can experience some dimensions of the inquiry thinking —wondering and asking questions, investigating, concluding and communicating— The final aim for learning is that the learners had different opportunities to think trough inquiry and to explore key concepts behind the structures surrounding us –structures constructed by the humans and also biological structures like the human body.

assumed that every child has diverse experiences and thus not all of them will have the same kind of answers. Then again, a distinction is made between summative and formative assessment. In this sense, it is expected that the information of the assessment will help plan the learning sequences, and provide support in those aspects in which each child needs support. Furthermore, according to my perspective on assessment for learning in IBSE, knowledge and those learning expectations required to be analyzed establishing the distance between proposed learning goals and evidence. When comparing the initial answers with those of each student in the intermediate and final assessments, the changes in the behavior could be established, accounting for a particular learning in relation to the structures topic.

Empirical material Nº 8
Structures Module[78], p. 27, Pequeños Científicos

[78] Tell students that they will start a study on structures, but before, you want to know what they know and do not know yet, and which topics generate confusion. Tell them not to worry if they don't know the answer, but explain them that if they believe so they can infer then answer. Make sure your students know that you are not expecting them to know all the answers, given that they have not yet begun to study structures. Tell them that the questionnaire will not be graded or used for any school report.

Distribute the questionnaires. Tell students to seek help if they do not understand a question or have trouble reading. Feel free to paraphrase the questions, or give further details, but do not tell them the answers. It is understandable that by now there are many things they still do not know.

If students are going to answer the second section in the same class, identify partners and guide students.

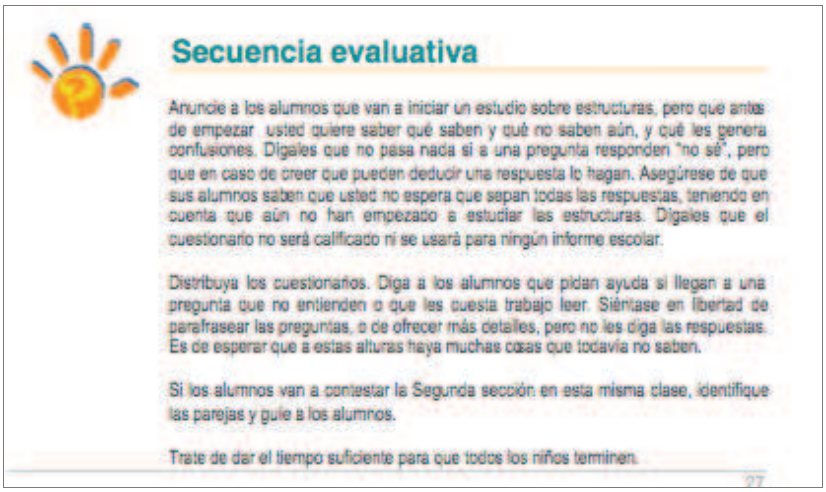
Try to give enough time for all children to finish.

When everyone has finished, collect the questionnaires.

If you do not do the second section of the questionnaire on the same day, try to schedule it for an early date.

Evaluate data using criteria. Look for areas where there is already some understanding, areas of confusion or naive concept, and also seek interest, so you can tailor your teaching to include it in the following classes.

Save the questionnaires in order to compare them at the end of the module. The final evaluation will use a similar questionnaire, along with a performance evaluation. At that point, you can allow students to compare their answers at the end and the beginning of the module, and celebrate with them how much they have learned during these eight or ten weeks.



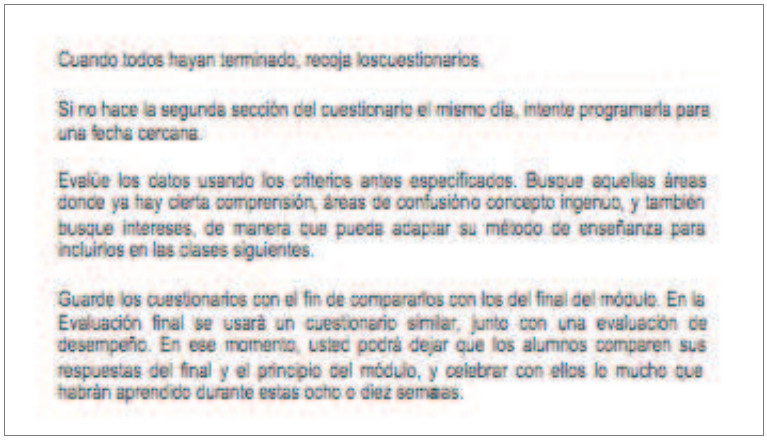
Secuencia evaluativa

Anuncie a los alumnos que van a iniciar un estudio sobre estructuras, pero que antes de empezar usted quiere saber qué saben y qué no saben aún, y qué les genera confusiones. Dígales que no pasa nada si a una pregunta responden "no sé", pero que en caso de creer que pueden deducir una respuesta lo hagan. Asegúrese de que sus alumnos saben que usted no espera que sepan todas las respuestas, teniendo en cuenta que aún no han empezado a estudiar las estructuras. Dígales que el cuestionario no será calificado ni se usará para ningún informe escolar.

Distribuya los cuestionarios. Diga a los alumnos que pidan ayuda si llegan a una pregunta que no entienden o que les cuesta trabajo leer. Siéntase en libertad de parafrasear las preguntas, o de ofrecer más detalles, pero no les diga las respuestas. Es de esperar que a estas alturas haya muchas cosas que todavía no saben.

Si los alumnos van a contestar la Segunda sección en esta misma clase, identifique las parejas y guíe a los alumnos.

Trate de dar el tiempo suficiente para que todos los niños terminen.



Cuando todos hayan terminado, recoja loscuestionarios.

Si no hace la segunda sección del cuestionario el mismo día, intente programarla para una fecha cercana.

Evalúe los datos usando los criterios antes especificados. Busque aquellas áreas donde ya hay cierta comprensión, áreas de confusiónno concepto ingenuo, y también busque intereses, de manera que pueda adaptar su método de enseñanza para incluirlos en las clases siguientes.

Guarde los cuestionarios con el fin de compararlos con los del final del módulo. En la Evaluación final se usará un cuestionario similar, junto con una evaluación de desempeño. En ese momento, usted podrá dejar que los alumnos comparen sus respuestas del final y el principio del módulo, y celebrar con ellos lo mucho que habrán aprendido durante estas ocho o diez semanas.

If I use my capacity to make sense of those words, with the collective significations, I see that the purposes of assessment is to collect information that would be relevant so that the children, by the end of the learning sequences, could be able to determine what they had learned comparing their answers. Likewise, it is useful to have relevant information that supports future decisions on teaching. What has been expounded refers to finding areas of confusion and naive concepts in the answers, as well as other reasoning based on previous knowledge. From an individualistic perspective, some answers could be evidence of the own ideas that come with the child, regardless of the cultural context where he or she lives.

However, another interpretation can be done if a socio-cultural cultural sensibility is used. The child's answers can be seen as mediated by the questions

and the individual possibilities of answering them, as a result of their interpretation of the questions based on their 'cultural knowledge' in terms of Radford and Empey (2007). Their answers can have different reasoning that gives an account of what is usually expected from them in the school tests, what chances they had to participate in social activities where the expected meanings of concepts are constructed, or, depending on another kind of social activities where those words are used but giving them another cultural signification.

In the moment of assessing, according to the aims of the research, Inés and I discussed about the way in which we could turn this activity into an assessment activity focused on groups and not on each individual child. We thought about how to prevent the children from having problems to interpret the words and the contexts implicit in the questions. For this, we considered language as part of the learning process and the diversity of possible interpretations of words, as well as the possibility of negotiating meanings in the class group, in this case comprised by the teacher and the different groups that would answer the questions, based on assumptions of the socio-cultural theories (Leach & Scoth, 2003; Mercer, et al., 2004; Wenger, 1998). We wanted the children to be able to give a particular meaning to the terms of the questions. We talked about several words, meanings of words and significations according to the social activities in which the children could built collective significations (Roth & Radford, 2011; Schoultz, Säljö, & Wyndhamn, 2001). From the ideas we exchanged, Inés took several decisions and conducted a few sessions that were very different from what was expected from my individualistic interpretation of the module questionnaire.

The context of the moment —my presence with what I was trying to understand, the way Inés interpreted my ideas, the evaluation designed in the module, that group of children in the United Organization, Inés's interpretation of inquiry and science teaching, and my way at that moment of interpreting socio-cultural theories— resulted in decisions, meanings and a way of building the classroom reality in that cultural-historical moment we was living.

Looking closely to one of the questions, Inés considered that snow and skis were aspects that carried no meaning for the children given their previous experiences. In fact, Colombia is a tropical country where there is snow only at a few mountains tops of around 4.500 mts of height, and most children have never seen the snow, nor used skis. They did not have the chance to participate in social activities such as skiing. The most likely contact that they might have had is through television programs or explanations in geography class, but not through knowledge produced by their experience. The question of the module was the following:

Empirical material Nº 9
Question of the initial questionnaire[79], Structures Module, p.31

6. Cuando caminas en nieve profunda, te hundes. Si usas skis puedes mantenerte en la superficie de la nieve. ¿Sabes por qué?

Inés decided to adapt the question. She was looking for another physical experience that involved the same physical concepts, which the children could have experienced before, and also that could be experienced during classroom activities. The adapted question was as follows:

1. Draw what happens with the mattress when:

A. Juan is lie. Why?	B. Juan is seating in the middle of the mattress. Why?
C. Juan is stand in the middle of the mattress. Why?	D. Juan is lie on side on the the mattress. Why?

Graph Nº 4. Transformation of the module's question

First, the children were asked to draw, and second to explain why. Looking at the first version of the question, there are many transformations that could change the answer. In the module question was asked information about the child's experience: when you walk…. In this version, it is about imagined situation with Juan in relation to the mattress: what happens to the mattress when

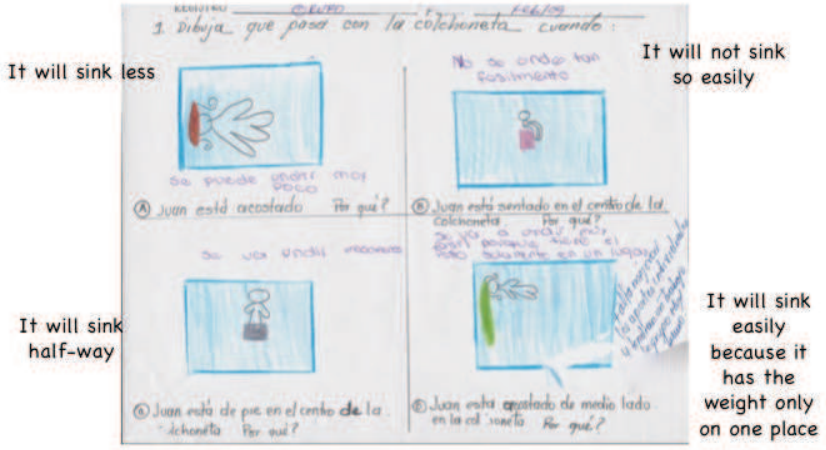
[79] When you walk in deep snow, you sink. If you are using skis you can stay on the surface of the snow. Do you know why?

Juan is… Another transformation was the way the question was represented for the children. Indeed, it was not presented as a sentence like in the module version. There were some spaces where the children were expected to draw each possibility. The students made drawings and represented what they thought. In the subsequent class, a mattress was brought and they discussed what they had thought in light of what happened with the mattress. This is another way to ask the question and the result will be different since, in the module questions, it is a question that expected the children to have experienced skiing and to recall his or her experience in order to answer. In the second case, the question is about an imagined situation, and in the third case, the experience is there. They can see what happens to that mattress in the classroom when one of them is seating or laying or standing or laying on one side.

The following picture illustrates a first example of the type of drawings the groups made and the phrases they wrote down. When we imagine assessment from the socio-cultural point of view, these answers may be used to work collectively on the different interpretations, ways of expressing and reasoning that are present in the tasks the students did. Similarly, it is possible to analyze the conditions within which those answers —not others— emerged.

The question, which apparently was the same, only with a different context, was actually quite different. When the children were asked to represent their thoughts, another kind of thought appeared, different from the one expected to be prompted by the question about standing on skis on snow. When they had the context in the classroom and were able to prove the situation, thinking changed completely and hence the answer that was expected.

Empirical material Nº 10
Picture Group's answer to teacher's question



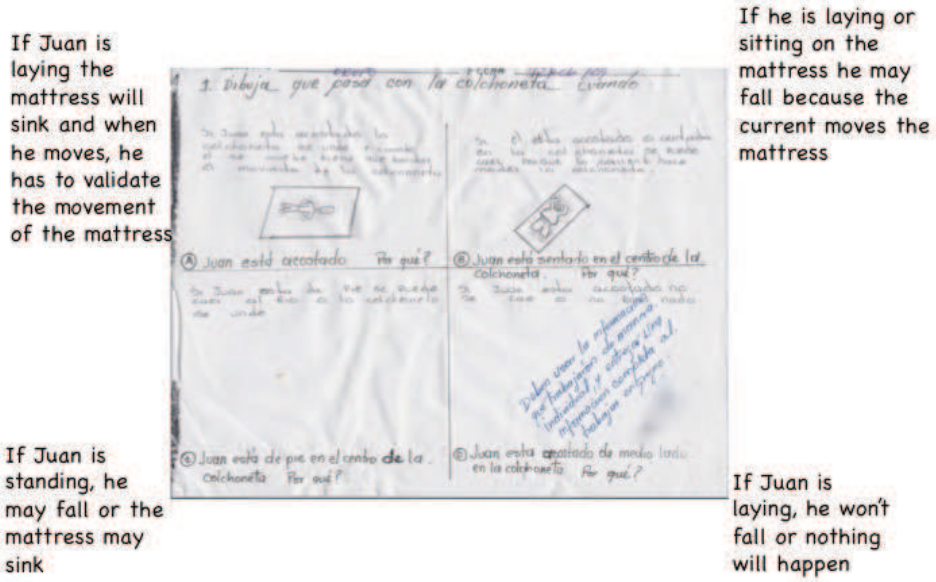
From this image, different interpretations may be done, depending on the theoretical support to assessment activity. One possibility is to have the children's explanations as evidence of those ideas that are in their minds. When we read the answers to each of the questions, it is easy to see the ideas they want to communicate, although only in the last quadrant do they give an explanation that justifies their answer: "It will sink less", "It will not sink so easily", "It will sink half-way", "It will sink easily because it has the weight only on one place". Nonetheless, the language used is far from the one used in a rational scientific culture. For instance, "sink less" is an answer without the reference; this is less with respect to what? How much is less? Also, the drawings were not precise as it is the case on the scientific representations. We can interpret that they have not developed those inquiry skills.

Another possible interpretation is to see the use of language and the type of answers as aspects to work on. In fact, if we assess to help students to learn, the point is to give the children tools so that they can express ideas in a more rational way and more accordingly to the written language. If we use a socio-cultural perspective, these answers would be seen as existing ways of giving meaning to a particular situation, with a language that comes from the way people speak, which is different from the written language. Alternatively, instead of thinking that those that answered do not have the ability to write and reason as it is used in the rational and scientific environment, attention could be drawn to

what type of sentences are desirable for the children to produce. This would be useful to introduce new tools and ways of expression in the interactive moments, so as to facilitate the generation of different ideas and expressions. Thus the activity in the classroom should produce the kind of sentences that are expected.

Those answers were from one group of children. That information does not give an account of the reasoning that children were engaged on. However, there is another answer that gives more information and we can perceive the relation that children did with they experiences out of school with mattresses.

Empirical material Nº 11
Picture Group's answer to teacher's question



The second image shows a more elaborated construction of sentences in the answers: "If Juan is laying on the mattress, it will sink and when he moves, he has to 'validate' the movement of the mattress"; "If he is sitting on the mattress, he may fall because the current moves the mattress"; "If Juan is standing, he may fall or the mattress may sink"; "If Juan is laying, he won't fall into the river, nothing will happen". If we look carefully at these answers, they are different from the first ones. The sentences are more elaborated, there are still spelling mistakes in a culturally accepted way and they express an interpretation of the

situation that is different from the one the first group made. There is a river; it is as if they thought in a context in which the mattress was on a river; they said what could happen then. In fact, in Colombia, the word mattress has several meanings: it may be an artifact to sleep on, or an artifact to float on water. If the mattress were on the water, the results would be completely different from those possible if it were on land. Those differences in answers show how what emerges in daily situations in a classroom is mediated by the meanings that children develop in their social activities, such as playing in water with a mattress.

Then again, the criteria for assessment also had multiple possibilities. In the module I present some criteria to evaluate children answers. When we assessed what the children had represented, Inés and I would focus on different things. Inés was looking at the interactions within the group and how that was reflected in the answer, and I was focused on finding the inquiry thinking. In our conversations, we realized that she would give priority to the concepts and I would look at aspects related to scientific skills in addition to the concepts.

In fact, when we took the mattress to the classroom and they could see the girl sitting, laying, standing or laying down on one side, other ideas appear based on what they could observe; the meaning changes. The expressions in the situation are full of meanings that emerge in the moment and in the situation taking place. Moreover, in the interactive sessions we would work on ways of expression closer to scientific thinking. From an individualistic view, we could think on how to improve the writing skills of each individual and the skills to represent ideas in a more proper way according to the scientific thinking, as well as spelling; for example, how to draw a graph that illustrates the difference in the sinking of the mattress (graphing skill). Adopting a socio-cultural perspective, the intention is to provide those tools that exist in culture in the spaces of social interaction and activities. Then, we would look for opportunities and activities in which the children can progressively appropriate those tools.

Inés and I noticed different things in the students' answers, and the two groups interpreted the question differently. We would share this in our conversations and we would discuss the drawings the children had made and what to do in order for them to draw and write more accordingly with a rational scientific language. A few months later, the students had an institutional evaluation in which they had to represent a body system. Inés decided to go group by group showing different representations that the children had done and discuss in every group which one they considered the best of all and why. Table by table, the kids expressed which one was the clearest in its message and which one was the least clear. When the turn came for the table of one of the kids whose representation had been declared as confusing, he showed us that our interpretation of the drawing was wrong. In fact, in his representation, different from the others, he used codes that enabled a different reading of what was

apparently chaotic. Furthermore, his representation was closer to one of rational-scientific type than the others.

The assessment seemed to be what was written on the module, but it was not. It became an artifact to think and adapt according to the interpretations of those who were in that particular historical moment. The interpretations were made around assumptions and ways of thinking: Inés's with her local cultural sensibility, and I with my meaning making based on my IBSE experience. Mine were independent from the institution and mediated by the way I understood theory and by my own experience. Only in my interaction with Inés in the process to make decisions and looking at the effects, it was possible to identify these differences. It is in the everyday moments and instances at school that I begin to make sense to the socio-cultural perspective.

According to Lave (1988) and the theory of situated cognition that she exposes, knowledge is not in our minds but in the interaction between individuals, social activity and others. Roth (2006a) also point to the fact that interpretations and meanings change with time. When each of us expressed her points of view in our daily activity, Inés and I were able to identify other possible realities. I realized how the expectations and interpretations on the same text could be different and Inés found the possibility of assessing other aspects different from concepts.

With this event, I want to point out that when an individualistic view is adopted in assessment for learning, interpretations are focused on what the individual is lacking in his or her cognitive process; on those skills that the individual does not yet have. From the other perspective, I propose to look at the tools that the individuals need to think differently from what they are able in that particular historical moment of the class. Mercer, et al. (2004) and other authors such as Kaartinen and Kumpulainen (2002) propose strategies to help the groups produce scientific reasoning: argumentation skills, ways to validate knowledge, according to the type of conversation expected in the groups.

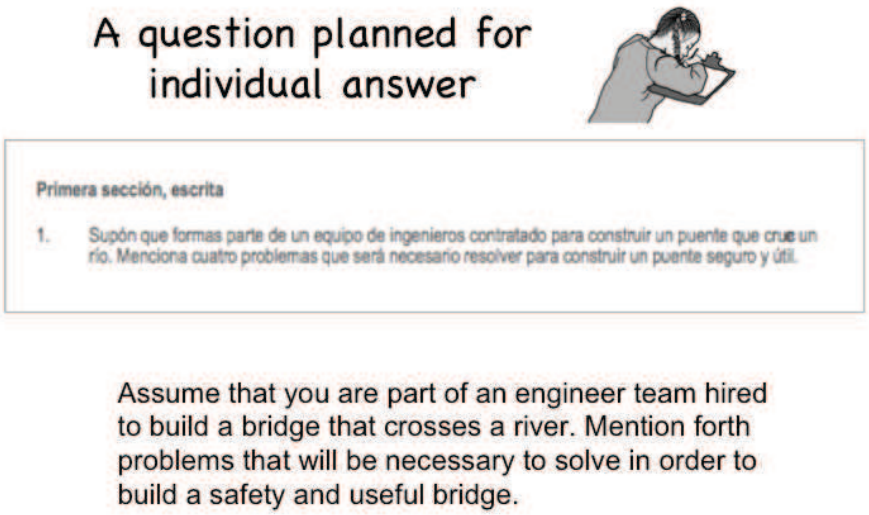
A second point is that, when analyzing the situation with a socio-cultural perspective, it became clear to me in our interactions and decision making that we had different ways to make sense of things when interpreting the facts. It seems to me that we experienced two different social activities around IBSE, my activity as teacher educator and focalized on shared meanings about inquiry, her reading and interpreting with her experience in social activities that where different from mine. Thus, I was feeling as a foreigner in the classroom activity.

EVENT 5

Inspired by the socio-cultural literature, I started to imagine learning and language as closely tied. I shared that idea with Inés, and based on that, we

changed another question of this initial questionnaire. Inés thought the question for a group instead for an individual answer. In the enunciation of the question, the students are invited to imagine that they are part of a team of engineers hired to build a bridge over a river. The question is: Point to four problems that it would be necessary to address in order to build a safe and useful bridge.

Empirical material Nº 12
Initial questionnaire question, Structures Module, p.29



Although the activity was the same, several contextual features changed. The first was that, in order to make sense of the question, we decided that it was necessary to inquire about the meaning of the word engineer and assume with the group one meaning in particular. This resulted from our discussion on how there were different interpretations for the words in the questions. We wanted to explore this aspect. Inés devoted one session to this point. Every group of children discussed and presented their view in open discussion by means of a spokesperson. These are three answers to the question what is an engineer?

Empirical material Nº 13
Spokesperson's group answer

Spokesperson for Group1: An engineer is a person in charge of managing construction works, with plans and structures.

Spokesperson for Group2: An engineer is one who builds plans, manages a group and also respects peers and he earns the support of others by respecting and helping in things.

Spokesperson for Group3: An engineer is a person that has experience on one topic like computers, environment.

We observed that each group constructed different answers to the question and gave different meanings to the word "engineer", but some aspects were common. When asking a question like the one in the initial assessment, the expectations are that every child has different meanings for words, according to their own experiences. The word engineer had a meaning in that moment of the class, related to the work environment of the engineer: making plans, managing a group, respecting the people he/she works with and having experience in particular topics. From the discussion, Inés gave them a definition of engineer and provided a context to the word.

Empirical material Nº 14
Teacher's problem formulation in context

Inés: We will step in the shoes of an engineer who has these functions: making plans, structures, right? Doing works; an engineer that studied to be engineer and that in addition is concerned about the environment […] we have a group of engineers; we have 4 engineers, […] hired to build a bridge that crosses a river. Mentions four problems, understanding the word problem as the things that may happen while doing the works […]

Furthermore, she gave a definition for the term 'problem', which she will address again group by group, while she listens to the ways in which each group understood the question.

The idea of the initial assessment as a mean to look for the ideas that each child brought and the understanding of the issues to be addressed became that moment of the class and the way Inés addressed it. One question of the module questionnaire gave place to an activity that lasted more than expected, if it had been answered individually. When considering a question as a cultural artifact we may think in different meanings that may be given to it in different contexts in which the artifact is used. It is not the same to have one single child looking at this artifact with his/her own ways of interpreting than having a group response after several children have given and shared meanings orienting the thinking and doing possibilities. Likewise, working on the meaning in each group generates different possibilities to those achieved when thinking individually.

We could do two interpretations of the facts from an individualistic perspective. The evaluation would be intended to look at the contribution of each child or the ideas that each child has in mind and shares, and reasoning within the group discussion. The facts would be seen as the sum of individual contributions and exchanges of a cognitive activity that occurred in the inside of each child. Every space in the classroom, the work in groups, the sharing of what the groups concluded, were moments that enabled the generation of a particular thinking that was only possible there. The activity would be seen as a collective thinking activity, in which every child would be included in the sharing of different ways of interpreting the word engineer. With this activity, new ideas and thoughts were possible in that historical moment and in that particular place, and they cannot be reproduced again. The character of situated cognition becomes evident here.

EVENT 6

Of all my readings on group work, the one of Mercer et al. (2004) especially touched me. Mercer et al. show a work in a classroom to help student groups talk with some rules that belong to the scientific rationality and way of argumentation. The aim of the teacher was to make expectations clear about groups' conversations around planed activities. In our conversations with Inés, we would talk about this and tried to change our ways of giving meaning to group work. For me, group work was where the learning was taking place. The dialogues and the activity that was being done gave place to possibilities of learning from the contact with the artifacts, the others and the meanings that were being used in that interaction. Inés gave another meaning to the groups, enabling the interaction between children and the presentation of their group work. The institution that she worked for had cooperative work —in each level of primary schools teachers developed strategies to help students to work cooperatively, for instance one member of the group assumes to be the spokesperson, another the time controller, another some one that writes the group's ideas—, among their guidelines as a learning strategy.

Empirical material Nº 15
Final dialogue between Inés and Cristina, video M2U0028, 6:50 to 7:31

Inés: I work by groups as a working tool, but not as... I mean, I think that the management in groups, I mean: if there was something as for example an activity of doing a board or a map, a general valuation was given. But I had not thought really how we could determine the internal dialogues and roles in the group so as to assess it.

When we really focused on trying to support those internal learning processes in the groups, several questions and ways of approaching assessment arose then:

Empirical material Nº 16
Final writing of Inés "Chaotic", p. 1

Starting from the management that we wanted to give to the research and enhancing it with the constructivist work and the methodology of *Pequeños Científicos*, we identified in the first 10 sessions that the children did cooperative work, followed inquiry strategies and progressively improved their interventions. However, there was no organization of the groups that could help us in identifying the internal progress of the groups, guiding the dialogues within them and boosting the own need to progress in scientific skills that will lead to an improvement of their academic level, but as something of their own, not imposed, with the end of tracking to make the idea of the research concrete. This is why we started with strategies exclusive from inquiry proposed by Cristina and the proper management of the science notebook as an essential tool for the class and the assessment.

But still there was an internal disorder in the groups that wouldn't let us identify clearly the progress; thinking of that and walking around the patio in recess time, I noticed that a card game of a children TV show called CHAOTIC was in fashion and I thought that we had forgotten to consider the interests of the students. So I asked myself how we could include the game in the science class and make it more interesting for both the kids that played it and the ones that didn't.

Apart from the traditional aspects that are considered in the assessment, Inés realized that the activities were not taking into account the interests of the students. With her sensibility to grasp what catches the kids' attention, she came to the idea of using the typical interactions expected by children when they play the game. She then proposed to use card games that children are familiar with and changed the kind of interactions proposed by the rules of the game for ones representing the expected abilities to be valuated. For me, this was a new world and it was hard for me to understand the logic. But for Inés and for the children these artifacts were full of meaning. The assessment strategy focused on aspects that differed from the ones that I could have ever imagined from my researcher perspective centered on inquiry language. From the skills centered in inquiry processes, the assessment strategy showed others that were relevant for the learning process and for the possibility of participation of the individuals in this particular context:

Empirical material Nº 17

Example of a card of Chaotic and the way Inés interpreted the powers
Inés's final writing "Chaotic", p. 2,

Powers of a group
Courage to express what I think
Power to defend or refute ideas
Knowledge of what is right and being able to write it down
Speed to control the time during the activities, achieving the objectives of the activity in a better way

The cards had some actions that Inés interpreted in relation to what she wanted to highlight in the group work and the relation of the individual with the group, as well as with the whole class.

Empirical material Nº 18

Evaluation strategy proposed by Inés
Inés's Final writing "Chaótic, p. 2,

The strategy consists of giving every student a card that will be stuck on their notebook, and clearly explain the skills and powers that each child has to contribute to the class and to his/her group with, so as to give a sense of belonging with the character and the powers that the cards have. In this case, the cards have 4 powers: **courage, power**, **knowledge and speed**, with its corresponding rank, which were described for the class as scientific abilities, from which every child chooses which of these skills is their own and will put it in practice both in class and in the group when summoned. A percentage in points attached to this skill will help them to assess themselves both in the group and as individuals, to achieve the tracking we wanted. The students would learn the requirements for every skill, giving them the option of being evaluators and evaluated and motivating competence in the classroom.

In addition, at the group level, they would have a folder with the copy of each one of the cards of the members of the class, as well as the meaning of each power and each scientific skill to facilitate the tracking and the autonomy of the children.

All these meanings were worked in consensus between the students and Inés. Nothing was imposed.

Given that for Inés evaluating inquiry skills was something new, she started to work with the students in class to see which of the skills that the children perceived as important for working in science class were present. From what the children expressed, what she saw, and from conversations with other teachers, we both wrote the skills that we would work with during class. Inés's writing illustrates the strategy designed and the way in which scientific skills were interpreted in that particular context. These are quite different from the way the indicators and constructs are presented in scholars' texts. Next, I will list the skills that we worked on during the classes.

Empirical material Nº 19

Skills to be learn by groups
Inés's Final writing "Chaótic, p. 3

Ideas worked by the children of 6thB of Camerun School
Scientific skills
Thinking: This is when I have ideas about something and I share them.
Reasoning: This is when I have ideas and I can convince others with arguments or experiences.
Memory: Remembering what I learned.
Explaining: This is when I communicate what I know, think or understand about something by means of drawings, writings, words, experiments, readings, exhibitions.
Explaining with drawings: What my drawing illustrates is so clear that I am able to explain something that I think about what I observe (It must be equal to what I observe)
Expressing coherent ideas: Saying what I think in a clear way that everyone understands
Talking: Saying what I found out, what I think, what I analyzed in a clear way
Contributing with ideas: Saying what I think to the group to help in finding solutions to the problems proposed.
Opinion: Saying the first thing that comes to mind
Knowing how to write: Think of what I will write about what I observe and I get the others to understand what I write
Proper writing: I use punctuation signs and write clear ideas
Understanding: Expressing what I know about something and do things with what I know
Paying attention: Knowing what is going on and contribute if necessary
Listening: Using what I hear to give ideas
Observing: When I use the senses (smelling, touching, seeing, hearing, tasting) to describe different characteristics of what surrounds us. I express characteristics by means of drawings, phrases, diagrams and categories.

Reading: Reading out loud in a clear way, considering the punctuation signs

Reading in science: Having purposes when reading: get information, answering questions, memorizing, clarifying ideas, comparing

Reading critically: I compare my ideas with the text and get to conclusions, I see if the ideas are coherent, I place arguments to explain why I agree or disagree with what I read

Executing: When I carry out experiences or actions that demonstrate what I think about something

Experimenting: Executing actions that help me to explain what I observe.

Being careful: Clearly knowing the instruction that must be followed and follow it

Quality: My work demonstrates what I learned in class.

Creativity: Innovating in the way I write and draw. Explaining what I learned in a different way from the way they explained it to me.

Knowledge: Feeling good about what I learned

Each child has in his/her card a different character and a different percentage for each power; this means that every child will have more points for the skill he/she has, which shows us the strengths of the group and the responsibility of each member to help his/her peers to improve in the ability in which he/she is an expert.

When we evaluate from an individualistic perspective, there is an evident difficulty to judge all those abilities and expectations about learners' possibilities of development. For instance, to see if each learner is understanding and acting according to the definition of 'reading' or 'reading in science' or 'listening' and so on. The list shows the great complexity of the different dimensions involved in a person's learning and the way in which a meaning is given in a particular context. Any selection done is not enough. If I compare these skills with the indicators that account for inquiry thinking (Harlen, 2006b), there is a gap in the sense that the processes needed to generate scientific explanations in contact with experiences of observation of facts are not reflected. There is mention of the meaning of experimentation though.

If I stand on a socio-cultural view of assessment, I suggest focusing more on learning in order to express phrases and do certain reasoning with them when the facts are being observed as part of an activity. For this, it is necessary to give meaning to certain words such as density, force, structure, in relation to what is observed in the activity, but in addition, the way in which reasoning is built.

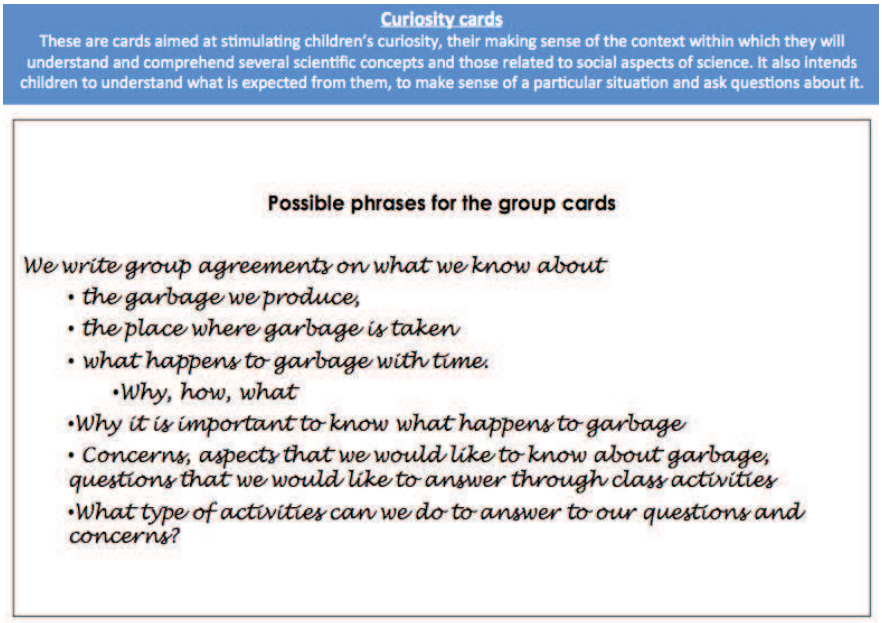
When we were imagining the assessment situation, I suggested to Inés that I should be in charge of designing certain criteria for the cards. These were not considered in the end, since the topic was changed for institutional reasons. But when looking at what we planned, a different way of thinking and organizing is evident. In particular, there is a need to contextualize. When we look at the skills described, these were formulated in abstract terms, isolated from the contexts that give them sense. My proposal used the topic of garbage

and waste as the theme around which the skills were to be developed. This topic of the curriculum was the topic we were going to work on before it was decided by the school coordinators that children needed to learn about the cell.

One of the important parts of inquiry is making the activities that are promoted in the class awaken curiosity in the children. We start from expecting that the inquiry process should be done on what the child wants to know about a certain topic. This is difficult to achieve, even more when we have groups of 42 children in one single class. However, I did the exercise of imagining questions in context that aimed at awakening curiosity, sending the message that was valid from something they felt attracted to. The following were the results of that exercise:

Empirical material Nº 20

Curiosity cards
Field work journal, Cristina, slide Nº11

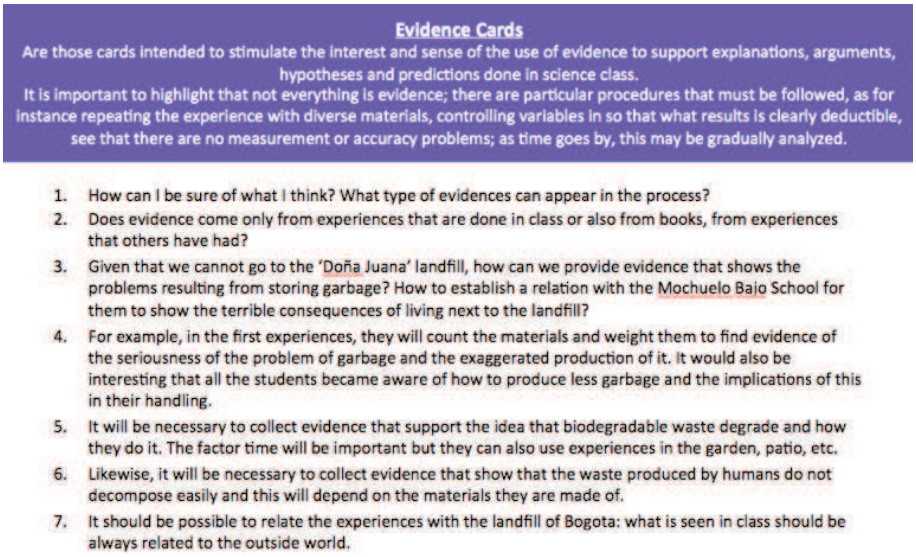


I designed different cards, using the questions proposed by Harlen (2006c) to assess the different dimensions of inquiry skills. For me, these became tools to design the cards, but besides, they gave me a meaning when I thought of them within a particular context: garbage. I called the following card the *golden card* because it was the final reasoning expected from the groups, explanations.

Empirical material N° 21

Golden cards

Field work journal, Cristina, slide N°18



Evidence Cards

Are those cards intended to stimulate the interest and sense of the use of evidence to support explanations, arguments, hypotheses and predictions done in science class.

It is important to highlight that not everything is evidence; there are particular procedures that must be followed, as for instance repeating the experience with diverse materials, controlling variables in so that what results is clearly deductible, see that there are no measurement or accuracy problems; as time goes by, this may be gradually analyzed.

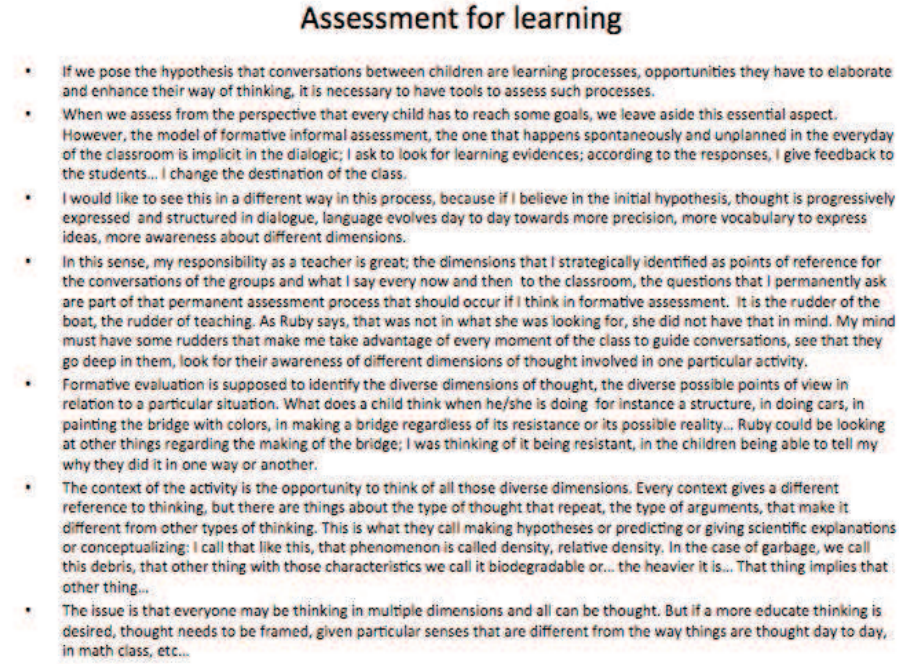
1. How can I be sure of what I think? What type of evidences can appear in the process?
2. Does evidence come only from experiences that are done in class or also from books, from experiences that others have had?
3. Given that we cannot go to the 'Doña Juana' landfill, how can we provide evidence that shows the problems resulting from storing garbage? How to establish a relation with the Mochuelo Bajo School for them to show the terrible consequences of living next to the landfill?
4. For example, in the first experiences, they will count the materials and weight them to find evidence of the seriousness of the problem of garbage and the exaggerated production of it. It would also be interesting that all the students became aware of how to produce less garbage and the implications of this in their handling.
5. It will be necessary to collect evidence that support the idea that biodegradable waste degrade and how they do it. The factor time will be important but they can also use experiences in the garden, patio, etc.
6. Likewise, it will be necessary to collect evidence that show that the waste produced by humans do not decompose easily and this will depend on the materials they are made of.
7. It should be possible to relate the experiences with the landfill of Bogota: what is seen in class should be always related to the outside world.

At that time, I was looking for mechanisms to move the focus towards language rather than skills. According to Mercer, I wanted to give tools to the children so they could give meaning to what explaining was, rather than assuming that the explanations they gave were made with the proper language. For this, I considered that the linguistic tools for the production of the expected reasoning would be progressively introduced in the classroom.

While reading, ideas came to my mind about the way in which assessment should be from a socio-cultural perspective. In my fieldwork journal, I wrote the following:

Empirical material Nº 22

Ideas for a socio-cultural view
Field work journal, Cristina, slide Nº7



Assessment for learning

- If we pose the hypothesis that conversations between children are learning processes, opportunities they have to elaborate and enhance their way of thinking, it is necessary to have tools to assess such processes.
- When we assess from the perspective that every child has to reach some goals, we leave aside this essential aspect. However, the model of formative informal assessment, the one that happens spontaneously and unplanned in the everyday of the classroom is implicit in the dialogic; I ask to look for learning evidences; according to the responses, I give feedback to the students… I change the destination of the class.
- I would like to see this in a different way in this process, because if I believe in the initial hypothesis, thought is progressively expressed and structured in dialogue, language evolves day to day towards more precision, more vocabulary to express ideas, more awareness about different dimensions.
- In this sense, my responsibility as a teacher is great; the dimensions that I strategically identified as points of reference for the conversations of the groups and what I say every now and then to the classroom, the questions that I permanently ask are part of that permanent assessment process that should occur if I think in formative assessment. It is the rudder of the boat, the rudder of teaching. As Ruby says, that was not in what she was looking for, she did not have that in mind. My mind must have some rudders that make me take advantage of every moment of the class to guide conversations, see that they go deep in them, look for their awareness of different dimensions of thought involved in one particular activity.
- Formative evaluation is supposed to identify the diverse dimensions of thought, the diverse possible points of view in relation to a particular situation. What does a child think when he/she is doing for instance a structure, in doing cars, in painting the bridge with colors, in making a bridge regardless of its resistance or its possible reality… Ruby could be looking at other things regarding the making of the bridge; I was thinking of it being resistant, in the children being able to tell my why they did it in one way or another.
- The context of the activity is the opportunity to think of all those diverse dimensions. Every context gives a different reference to thinking, but there are things about the type of thought that repeat, the type of arguments, that make it different from other types of thinking. This is what they call making hypotheses or predicting or giving scientific explanations or conceptualizing: I call that like this, that phenomenon is called density, relative density. In the case of garbage, we call this debris, that other thing with those characteristics we call it biodegradable or… the heavier it is… That thing implies that other thing…
- The issue is that everyone may be thinking in multiple dimensions and all can be thought. But if a more educate thinking is desired, thought needs to be framed, given particular senses that are different from the way things are thought day to day, in math class, etc…

Looking for a way of assessing the learning processes of the groups took me to think in dialogue as the core of learning. The problem then was to understand how to provide tools for the groups to guide what they did. I stated that a socio-cultural perspective of assessment should consider the ways in which language increasingly evolves. From phrases such as those written by the kids at the beginning of the class: “It will sink less”, it is expected to evolve to phrases in which the context is present. In other words, from phrases that refer to a mattress and to a person sitting or laying or standing, it is expected that children could produce sentences that express what is likely to happen with the mattress using a particular reference, i.e. it will sink completely, it will sink half-way or one third. Likewise, the tools to gradually improve the way of expressing both in writing and orally should be given in the groups and in the moments when summaries are done with the entire class.

Similarly, I point to the need of formulating ways to argue, linked to the topic. It is not the same to argue in biology than in physics or chemistry.

Similarly, it is different to argue in a context where something is being observed rather than doing it on a hypothetic situation. In the case of the mattress, it was easier to explain better and describe more precisely what they wanted while they were observing what happened. The dialogue in an inquiry-based science class is mediated by the artifacts that are present in the moment of the activity, the meanings generated in that moment, in addition to the authority of the speaker. A child speaking to another child is not the same as when she child speaks to the teacher. In particular, in some occasions, the children were expecting the teacher to tell them if they were right or wrong. For them, the teacher was the authority, as it has always been in their history in the institution.

The collection of filed notes and artifacts in this event shows the difficulties I had to change my point of view. My tendency by choosing them and talking about them is always framed within my individualistic view. I reduced the socio-cultural to the work on language, but at the end it was the same, we were working to assess the individuals' interactions from the individual point of view and not considering the activity in which the individuals were involved. This has being one of the most complex change to adopt, since it is even outside the IBSE network, what it is usually understood as a process of assessment. What is also relevant from those materials is that, through our work, we produced artifacts that had meanings for us, and that materialized our thinking at that time. Artifacts have several meanings as well as words.

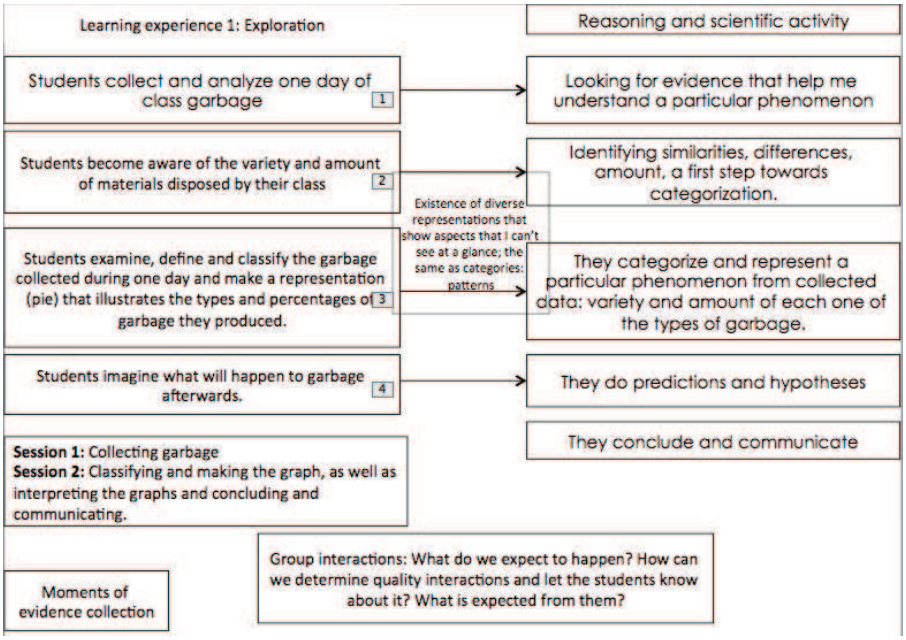
EVENT 7

After finishing the learning sequences of the structures module, Inés and I spent two days planning "The Imagined Situation". This was the meeting of my ideal laboratory world with Inés's pragmatic world; going from my configuration of reality to another possible configuration.

Before our planning meeting, I studied the module to make sense of it in terms of what I was looking for in the research. My laboratory reality was facing the everyday activity. Given that the translation of the module into Spanish was done from an old version, I took the new version in English and I translated for Inés the questions that I thought were important and that were not included in the version she had. I showed her the ideas that appeared as essential in the module. Every activity was related to one of those ideas. The two first ideas would be part of our conversation of April 30: "Humans need and use many products made of different materials" and "There are risks and benefits associated to the current systems. The products that make the garbage may change their shape but cannot be destroyed". (I had problems to translate the second one, I did not understand it very well and it is evident in the sentences).

Empirical material Nº 23

Ideas for a socio-cultural view
Field work journal, Cristina, slide Nº3



My intention with the analysis was to find out the kind of reasoning that was behind the activities proposed in the booklet. For instance, if the students collect garbage and analyze what they did, I assume that it was to find evidence helping them understand a particular phenomenon. Or, if they imagined what would happen to the garbage in the future, then it was to predict. I arrived to our weekly meeting with my analysis in paper and on my head. I started to explain to her the way in which I had made the analysis. The following empirical material is one part of my explanation.

Empirical material Nº 24
Dialogue Inés and Cristina, Planning meeting of the Imagined situation, 30/04/2009

CRISTINA: THIS IS THE CONCEPTUAL MAP WE HAVE ON THE DIFFERENT CONCEPTS, THIS IS, WITH THE LINE OF CONCEPTS OF WHAT THE MODULE WANTS.

Empirical material Nº 25
Dialogue Inés and Cristina, Planning meeting of the Imagined situation, 30/04/2009

CRISTINA: I took the first learning sequence and I said well, this is the activity and what things of the reasoning and the scientific activity are within that activity that we are proposing. So, for example, the students collect and analyze one day of garbage. There, I would say: Search for evidence that help to understand a particular phenomenon. OK? This is, they are going to...

INÉS: Group, classify

CRISTINA: Group, classify and then what they have to gain perspective of is the phenomenon. The phenomenon is not there, this is not a phenomenon; the phenomenon is analyzing a bunch of particular things.

INÉS: The phenomenon is, is the object, is it?

CRISTINA: Much more than the object; that is, you don't see garbage.

INÉS: Oh, yes, that's obvious; it would be all the surroundings, the context

CRISTINA: And the phenomenon of garbage is something that you don't see. What you are going to do, the way that you collect the data, the things, what this is going to do is that it will give you perspective on the importance of a phenomenon that you don't even have (I point at the head). Because your contact with garbage is going to the garbage and the disposal. But here what they are doing is putting a lens over some particular aspects. Right? Identifying similarities, differences, amounts... So here we are in... All this is observation eeh. Students define and make categories with the garbage they collect during one day and they make a representation, a pay that represents the situation. Well, there is a representation; why doing a pay? Or not? Why not letting them do another representation? How do we do to see and measure what we are looking at there? If we do it like that we don't see things; if we do it like that, then we see things, what do we see? All those questions. The day that you gave them for homework to make the chart, several of them came and asked me what a chart was and 'what is it that I have to do?' and 'why do I have to do that?' Those discussions should be part of the learning process. What is relevant for us to understand, how organizing information helps to see things that I wouldn't see if I don't organize it. If not, then I just do the chart because the teacher told me to do so, but why on earth

DID I DO THAT? SO MANY OF THEM DID NOT FIND ANY SENSE ON DOING THAT CHART BECAUSE THEY DIDN'T KNOW.

INÉS: WHAT FOR...

CRISTINA: WHAT IS THE REASON TO DO THE CHART? THEN THESE ARE LIKE THE QUESTIONS THAT ARE RELEVANT TO UNDERSTAND IN SCIENCE, I MEAN...

INÉS: WHAT IS OBVIOUS FOR ME IS NOT OBVIOUS FOR THEM

CRISTINA: NOT FOR THEM, NO. "STUDENTS WILL IMAGINE WHAT WILL HAPPEN TO GARBAGE AFTERWARDS", THEY DO PREDICTIONS, HAVE HYPOTHESES, THEN. IT IS NOT SIMPLY DOING THIS, BUT HOW I TURN THIS INTO MAKING CATEGORIES OF THE TYPES OF INFORMATION THEY GIVE TO ME, THE EXPLANATIONS THEY GIVE TO ME, BECAUSE IF I DON'T HAVE THIS IN MIND, ACTIVITIES JUST TAKE PLACE AND THAT'S IT.

CRISTINA: SO HERE THE STUDENTS IMAGINE, SINCE THERE HAS TO BE SOMETHING THEY CONCLUDE AND COMMUNICATE, SO THE SESSION THAT I CLEARLY PRESENTED TO YOU TODAY... IT IS VERY IMPORTANT FOR THE GROUP TO COMMUNICATE WHAT THEY DID, WHAT THEY THOUGHT. ALL THAT IS ESSENTIAL FOR LEARNING FROM THE POINT OF VIEW OF INQUIRY. IN OTHER WORDS, THAT CANNOT BE MISSING: DOING AN ACTIVITY AND THEN REFLECTING ABOUT THE ACTIVITY THEY DID AND DRAW CONCLUSIONS REGARDING THE ACTIVITY THEY DID. I MEAN, IF THEY DON'T KNOW WHY THEY ARE DOING A BRIDGE OR WHAT THEY ARE DOING IT FOR...

INÉS: THEY DON'T DO IT, IT DOESN'T MAKE ANY SENSE.

In this dialogue, there are many elements that I imagined important from the activities that appeared in the module. I was focusing in all those ways of thinking that shape the phenomenon we were approaching: garbage. But the students need to learn to communicate what they think at every moment. Looking at the complexity of what I tried to communicate to Inés, the inquiry thinking process and the result of it is not about simple conclusions resulting from intuitive internal ideas. For that kind of reasoning to be part of classroom activities it needs to be explained. This is about a cultural way of speaking, of making sense of the facts they observe.

Following what I just presented, I connected with aspects that I had observed in the class sessions. Considering this inquiry radar, I did not feel that the children were pointing to those ways of thinking and reasoning in their conclusions and in what they did in the groups. For them, there were other interesting things when they saw the structures, when they built them. They were able to distinguish those that were solid from those that were not, but they did not arrive to the use of concepts that give shape to structures in a scientific way.

In other words, from a socio-cultural approach, although the facts may be the same, each one sees and notices different things and makes an activity with different. The art of the teacher is to put the lens on the one that he/she wants to teach.

Empirical material Nº 26

Dialogue between Inés and Cristina, Planning Session of Imagined Situation, 30/04/2009

CRISTINA: THEY MAKE THE BRIDGE TO DO INÉS THE FAVOR OF MAKING THE BRIDGE, BECAUSE THE TEACHER INÉS SAID SO

INÉS: SHE WILL GIVE A GRADE TO THE BRIDGE.

CRISTINA: SHE WILL GIVE A GRADE TO THE BRIDGE, BUT NOT IN RELATION TO A QUESTION THEY HAVE ASKED THEMSELVES OR TO THINGS THEY WANT TO PROVE BY DOING THE BRIDGE. I MEAN, WHY DO THEY DO THE BRIDGE? DO THEY DO IT TO PROVE RESISTANCE? TO PROVE THAT THERE ARE INDEED TENSIONS AND DISTENSIONS? TO SEE THE PHYSICS BEHIND ALL THAT STRUCTURE? I MEAN, WHAT IS THAT I AM LOOKING FOR IN DOING THE BRIDGE? THEN IT'S A LITTLE, WELL, WHAT I HAD IMAGINED, I MEAN, THAT WHILE WE LOOK AT THE SESSIONS WE COULD SEE WHAT THINGS ARE SUITABLE FOR A PARTICULAR ACTIVITY THAT IS RELATED TO THAT, SO THAT YOU HAVE THAT RADAR IN YOUR HEAD (I POINT AT MY HEAD). UH... AND NOT SIMPLY FOCUS ON THE ACTIVITIES THAT ARE GIVEN THERE. THE OTHER THING IS THINKING ABOUT THE NOTEBOOK, TO WORK ON THE WRITTEN RECORDING AND THE OTHER THING THAT I HAD IMAGINED ALSO WAS THE GROUP WORK. ALL THAT, I DIDN'T HAVE TIME TO WORK ON THAT, BUT WHAT WE WERE EXPECTING TO HAPPEN, WHAT WE EXPECT TO DETERMINE FROM A QUALITY INTERACTION AND THAT THE STUDENTS KNOW THAT; WHAT IS EXPECTED FROM THEM IN THAT INTERACTION IN GROUPS. ALL THAT HAS A RESPONSE IN THE GAME, WITH THE CARDS. SO THIS IS WHAT I TRIED TO LOOK AT AND WORK ON IT; THAT'S WHY I TOLD YOU THAT THIS IS A LOT OF WORK, BECAUSE EVERY SESSION IMPLIES...

INÉS: DEPENDING ON WHAT THE KIDS DELIVER,

CRISTINA: I MEAN, THIS IS USEFUL ALREADY AS A GENERAL FRAMEWORK TO LOOK AT THE CONCEPTUAL AREA, RIGHT? IF WE THINK, AS YOU TOLD ME THIS MORNING AND I AGREE WITH YOU, THAT WE HAVE TO SAIL AND SEE THAT WHAT HAPPENS EVERY TIME WILL GIVE US ELEMENTS FOR THE NEXT ONE, SO WE CAN'T BE VERY RIGID AND DO A PLANNING.

INÉS: TOO RIGID

CRISTINA: TOO RIGID; BUT WE DO HAVE TO UNDERSTAND THE GENERAL PURPOSE OF THE MODULE, WHERE IT IS GOING TO, WHAT WE ARE LOOKING FOR, BECAUSE THEY HAVE DONE LOTS OF ACTIVITIES AT SCHOOL THAT HAVE NO SENSE; I MEAN, IF MAYBE THEY HAVE SEEN RECYCLING BINS, MAYBE THEY ALREADY HAVE MANY THINGS TO GET HOLD OF, TO SEE WHAT WE CAN CHANGE TO THE MODULE.

This dialogue shows my effort to show Inés how the inquiry thinking is something unknown to the children's thinking. I tried to show her that doing the activities does not imply that they will think according to the inquiry principles. Thus, it is necessary to generate possibilities for the children to see other ways of thinking the facts they observe in all the possible interaction moments.

After my presentation I asked Inés what she had learned from all that I had told her and presented her. What had caught her attention? What had she seen?

Empirical material Nº 27

Dialogue between Inés and Cristina, Planning Session of Imagined Situation, 30/04/2009

CRISTINA: WHAT DID YOU LEARN TODAY?

INÉS: WHAT DID I LEARN TODAY... THAT I NEED TO GAIN SOME STRUCTURE MYSELF TO BE ABLE TO COMMUNICATE IT, BECAUSE A LOT OF WHAT YOU SAID HERE CAN BE MY DREAM OF, I MEAN, THIS THAT YOU SHOWED TO ME IS STRUCTURED, YES, THIS IS SOMETHING THAT I WANT TO VISUALIZE HERE AND I HUMBLY TRY TO DO IT BUT SINCE I DON'T HAVE IT INTEGRATED IN MY HEAD IN THAT WAY, I CAN'T COMMUNICATE IT SO THAT THOSE THINGS THAT ARE MOST IMPORTANT ARE TRANSMITTED TO MY STUDENTS; I CAN SOMETIMES CUT THINGS OFF, NOT LETTING THEM THINK FROM SOME PERSPECTIVES THAT ARE OBVIOUS AND THAT ARE IMPORTANT FOR THEM AND MAYBE I BIAS A LOT OF INFORMATION THAT I... HAVING THIS CLEAR THIS MAY GENERATE MUCH MORE RESULTS, BETTER RESULTS IN THE SENSE THAT THEY FEEL THAT THEY HAVE LEARNED AND THAT THEY UNDERSTAND CERTAIN THINGS AND ALSO STRUCTURE THEIR THINKING, BECAUSE IN SUMMARY THAT IS MY FUNCTION, SO THAT THEY MAY STRUCTURE AND THINK IN A WAY THEY CAN SOLVE AN EVERYDAY PROBLEM IN ANY MOMENT OF THEIR LIVES.

In research studies that have some support on socio-cultural learning theories, emphasis is made on the fact that there are many discourses that may result from the activities that are carried out or in relation to objects (Schoultz, Säljö, & Wyndhamn, 2001). Inés was gaining awareness of this fact when she mentioned

that if you do not have that integrated like that, it does not happen. She refers to this fact. There are so many ways to see things and so many languages that can be built around facts that it is necessary, when you are a teacher, to consider these differences. When she says that it is necessary to structure their thinking, it may be interpreted as giving them the tools they need to use other ways of reasoning about facts.

The event is also an example of my need to capture the inquiry in the everyday activity of the classroom. I was looking for the phenomenon that I learned in a theoretical perspective. I was making sense to the idea that during group work children may not see or notice what you expect them to see. As Inés realized, behind the possibility to see the phenomenon, as inquiry theoretical perspective hopes, it is important to be embedded in inquiry reasoning. This is an illustration of what I called the *diversity of cultural sensibilities*. Inés, with her local cultural sensibility, learned to notice and interpret classroom activities in one particular way, I learned to notice other aspects. The artifacts such as the Insight modules are then interpreted from each cultural sensibility. It was only by talking everyday that I finally realized that we were looking differently, and it is why I spend time explaining to her my perception of the activities. At the same time, it shows my resistance to adopt the set of socio-cultural assumptions.

UNDERSTANDING THE PROBLEMATIQUE

The analysis of this chapter is relevant to understand how to incorporate of teachers' and students' modes of lives while engaged in their daily activity at school, when thinking about conceptualizations of assessment activities. I tried during this sensibility space to make sense of those assumptions of the socio-cultural cultural sensibility that I had difficulties to grasp. One was the relation of the individuals with the social organizations and institutions, and the other was to consider that artifacts mediate the individual's thoughts. According to my interpretation, these artifacts vary in their nature. It could be a notebook, a computer, a telephone, a theory, a model, a concept a word, etc. Some of them are linked to concrete objects that we can use with our bodies (e.g. diverse machines as a computer or electronic devices), others are abstract objects, but that have an impact on the activities of the individual (e.g. a test or the concept of weight). Our way of seeing reality is culturally and historically constituted. Every situation that happens in a given place and moment is loaded with those meanings that are given and then assumed as universal, but when we look at them closer, it is evident that they depend on a specific culture.

Taking into consideration the situational character of cognition and taking into account social structures, the tools acquire a meaning within new worlds.

The activities in which the individual participates are those that will generate the ways of seeing and feeling reality. There is a close relation between the individual and the context that in our case is the activities that are carried out in the school classroom.

I used to think that artifacts were stable, independent from the individuals and the conditions where they are used. I now think that the diversity of human activities and the uses of artifact there change the way in which individuals attach meanings to those artifacts. The meaning is attached to the way the collectivity use them. I use the expression 'unstable artifacts' to highlight this last one characteristic. The social activity in an historical moment gives sense to the artifact; it is inseparable from the activity. There are meanings that can be given to the artifact depending on the moment and the people present in that moment. In the collective activities, meanings for that artifact emerge, while others are denied. Artifacts themselves do not bring their meaning or their possible uses. Social activities transform them and make them what they are in that historical moment located in specific culture and in a physical space.

Thus, we may think that assessment for learning with a socio-cultural perspective should consider the different interaction spaces of individuals, the meanings given to the artifacts, as well as their uses; the way children and teachers give meaning to the activities they are involved in, the different manifestations of language in relation to activities, and develop ways to make visible those other ways of expressing thoughts of what is being done. It is important to make a difference between activities that require writing what is thought using the existing resources in scientific cultures and those that demand processes of oral expression. The first one is more complex and requires a different pressure level than the second one. Inés points out the need to structure thought. For this, I expect that if in the different interactive spaces of a class new ways of seeing, writing and pronouncing are introduced, each individual will gradually appropriate the necessary tools to be able to think as the teacher expects. If these tools are not made visible as Inés says, this will not happen. The teacher is responsible for constituting activities full of inquiry, and inquiry is also a way of thinking that needs to be learned. It does not come with us naturally.

According to this, I propose that assessment for learning must consider thought as Re-flection according to Radford's (2008) words:

> The reflexive nature of thinking means that the individual's thinking is neither the simple assimilation of an external reality (as the Empiricists and Behaviourists suggested) nor an ex nihilo construction (as certain constructivist schools claim). Thinking is a re-flection, that is, a dialectical movement between a historically and culturally constituted reality and an individual

> who refracts it (as well as modifies it) according to his/her own subjective interpretations, actions and feelings.

With the presentation of diverse events that determined my field research, I wanted to make visible a new way of looking at social activity in which the learning activities of the individuals take place. I used fieldwork to give meaning to several theoretical constructs that differentiate the individualistic view from the socio-cultural view. Although the methodological triangle of Skovsmose and Borba (2004) guided my work with Inés, I did not develop it as an empirical research to document what may be the case of a classroom and how to design and implement a change in practice.

Giving meaning to Lave's (1996) and Engeström's (1996) ideas, I assumed that my previous view about context followed the individualistic perspective: I conceived context as a container in which individuals interact. The context generates external variables that affect learning situations. Making sense to those socio-cultural ideas about context, I assumed that when you look at what happens in a historical moment, context becomes what is possible at that particular moment. In that case, context is not static and it is shaped by the interaction of individuals, with the state of relations and the meanings they give in that moment to artifacts involved. This has an impact in the way of seeing assessment for learning in IBSE.

When I analyzed my difficulties to carry out my field research as planned, I illustrated that the context is not static; it is generated while individuals interact; it is also changing. The same people that interacted in one way when engaged, in the same place, in one social activity, such teacher educator workshops with teacher, will modify in another historical moment and other social activity, such as the fieldwork of my research. Changes in people's relations with the institutions in which they interact, the replacement of one person, the situations they live, all this generates changes in the meanings and in the relations.

Looking at some events of the fieldwork, I focused on the changes that my relationship with Inés generated in what happened in the classes. I showed that the assessment activities designed in the module with an individualistic approach could be transformed into activities that took into consideration the diversity of interpretations, interaction and group work. From an assessment centered on the individual, we tried to move towards an assessment centered in the group. But the analysis on the events 4 to 7 were not meant to document the implementation of an imagined new situation in the classroom. The analysis shows how, in the dialogue between Inés and I, in a particular social and cultural context, my awareness moved from a vision in which the context is generated from the possibilities of relation and thinking in a particular historical moment and social activity. It was with this awareness that I could start imagining an assessment that leaves aside skills and knowledge as a list of contents that the

individual must know; it considers different languages around facts; it assumes that phenomena are not the facts observed but the way in which those facts are connected to language, giving them a particular sense for those interacting.

I suggest the need to be aware of this to guide the students towards the type of reasoning and thinking that is wanted to happen in the classroom activity. Assuming that knowledge takes place in the relation between the individual and the task being made, besides from the meanings shared, leaves behind the vision that when individuals answer by themselves, they show that existing knowledge is independent form a particular and transferable context. Instead, this considers that knowledge is those meanings that are gradually given to events and ways of thinking resulting from the activity with its restrictions. Then again, I give relevance to the idea that the artifacts that mediate thought vary in meaning and that this must be considered when assessing. Assessment for learning should make the artifacts visible together with their meanings in relation to the situation that is being analyzed, in that particular historical moment, with the feelings and reactions that the individuals have established.

8. Sensibility Space Five: Producing with Assumptions[80]

> Let us imagine a classroom where the children are sitting in rows and the teacher asks questions. The students raise their hands; the teacher asks a student; the student answers the question; the answer appears to be correct. We could just describe and interpret what takes place and what goes on in the classroom and leave it like that. Alternatively, we could associate our observations of the activities in the classroom with critical comments. We could describe how the classroom communication reflects a dubious idea about teaching and learning. Still, in both cases, what is happening in the classroom is left untouched by the research, although in the second case it is accompanied by critical comments. However, when critical research is concerned about changes, this also means researching what is not the case —but what could be a possibility. (Skovsmose & Borba, 2004, p. 211)

In Skovsmose and Borba's words there are three ideas that help me to situate the analytical process presented in this chapter. In their view, research is often associated with a process of doing classroom observations and using the data to describe and interpret. It is also possible to add some critical thoughts. In both cases, the capture of the object by the systematic observations is untouched by the research process. However, they conceive another possibility for doing research: a critical research perspective interested in changes. In that case, it is possible to imagine 'what is not the case'; that is, what is not there to observe but what may be a possibility. Such process of imagination is based on the observations. This is why it is a possible change, not that distant from what it

[80] This chapter builds on (Carulla, 2010; Carulla & Valero, 2011a, 2011b).

actually is. The analytical process was inspired in Skovsmose and Borba's perspective of critical research.

I constructed two cases of assessment for learning activities based on my observations of inquiry-based classrooms, my participation on Inés' classroom activities, and my critical analysis of the assessment for learning and IBSE research texts. I produced those cases as possibilities, or as 'what is not the case'. This is a space conceived to produce two examples of assessment activities with my two cultural sensibilities: the individualistic and the socio-cultural. I focused my analysis on the assessment activity conceived as involving actions such as the processes of constituting evidence of learning, interpreting students' outcomes and performances, producing judgments and feedback with assessment purposes. The intention was to imagine the consequences for the assessment activity when the group of assumptions supporting the activity changed.

In the first part I present some theoretical and methodological considerations about subjectivity changes, and the analytical process to produce the assessment activities. In a second part, I produce an assessment activity using the socio-constructivism perspective and the individualistic cultural sensibility, taking into account some theoretical considerations. Following this, in a third part, I imagine a different assessment for learning activity within IBSE by using tools from socio-cultural theoretical perspective. In a fourth part I produce a simulation of classroom assessment activities using my socio-cultural sensibility. Finally, I put forward some reflections on subjective changes and production of assessment activities.

METHODOLOGICAL CONSIDERATIONS

While some of the previous spaces of sensibility were spaces of analysis that tried to grasp my struggles as a researcher in acquiring and appropriating a different cultural sensibility, here I used my new possibilities to create an ideal classroom activity, as an artifact supporting me in the objectification of my process of learning. Thus, the analysis was made while the other analytical processes were done.

Across the different chapters, I have followed two kinds of analysis. First, I have focused on the link between the researchers' assumptions and the constitution of their research objects. An example is the connection between researchers' criteria about assessment of student's inquiry skills and students' ideas with individualistic assumptions. Second, I have observed researchers' productions and objects of research about classroom activities. For instance, how researchers conceive assessment classroom interactions and which artifacts are

constructed for assessment activities in classrooms, such as Ruiz-Primo's assessment conversations and Harlen's assessment criteria presented in Chapter five. I have been investigating about the objects that researchers have produced in their research activity. These two analytical approaches aimed at finding theoretical tools to conceive research objects of assessment for learning for inquiry-based teaching and learning situations in such way that the socio-cultural conditions of teachers and students were considered.

From perspective of the thesis problematique, until now, I have identified a set of assumptions that guide researchers in their conceptualizations were learning is implicated, such as inquiry-based teaching and learning, and assessment for learning —In Chapters four and five the assumptions were systematically tracked in researchers' texts through the observation of ideas and formulation that are repeated. I have found two cultural sensibilities guiding researchers conceptualizations about learning, knowledge and thinking. I understood cultural sensibility as the way by which a group of researchers constitute their objects of study supported in one group of assumptions —In Chapter four the individualistic cultural sensibility and the socio-cultural cultural sensibility were described grouping the assumptions found in the researchers' texts. I have linked my capacities to research classroom phenomena with the individualistic cultural sensibility, showing the connection of my ideas with the group of the individualistic assumptions —In Chapters five, six and seven were established the link between the researchers' texts and ideas of assessment for learning and IBSE and the group of individualistic assumptions, and the link between my ideas, the researchers' ideas and the group of individualistic assumptions. I have also built a different sensibility to research classroom phenomena with socio-cultural group of assumptions —In Chapters six and seven, the implications of using the group of socio-cultural assumptions were presented analyzing critically my ideas supported by individualistic cultural sensibility.

In Chapters one and two, I claimed a need to consider assessment for learning research that takes into account diversity of educational cultures of assessment and science education across schools, neighborhoods, states, countries and continents. I saw a need to consider an assessment activity producing judgments and statements about 'something' (objects to be learn) recognized and built by the teacher and the students in their everyday experiences and interactions at school and in the classroom. I recognized a need to give meaning to the relation between culture, assessment activity in the classroom, and teacher and student interactions supporting individual learning. I identified a need to focus on the vision of assessment for learning activity where interactions among students and with the teacher were guided by their historical experiences at school and also by their individual experiences. In other words, I identified that their relationships, their modes of interaction, their expectations

are driven by the educational culture were they are experiencing everyday activities at school.

I have used Radford and Empey (2007) representation of social praxis to identify my research objects. Therefore, I have considered researchers activity and classroom activity as social praxis. In this chapter I focus the attention on the classroom activity as social praxis. I assume that assessment for learning and IBSE researchers produce artifacts that frame classroom interactions. Thus, their object of research is classroom activity focused on assessment activity. I suppose that researcher's artifacts are used in the IBSE Network to adapt assessment for learning and IBSE principles to current classroom activity, or to adopt the foreign educational culture. As documented in Chapter five, in the IBSE Network curricula material —such as the Insight collection and STC Science and Technology Concepts Program—, theoretical frames —such as the frame of Education Development Center and the NSRC learning cycle—, and research texts —such as Harlen's texts and Shavelson' et al.'s texts— are used to support the expected educational change. All these artifacts objectify which kind of classroom activity should be observed. I suppose that all these cultural artifacts, my practice as teacher educator producing inquiry-based teaching and assessment for learning activities, my contact and exchange of ideas with researchers that produced these artifacts, and the awareness of the individualistic sensibility guiding researchers is what drives me in the simulation of classroom activities with my individualistic sensibility.

For the analytical process in this chapter I adopted Skovsmose and Borba (2004) view of critical research. I see that critical research is concern about educational change and the involvement of the participants in the research process. Skovsmose and Borba (2004) explain two ways of conceiving educational change. One is what they call a top-down process: "Curriculum developers identify a new curriculum, which then put into practice, and teachers are instructed to follow this new curriculum" (p. 221), which is the case of the conception guiding the IBSE Network. In this study, I envisioned a change in conceptualizations about assessment for learning and inquiry-based teaching and learning. The problem from where I framed my research —as researcher and practitioner of IBSE Network—, was my concern to situate teachers difficulties to understand and put in practice research ideals of classroom configurations. I started by questioning the top-down processes, which are used for the implementation of IBSE and assessment for learning pedagogical principles around the world.

The other kind of change envisioned from a critical research perspective is when research and practical knowledge are used during the research process to change current educational situation and to imagine new possibilities for educational activities (Skovsmose & Borba, 2004). This kind of research involves practitioners and researchers. In this chapter, the simulation of two

assessment classroom activities is framed within this perspective. Their methodology has been used and transformed to fit in the purpose of this study.

The challenge for the analysis is to produce a research object, a classroom activity, which will be a transformation of the existing IBSE and assessment for learning classroom activity, which is conceived with the individualistic perspective. I have focused the analysis on the way as children's ideas are conceived from individualistic perspective, and the way as this is made visible in assessment artifacts and research texts. The other element of the analysis was to make visible the socio-cultural conditions claimed from a socio-cultural perspective as hidden in the current conceptualizations about classroom activities. My experience interacting with Inés at school, our thinking about assessment of group work, and the observation of classroom inspired me to the construction of the assessment classroom simulation, also my observation of classroom activities in the IBSE Network. Thus, this is the *current situation*, which Skovsmose and Borba (2004) identify as the classroom that will be investigated. The analytical strategy was to build an assessment current situation based on the individualistic perspective and imagine a different situation when the socio-cultural conditions are made visible.

The current educational situation in my case is not a classroom activity as it is for them in their critical research perspective. Indeed, I supported my process of production with my practical knowledge, my observation of research activity and the observation of one classroom of the IBSE Network. I was exploring changes in research activity. Although I did not report it in this document, I also tried the new theoretical perspective in my own teaching at the University. In that sense, what I produced is imagined with possibilities to be, since I experienced using these ideas. I did not just imagine a reality, but a possible one, because of my experience in Inés' classroom, my teaching, my observation of videos produced in the IBSE Network, and classroom observation in the IBSE Network. I should say that this is a bottom-up process. It means that it is by understanding and changing the current situation that the research knowledge is produced. It is conceived as an interaction between research knowledge, practical knowledge and knowledge in everyday activities.

This space of sensibility is a process of production by enunciating new possibilities to conceptualize assessment activities in IBSE, given my new forms of understanding and imagining classroom activities. I identified two actions. The first one is about my subjective changes and possibilities of production using deliberately my cultural sensibilities. The second one is the analytical process behind the production of the classroom simulations. This sensibility space challenged me to think with each one of the learned cultural sensibilities by identification and differentiation.

ACTION 1: SUBJECTIVE CHANGES AND OBJECTIFICATION

I found that scholars investigating with socio-cultural theories of learning criticize the individualistic approach to learning. The main point is that by studying psychological processes, consciousness and thinking, and linking human activity to the individual cognitive activity, the individual's mode of life disappears, the role-play by social relations, modes of production and assumptions about possibilities of knowing are external to the individual learning process. Therefore, scholars with a socio-cultural perspective claim that the modes of life of individuals are linked to the socio-cultural conditions such is the activity at school and in the classroom.

As documented in previous chapters this critique became a challenge for my subjectivity, since I was unable to see the link. In this sensibility space, by imagining and producing a classroom scenario, with my individualistic perspective, I will start by moving away from the basic assumption that learning are merely mental processes of the individual. Instead of this, I will take the assumption that learning happens in the inter-subjective, social spaces where subjects participate in social activities where cultural products are available to them in complex social and historical settings.

In Chapter seven I have started to move. In this space, the analytical processes aimed at concretizing my learning, by imagining a classroom scenario or a hypothetical situation. First, by creating a scenario with the individualistic perspective, and second, by thinking which changes were needed for conceiving a classroom scenario with socio-cultural perspective. I was looking for making sense of the socio-cultural researcher's discourses, explaining learning occurring while the subject, a fundamentally social being, participates in socially structured practices (M. James, 2006; Leach & Scoth, 2003; Radford, 2008). My point was that if assessment is about supporting individual's processes of learning, then it was necessary to concretize the different conceptions of learning in classroom interactions. I had a clear picture of how to look for psychological process of the learner in classroom interaction. However, I had not for looking at processes of learning as a social phenomenon. I needed to make sense to the researchers' ideas such:

> [...] learning is by definition a social and collaborative activity in which people develop their thinking together. (M. James, 2006, p. 57),
>
> Social interaction aids cognitive development when partners actually engage in shared thinking processes, not simply when individuals are in the presence of other people. (Barabara Rogoff & Toma, 1997, p. 471).
>
> [...] thinking is conducted through actions that alter the situation and the situation changes the thinking; the two constantly

> interact. The notion that learning is a mediated activity in which the cultural artifacts have a crucial role. (James, 2006, p. 57)

I started to consider that symbols, concepts, cultural ways of talking, historical experiences of the subject and of the society, the historicity and framing of a situation, and the artifacts available in a particular moment guide teacher' and students' perception and the sense that they are able to make of the different elements involved in a situation. I also moved towards the idea that the development of scientific knowledge is not only constrained by empirical data emerging from experiments, but it is also socially validated by language, symbols, norms and tools that are available in the classroom activity in a particular historical moment. That is, if the scientific knowledge cannot be learnt from sensory experience alone (Leach & Scoth, 2003), I needed to conceive classroom activity as historical and locally situated, developed with time a shared history of interactions that provides the setting in which particular forms of thinking can emerge. I started to think that considering the learning of an individual outside that context and setting, such I use to think, was simply not possible.

This process resulted in an inner-cohabitation of assumptions from different theoretical perspectives. Indeed, my individualistic view was strong and resisted the socio-cultural one. I could find myself in this struggle, as I have shown in the discussion in Chapters six and seven. Although I changed several of my initial assumptions, I had in mind inquiry-based classroom activities with the individualistic theoretical support. This is theoretically problematic since it interferes with the production of new proposals for assessment activity based on socio-cultural assumptions.

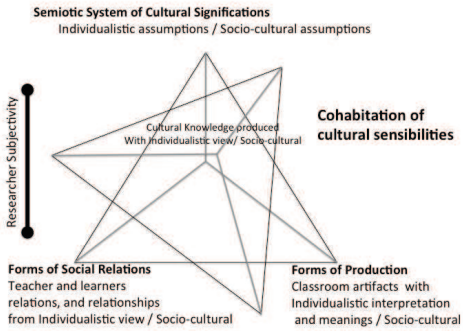
This action is materialized in the analytical process which goal was to move my possibilities and ways of thinking within the individualistic cultural sensibility, towards opening up new possibilities to think assessment classroom activities for IBSE, when adopting forms of reasoning from socio-cultural cultural sensibility. As Radford's words remind us, the true outcome of learning "is to be found in the fact that, in the encounter with the other and cultural objects, the seeking individual finds herself" (Radford, 2008, p. 225).

I used Radford and Empey's social praxis representation to explain my subjective possibilities of thinking assessment activities in classrooms. I started my research with a clear picture of assessment for learning activity in inquiry-based classrooms with an individualistic perspective. To become socio-cultural researcher is also be able to identify the assumptions guiding the conceptualizations and differentiate them from the individualistic perspective. In my examination of researchers' texts, I found that scholars from individualistic cultural sensibility never compared their theoretical positions with the socio-cultural one. Additionally, I found that scholars, when talking and presenting

socio-cultural perspectives, differentiate their theoretical position from the individualistic perspective. My analytical thinking results from these observations.

I consider classroom activity with the four elements of Radford' and Empey's (2007) view of social praxis. In my analysis there are two different research objects, one is the classroom activity that I conceived with my individualistic cultural sensibility, and another object that I conceived with my socio-cultural cultural sensibility. In order to understand my possibilities for creating the two classroom scenarios, I have used Radford' and Empey's representation describing the tensions and differences emerging when one or another perspective is used. The difficulties for making the analysis is due to the recognition that researchers have built IBSE and assessment for learning frames and artifacts conceiving learning as an individual, psychological processes. I faced the challenge to imagine a different focus for assessment activity. What happens if learning is considered as social phenomenon? How can be imagined the assessment activity if the aim is to support the social process of learning?

My subjectivity had access to two different forms of researching classroom activities, with a dominance of the individualistic perspective. In the Graph Nº 1, I represent this double capacity that my subjectivity built during the research. I call the cohabitation of cultural sensibility *the subjective capacities to move from one theoretical perspective to another*, an also to share sometimes the theoretical perspectives that resisted to the change. One triangle represents the possibilities of my self to conceive assessment classroom activities with the individualistic cultural sensibility, and the other, my capacities to research assessment classroom activities with socio-cultural cultural sensibility. By changing the assumptions, element from Semiotic System of Cultural Significations, the other dimensions are also modified. The Forms of Social Relation of teacher and students are conceived differently as well as Forms of Production and cultural knowledge. The challenge became to perceive the differences and use them in imagining the scenarios.



Graph Nº1. Representation of Assessment for learning activity in Inquiry-based environments with cohabitation of cultural sensibilities

The first classroom scenario was conceived by following my ideas supported in the 'Semiotic System of Cultural Significations' guiding the individualistic cultural sensibility. I conceived learning as a conceptual change, and the child as a kind of little scientist producing theories about phenomena. In the second classroom scenario I moved towards imagining that the child cannot be seen as a little scientist able to ask the right questions and find evidence to support or deny hypotheses. Instead, I perceived the child as an individual ready to catch up ways of thinking present in the classroom interactions. I thought that if the child was able to produce theories and hypotheses about natural phenomena, it was because he or she has learned to do it during classroom activities. He or she must learn to see and notice natural phenomena in the way the school or the teacher want him or her to see them. That means that the assessment activity should be conceived as helping individuals to notice and to produce the expected reasoning in the classroom setting. It is conceiving learning as a process of objectification-subjectification.

As previously discussed, assessment for learning is an important tool available to teachers to support students' conceptual change and modification of mental structures. In the construction of the first classroom scenario and the interpretations, I have followed the assumption that when the students learn in inquiry-based constructivist environments, they experiment the "conceptual change" that will modify their mental structures. I also have considered Yin, et al. (2008) ideas that assessment for learning should go "beyond the usual definitions of science achievement as largely acquisition of declarative and procedural knowledge" (p. 299), as well that students' justifications and explanations "reveal their schematic knowledge (knowing and reasoning why) and become the focus of classroom discussion with the goal of closing the gap in "mental models" for explaining what they saw, based on empirical data" (p. 304).

I also followed the IBSE assessment models presented in Chapter five. I saw as relevant to imagine teacher and students interactions where the teacher inquire about the learning process of students in order to judge how far their understanding is from the learning goals. I considered that the final objective of the teacher should be take action in order to "close the gap" between stated learning goals and students' externalized justifications and explanations.

I faced a tension when I tried to imagine learning from a socio-cultural perspective. If learning is not the change of the learner idea or misconception or a conceptual change in an individual's mind, then, how to see learning as a social phenomena? I decided that adopting a socio-cultural perspective implied to question the source of child's own ideas, and forms as those own ideas are used to support learning. For that, I needed to move from the idea that the child produces theories about phenomena, and that natural phenomena is an object that individuals encounter in they daily life. For the production of each

classroom activity, I made explicit the interpretations and planning of assessment activity that bring those elements of tension.

As documented in Chapters four and five, the dominant discourse is based on the assumption that a child is born with a set of hypotheses that develops and changes following established levels of development according to the child's age; and a child's mental structures change when the social and natural environment give feedback that enables accommodation and assimilation. As showed in Chapter four, Piaget's suggestions are that the feedback is necessary but that the individual level of development must be in a certain stage to recognize it. Inquiry-based discourses assume that inquiry thinking is the way in which a child, in everyday experiences, accommodates and assimilates producing changes in mental structures. When a child expects something to happen in natural and made worlds and something else happens instead, this is evidence that his or her theory does not work and a new one emerges. However, new kind of experiences, different from everyday experiences, are provided during inquiry-based teaching to help the child's curiosity for the natural and made worlds to design experiments looking for evidence that supports or not his own ideas and explanations. The aim is to move those ideas of the mind towards more accurate ones.

Moving my subjectivity towards socio-cultural assumptions implied to see the child's own ideas as connected to the situation in which he or she was involved in a historical moment, and a culturally determined place. Following Vygotsky's assumption, learning pushes development. Learning depends on language and ways of reasoning present in the activity where the child is embedded. Experience in the world is possible by using representations that are historically and culturally determined. Vygotsky's ZPD is interpreted as this strong connection between the individual consciousness and the collective one. This means that those children's ideas about the world change depending on the social activity in which they are involved, which who they are talking, what they are doing, for which purpose and with which artifacts they are interacting.

I felt a tension when looking closer at the way the child builds evidence during his/her experiences. What counts as evidence and how does it support the hypotheses and theories of a child? As I showed in Chapter six, the son, in Quinos's cartoon, constituted evidence and used scientific reasoning based on his meanings of time and interpretations of the facts. But the evidence presented does not fit the scientific reasoning. Hence, I realized that evidence is not what we see but is constructed with culturally and historically determined rules and norms. This particular way to constitute evidence is in the activity of researchers doing science, and there is another that is shared in classroom activity where the child is observing facts. The child appropriates what is present in that particular moment. Using my socio-cultural cultural sensibility, I needed to imagine in the

classroom scenario that the child, in interaction with others, builds the ideas, and also with his or her experience in other social settings and activities.

The other element to be considered in the construction of the scenarios was the way as interaction is conceived in one or another theoretical approach. The interactions in the scenario with individualistic sensibility were constructed by considering social interaction as mainly individual. I was framed by the interpretations of interactions and conversations in the different spaces promoted in IBSE classrooms limited in possibilities for acknowledging what may count as "evidence" of learning.

The challenge was to make appear the daily modes of life in the scenario constructed with my socio-cultural sensibility. The first scenario was constructed by omitting the socio-cultural conditions in which classroom activities where lived by the teacher and the students. I considered the context as container of behaviors never touched by human behaviors (Engeström, 1996), and as a delimited container where individuals are interacting driving from each individual mind full of thoughts, skills, and abilities, independent on culture. For the second scenario, I moved towards a view considering context as a cultural situated cognitive enterprise, connecting actions, thoughts, feelings, and values with their collective, cultural-historical forms of located, interested, conflictual, meaningful activity (Lave, 1996). I followed the idea that context is conceptualized as inseparable from learning. Furthermore, the context becomes the social activity in which the individuals are involved in the school setting.

I also moved from using the idea that the child is able to see a phenomenon when he/she encounters the facts in the classroom, towards a view that imagines different speech genres (Mäkitalo, et al., 2009) around those facts, and sees the phenomenon as promoted by the classroom activities, norms and values, artifact meanings shared by children and teacher in particular time and space. The different languages and speech genres that could shape facts are not considered in the example and neither is the impact of artifacts —with their local meaning— on possible thoughts. As presented in chapter six, Mäkitalo, et al. (2009) explain the different speech genres as those that can be adopted by different groups of people according to which social activity they are involved in, and also for the same object how different interpretations and views can be done. I faced problems to consider all participants views in the process of assessment activity, since my individualistic perspective focus the assessment activity as teacher driven, and not as an activity of all the actors in the classroom scenario.

The impact of the individualistic perspective on 'Forms of Social Relations' is that for the first scenario, I conceived the teacher as the leader and in charge of the assessment activity, supporting each individual to learn. I imagined the learners as part of the assessment activity as receivers of feedback,

and as individuals able to assess their own learning and their peers' learning as an exchange of individuals' minds. For the second scenario, I moved to a view of the learners and the teacher as part of a social activity sharing an object/motive (learning something), assessment also as a social activity which object/motive is to objectify quality of learning. I thought assessment activity to promote relationships recognizing each other's responsibility and motivation; and to respect and take care of others. Each person involved in the activity should contribute to the other's learning process by acknowledging how to help the other and to see what he is not looking at in the classroom setting. It is moving towards a process of learning happening in the interactional spaces and being possible because the activity in which learners are engaged produce the reasoning that is expected.

However, it was not very clear for me how communication and interactions among students necessarily help every student to learn what the teacher expect. I also struggle to characterize the processes happening when students are working in groups if they are not "little scientists". Indeed, I moved to the idea that the quality of group processes depends on the previous knowledge and the language that each student can use to describe and analyze the facts they are collectively observing. In that sense, I followed Mercer, Dawes, and Wegerif (2004) argumentations that a "possible explanation for the doubtful quality of much collaborative talk is that children do not bring to this task a clear conception of what they are expected to do, or what would constitute a good, effective discussion" (p. 361). They conclude that "many children may rarely encounter examples of such discussion in their lives out of school —and teachers rarely encounter their own expectations or criteria for effective discussion explicit to children" (p. 361). At the end, for the teacher who is confronted with the need of producing assessment statements in an IBSE environment, emerges the tension of how to distinguish or how to connect what seems to be happening in each child cognitive processes towards what is happening in the interactional space of children promoted by IBSE. In other words, getting closer to the learning processes happening in groups evidences that the situation exceeds what each one individual brings in, and what each one gets out of it.

Moving towards a socio-cultural perspective implies assessment must consider that there is more than individual cognitive activity happening in the group, collective and individual moments of activities: there are social and cultural dimensions involved in learning. Thus, relationships, power issues, values, conversational patterns and collective cultural ways to make sense and give meaning, are central for learning. In that sense evidence of learning must be thought out of the individual and more in the interactional characteristics of learning in a relation between subject, artifacts and others. For that, I imagined several interactions that I have observed in IBSE Network.

I also had in mind during the construction of classroom scenarios Forms of Production, such as skills conceptual knowledge, procedural knowledge, etc. They were my theoretical constructs to capture learning, and the indicators and criteria were artifacts to materialize the learning objectives, and notebooks as tools to follow individual changes. I conceived them as tools to communicate and materialize the scientific reasoning: to ask investigable questions, to write hypotheses, to plan experiments and to communicate the results. For example, in the French project La main à la pâte, the students' notebooks are divided in three parts, one to write the individual thinking, another to write the group discussions and results, and a third to write down the collective conclusions. Finally, in the dimension of Forms of Production, the notebooks, the blackboard, the material used in the activity should be regarded as full of meanings that need to be revised in the light of the inquiry perspective. However, in my experience with Inés, I saw another perspective of the notebook, which was part of Inés pedagogical culture. The notebook was there to write what was said by the teacher and had not place for the learner thoughts or for the group decisions. The tension emerges when considering that learning is not only an individual endeavor, but also a collective one.

In the construction of the classroom scenario with the socio-cultural cultural sensibility, I saw as relevant to think in a new conception of criteria and all those artifacts that are used to shape assessment interactions. Assessment research in inquiry-based environments recognizes epistemological dimensions of knowledge that must guide the assessment process (Duschl, 2003; Duschl & Gitomer, 1997; Ruiz-Primo & Furtak, 2006). For example, Duschl (2000) defines it as a movement from assessment criteria focused on data observation, investigations and experimentation towards criteria involving theorization and explanations. It is to develop and evaluate knowledge in classrooms with scientific perspective in mind. Duschl (2000) wrote

> [...] it is important for us that, each and every time we embark with students of all ages on scientific inquiries in various contexts, we face the problem of needing to make an epistemological break with common sense [...] While fully recognizing that sense perception observations are still an important part of science, the historical record makes it very clear that the practices of science with respect to evidence gathering, data acquisition and observation have moved steadily away from sense perception observations and common sense explanations, towards instrument and theory-driven observations and the development of scientific explanations. Science is the domain of inquiry that takes us beyond our senses and into the realms of reasons and reasoning, and models and modeling. (pp. 190-191)

I used this kind of argumentations to think assessment interactions. In particular, when thinking a socio-cultural perspective I started to see the scientific knowledge attached to norms and rules outside the individual mind and roots in the collectivity. Imagining tools for assessment purposes implied to see Scientific thinking not as a common sense driven and but understood as culturally determined in and by a scientific culture. The epistemological accounts of knowledge must be a tool that the child and the collectivity have in order to think during the inquiry activity in which they are involved. The child's ideas must be seen as produced during a social activity in which some tools to think are available in the collectivity. The teacher is the person who refracts those rules and norms that the child must use to think in the collectivity. The child's thinking and ideas are not separated from the socio-cultural conditions and the socio-cultural conditions drives child's ideas.

The dominant discourse provides different theoretical constructs to focus on the aims of inquiry-based teaching. Some prompts and indicators are considered the best to enhance the child's own ideas. It is assumed that the child answering those questions in an isolated way or solving problems will provide information that can be taken by the teacher as evidence of the conceptual change. By adopting socio-cultural assumptions, I moved towards seeing all those theoretical constructs as tools that visualize and objectify the culturally determined scientific reasoning and thinking. I thought that teachers and children could use them to give a meaning during the inquiry-based learning situation. The child's ideas are produced on the grounds of those tools available to him/her. In that sense, the situated characteristic of knowledge is recognized. A prompt, interpreted as good to enhance children's own ideas by researchers (Erin Marie Furtak & Maria Araceli Ruiz-Primo, 2007), can be interpreted as part of the resources used by the child to think and produce ideas in the historical moment where the child is. There, a local meaning emerges in the classroom, collective way to make sense.

I imagined the classroom scenario with an individualistic sensibility focalizing in the artifact phenomenon. I used the idea that a child can experience phenomena in the world with his/her senses. A child's ideas were the evidence of that. However, as I showed, I moved to the idea that a phenomenon is constituted by language and specific meanings in the interactional moment of the classroom, with the sense given in the activity. It is a culturally and historically constituted way of thinking. When the child is doing one activity with other children in a classroom, the phenomenon must be objectified. Some concepts, language and ways of reasoning must be available to children and to the child; the child must look for them and appropriate them. I conceived assessment as the activity which aim is to make visible the phenomenon, it means to write about it, to talk about it, to construct it in the interactional spaces.

The subjectivity movement and possibilities of production were framed by my knowledge of the existing assessment frames and artifacts, which were created by researchers with their individualistic cultural sensibility. From a critical perspective, it was necessary to systematically review my assumptions and questioning my forms of production. In the next section, I present the way as I produced the two scenarios.

ACTION 2: PRODUCTION

I called the second action 'production'. It is the analytical process whose goal aimed at producing the classroom simulations with one or another cultural sensibility. Following the reasoning in other chapters, I focalized the analysis in the assessment actions shaping the assessment for learning activity: fabrication of learning evidences, interpretation, production of judgments and support learners' learning.

For the analysis, I concentrated on how assessment for learning can be conceptualized from a theoretical perspective which allows unpacking the learning process occurring while a subject is acting, doing, thinking in a classroom space shaped by different interactive activity: group conversations, collective discussions, individual activities. I focalized the attention on which kind of evidences will be considered as reflection of the learning process. I questioned the assumptions and the implication in the constitution of evidences and in the interpretations from a research perspective. I considered that different activities and social configurations could be analyzed in a classroom situation. For instance, when students are engaged in a group activity, without the teacher being present, a learning process is going on during their interactions. It is in that case relevant to provide artifacts for thinking in the way as is expected. I also thought that the type of questions, or challenges or activity that the children were engage influenced the learning process, in that sense they were not a way to know about the individual learning, rather it was a tool to teach a way of thinking and reasoning about the nature.

I considered that each child makes sense of the situation with the linguistics tools, artifacts, relationship, roles, values and norms possible for that space and time embedded in specific institutional culture. I thought that this could be changed if the teacher is aware of different possible configurations and speech gender. In the individualistic perspective the teacher has access to that process in students mind by asking for their explanations. In the first classroom scenario, I have as aim to represent the assessment activity which goal was to have evidences from where it was possible to interpret that the learners had moved their misconceptions. In the second scenario, I move towards considering the social activity as the way to see how children were appropriating the cultural tools that the activity provided to them. In that sense, I thought that the teacher

needed to have a clear idea of the quality of artifacts that are produced by the social activity in which they are engaged. A teacher pays attention to different ways of reasoning, meaning of artifacts, uses of language, and conversations. I conceived assessment as how to making visible the common sense and other ways of talking, acting and being and to invite each child to appropriate ways of reasoning and thinking to use properly in different social activities. This is the analysis that guided me in the production of the classroom scenario.

PRODUCING AN EXAMPLE OF ASSESSMENT FOR LEARNING ACTIVITY WITH INDIVIDUALISTIC SENSIBILITY

In order to substantiate the claims presented above, I will illustrate certain typical moments in IBSE classrooms, where assessment for learning activity is happening. Based on experiences shared by teachers, research reports, IBSE videos, and my own teaching, I built a story that will help me contextualize my reflections and illustrate the contrast between different theoretical perspectives in assessment for learning. The story was built with the purpose of illustrating the main types of space for activity in IBSE classrooms, as well as the way assessment for learning, from a socio constructivism perspective, is involved in everyday teaching. This is a construction of classroom situation based on a theoretical approach where social and cultural dimensions are not considered as essential for learning.

Rebeca, a 45 year-old woman, teaches science in 4th grade and she has been very enthusiastic to use the IBSE principles and materials in her teaching. Today in her lesson, she will assess the learners' ideas in order to plan the sequences to teach the students about buoyancy. From experience, she knows that it is common for learners to believe that the mass of the objects influences the buoyancy; for instance, a big piece of soap will sink in water, while a little piece of the same soap will float (see Erin Marie Furtak & María Araceli Ruiz-Primo (2007), for a discussion of the diversity of stages on understanding about buoyancy of objects). She will collect their ideas at this moment, and will try to assess their capacity to make predictions and hypothesis.

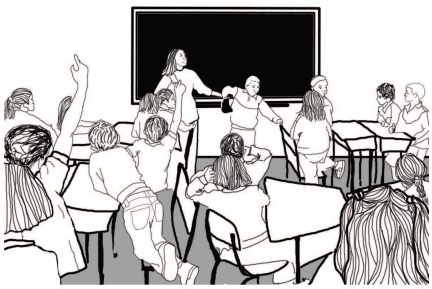
I call **Teacher Own Spaces —TOS—** the moments in which the teacher prepares the teaching by him/herself, as well as those in which he/she thinks and act during the class without interacting with others. He/she talks to his/herself and make decisions about materials, activities, assessment and uses of time by his/her own.

In the story, for example, Rebeca brings to the classroom

11 aquaria, 11 sealed containers with something inside (*Container A*), and 11 sealed containers that are smaller and thinner than the first ones (*Container B*), filled with the same material as containers A. In order to assess, she expects children to talk and write about their explanation to the behavior of *Containers A* and *B* when they are placed in the aquaria filled with water. Rebeca decided to use the same material inside the containers in order to reduce the number of variables to consider in the experience, but she managed to make the bigger containers less dense so that the bigger ones would float while the smaller ones would sink. She expects children to have different responses and to observe different ideas and explanations. Particularly, she expects children to hypothesize that the heavy, big containers will sink and the lighter, smaller containers will float, due to their mass.

She organizes the materials on the front table. Then, she hangs a big poster on the wall, and hands out a blank sheet of paper to each student. The poster has a three-column table. There are drawings of the objects in the first column. There is a label that says, "*what will happen"* in the second one. And there is a third column headed with the question "*why does the group think it will be floating or sinking?"* In the poster, the teacher expects to collect children's ideas before experimenting with the containers. That will allow her, on the one hand, to assess their capacity to make predictions ("what will happen") and explanations ("why does the group think it will be floating or sinking?"). On the other hand, she will be able to compare and observe changes in children's thinking after experimenting, observing and reflecting on the facts.

By **Collective Space —CS—** I refer to the moments when the teacher and the children are sharing ideas all together. These are the moments of class interaction, when the entire class is able to talk about something they are looking at, writing on the board, or answering and asking questions in a way that the thoughts become available to everyone in the room. They are also the moments when the teacher's reflections, comments, questions, and answers addressed to each individual are made available to the whole class.



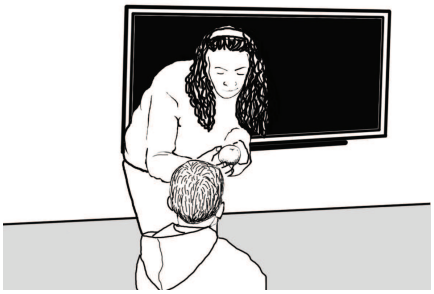
Back to the story, in front of ten groups of 4 learners each, all sitting at their own tables, Rebeca invites each learner to imagine what will happen if they introduce a *sealed container with something inside* and a *smaller and thinner sealed container* in the aquarium full of water. Simultaneously, she shows the *Containers A* and *B* to all the students. First, she discusses with the kids all the possible outcomes. One child goes to the board and makes a drawing illustrating the discussion. He draws a representation of the aquarium and the 3 possible

outcomes that they agree may occur. The object stays on top of the water; they say it floats. The object sinks half way into the aquarium; they say it sinks. The object falls completely to the bottom; they say it sinks completely. She reacts by saying that these ideas will be used in the following class. It is important for her that each student writes these ideas on his/her notebook. She knows from experience that there are more than three possibilities: the objects can "sink" to different levels and take different positions. At that moment she thinks that in the following class, she will bring different objects that float and sink in different levels in the water. She will discuss with the children the variety of possibilities.

Rebeca asks them to raise their hand if they think the first object will Float (F). She counts the number of hands and writes the number followed by an "F" in the second column of the poster. Then, she repeats the questions for the other possibilities and writes the number of questions for each possibility followed by "S" (Sink) or "SH" (Sink half way), depending on the case. She discusses the different answers with the children and names those ideas their 'predictions'. By doing this, she obtained information in order to assess each student's ideas and, at the same time, she was able to show to the children that there are different 'predictions' regarding the same possible events.

The **Learner Own Space —LOS**— are the moments in the classroom when the learner is drawing, writing on his/her notebook, touching or looking at objects, and reading books or browsing the Internet by him/herself. He/she is reflecting, making decisions, and thinking on his/her own, based on available resources. In other words, students "talk" to themselves in silence.

Each learner is writing —on the sheet of paper that Rebeca gave them— their ideas about what could happen to each one of the containers in the water and why. Juan writes on his notebook: "The *Container A* will sink because it is heavy". Maria writes: "Container A will sink because it is heavier than the *Container B*". Pablo looks around and seems not to be sure about what his answer will be… Each learner makes his/her own sense of the situation, by interpreting the teacher's questions, imagining the situation of the containers in the water, and giving particular meanings to different elements of the overall situation.

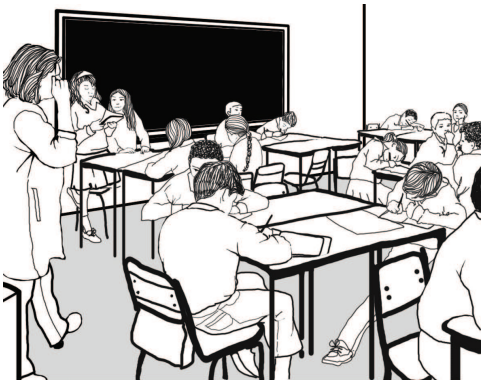


I call **Shared Own Learner Space — ShOLS—** those moments when a learner shares his/her ideas with the teacher, asking and answering questions, and doing activities together. The teacher shows something to one learner, and

asks questions. The student answers or asks questions, and shows things to the teacher. Either the teacher or a student can initiate this space.

Rebeca sees Pablo hesitating, so she goes to him and asks: "What are you thinking?" He answers: "I am not sure if it floats or if it just sinks half the way —pointing to *Container A*— I am sure it will not go to the bottom". Rebeca takes the *Container A* and gives it to him. Pablo takes it in his hands and shakes it. Then, he says: "Now I know, it will stay in the middle." Rebeca asks him: "Why do you think that *Container A* will only sink half way?" Rebeca knows that Pablo always needs support in order to produce ideas; he needs a little push; so she assesses the learner's concerns and decides to focus Pablo's attention on the container. She tries to make him aware of the characteristics and qualities of the container. Pablo makes sense of Rebeca's intervention and shows confidence on his thoughts.

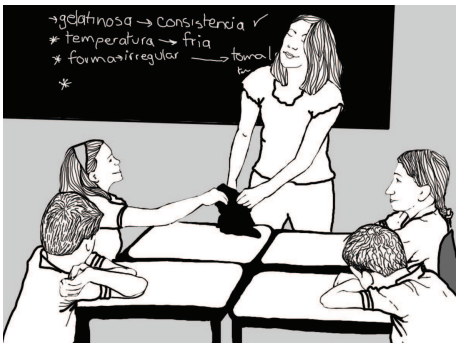
By **Collective Group Space —CGS—** I designate the moments when the teacher addresses the groups of students by asking questions, sharing activities and promoting discussions. While in **CS** the teacher addresses the whole class as the set of all individuals in the classroom; here, the teacher addresses the set of groups. In this space, the "units" of communication are not individuals, nor the whole class, but the groups. The teacher asks the groups to share ideas about their common activities, and asks them questions.



Rebeca instructs each group that they must discuss their individual answers, agree on the one that seems the best for all the group's members, and decide how the group will support its ideas. She expects that each group will debate and write down their agreements, and she will use that information later to contrast their initial expectations and explanations with what they will observe when experimenting with the containers and the aquaria. Then she gives each group an aquarium filled with water and a set of *Containers A* and *B*. She asks each group to put the containers in the water and observe what happens. They should also contrast the observations with their previous agreement, and write an explanation for what they observed. When all the groups finish, she asks each group to stick their responses to the wall, explain and communicate their thoughts to the other groups. Rebeca wants to assess the productions of each group, inviting them to comment on each other's. She also contrasts the groups' productions with what she expected, and tries to involve different groups into discussions in order to assess individual contributions to the group production.

The **Group Own Space —GOS—** are the moments when, inside the groups, two or more children are sharing ideas, talking, experimenting together, or sharing a common task. Continuing the story, for example, Maria, Juan, Pablo and Ana, as a group following Rebeca's instructions, see that *Container A* is in the surface of the water and the *Container B* sank to the bottom. Ana says happily to the others: "Yes! It is as I thought." Maria and Juan seem surprised, and Pablo pushes *Container A* to the bottom and releases it. The object pops out to the surface again. After they discussed and wrote their ideas on a poster, Ana stuck it on the wall and explained to the other groups what they had found. Each member of the group had different expectations, and some of them were confronted with facts they did not expect would happen. They know that their productions will be assessed by their peers and by the teacher. Their argumentation to support their claims will be considered by others.

Finally, I call **Shared Own Group Space —ShOGS**— those moments when the teacher talks and shares one activity carried out in one of the groups of learners. The teacher asks questions, looks whether there is agreement on the ideas or not, and points out particular facts and confronts the students' expectations and explanations.



Rebeca goes back to Maria, Juan, Pablo and Ana's table and points to *Container B* (the smaller one) that is on the right side of the aquarium, asking: "Why do you think this container is at the bottom?" Juan answers: "Because it is heavy". Maria interjects: "No, it is because it is heavier than the other one." "How could you know who is right between the two of you?" Rebeca asks. Pablo proposes to find out the weight of each object to see which one is the heaviest. They find out that the *Container A* is heavier than the *Container B*. Juan says: "I do not understand". Maria asks Rebeca: "But why?" The teacher, by questioning and considering the answers of group members, assesses their thinking about the relationship between the characteristics of the objects and the floating/sinking phenomena. She does not say what is right or wrong; she helps them to be aware of other aspects involved in floating that they were not aware of before.

So far, I have presented a possible situation of teaching and learning organized according to my individualistic cultural sensibility. I made explicit different types of interactional spaces that typically appear in IBSE classrooms. I am well aware that there could be more spaces. It is not my intention here to put forward

an exhaustive list of possible spaces. Rather, I wanted to highlight that there are different interactional moments, some with focus on the individuals or on a variety of groups. At the same time, I intended to exemplify how assessment for learning, that is, the teachers' continuous production of valuational statements about students' actions, becomes part of the teaching-taking place. Participants in the process are aware that their expressions, actions and performances are valuated all the time in order to give direction to the teaching and make all participants responsible for the learning process. In the story, I showed different activities that allow eliciting students' thinking (e.g., the big poster activity, the production of group activity, the presentations, the direct questioning and answering, etc.). I tried to make explicit the awareness and purpose of the teacher when making judgments in connection to a particular issue: Rebeca had the intention of making learners aware that the weight of objects is not crucial in the buoyancy phenomena. The activity of predicting how different containers would float was planned for that purpose. Her choice of containers allowed bringing this particular discussion to the fore.

INTERPRETING CLASSROOM SCENARIO

The classroom scenario was produced having in mind teacher's object/motive to help each student to review and modify their conceptions by confronting their own explanations with evidences that either support or not their own view. This helps me to imagine Forms of Social Relations and Forms of Production, as well as the kind of Cultural Knowledge. I followed my individualistic cultural sensibility as explained below.

For example, when Rebeca prepared the activity using containers, she was expecting students to produce predictions and explanations related to the floatation of two particular objects, and the material, size, weight and density of the two objects. She planned the situation in such way that each learner had the opportunity to express his/her own idea through a prediction (What will happen?) and an explanation (Why will it happen in that way?). At the same time, the teacher expected to assess how each learner confronts his/her own idea with a fact: the big container floats on the surface of the water, while the little one sinks to the bottom. Through different activities, she expected to make each one aware that there are more factors than the weight or size involved in the fact that one object floats or sinks.

During the assessment interactions that constitute the assessment activity, from a research perspective, the object/motive for a teacher should be to support conceptual change in each learner. To interpret the events let consider Harlen's (2007) constructivism representation of inquiry-based learning —used in the guide for teachers Satiel, 2006 as presented in Chapter five.

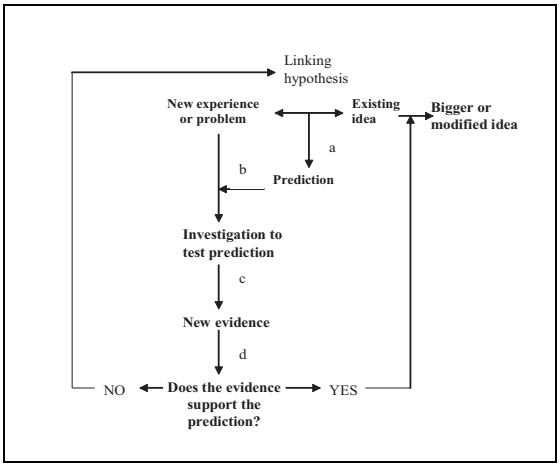


Figure 1. *The Harlen's constructivist learning model used in many IBSE documents* (Harlen, 2007; Saltiel, 2006)

During the teaching situation, the learner is confronted with a 'new experience or problem' such as the containers situation prepared by Rebeca —the teacher; María, Juan and Pablo —the learners— make explicit his/her 'existing idea' in a 'prediction', will float or sink because is heavy or more heavy than (e.g., what will happen and why), and engages in an 'investigation to test the prediction' (e.g., place the containers in water, observe if the containers float or sink). The learner observes if 'the evidence supports or not the prediction' (e.g., the big container is on the surface of the water and the little on sinks to the bottom, against the student's expectation that the small one would float on the surface, because it is smaller and heavier than the big one). The learner, by confronting his/her ideas with the evidence, formulates a new hypothesis in case that evidence does not confirm what she/he thought, or reinforces his/her previous ideas.

Based on these view of assessment, a possible interpretation about Juan and Maria's surprise when they see the *Container A* floating is that, for them, *Container A* was supposed to sink. Each one of them had a different explanation for that: "because it is heavy" or because "it is heavier than *Container B"*. In the face of a counter evidence, they measured the weight, and realized that there is something different that makes *Container A* float. The teacher can help them find this "something else" by arranging different experiences with the phenomenon, and trying to make them aware of the relationship between the density of objects and the density of water. She can invite them to express relations such as 'an object floats because its density is lower that the water's

density'. Such an expression will take time for the student to produce, but with good guidance it will be possible. From a constructivist point of view, if a learner arrives to that kind of explanation, after showing the first kind of explanation, then there is evidence that his/her mental structures have changed. Individual conceptual change has been achieved and it can be "observed". The interpretation of an evidence of learning creates a statement on what happens in the learner's head. The teacher needs to develop all kinds of strategies in order to assess and measure those kinds of conceptual changes in each learner's mental structures. At the same time, the teacher needs to learn how to use this information in order to modify the teaching. The teacher needs to develop assessment techniques, which encourage modification in each learner's mental structure.

As explained in Chapter five the purely individual focus of the above model, social interactions have also been important in the IBSE-teaching. Interactions are part of the assessment for learning perspective. Children do not only learn by making sense of new experiences on their own, but also in collaboration with others. Social interactions actively develop children's own understanding when communicating with others (e.g., Insight: An Elementary Hands-On Inquiry Science Curriculum, EDC Center for Science Education). In the assessment models, the teacher' and peer's feedback is considered as a resource that support individual learning.

During their interactions, the justifications and explanations produced by children reveal the thinking process expected; they provide evidence of "conceptual change". Going back to the story, one could expect Rebeca to collect information about the students' mental structure, to later try and stimulate discussions, activities, problems, etc., with the purpose of helping students to construct the idea that "what matters in the buoyancy phenomenon is the density of both the water and the object". The focus of the assessment process is on the explanations that students give during the class and how those explanations become part of the classroom discussions. Somehow, those justifications and explanations externalize the mental models inside the individual mind. The interactions with external actions or agents will provide some feedback in order to change the structure into a more "adequate" structure. As documented in Chapter five, in the assessment for learning model, the role of the teacher is fundamental in eliciting, recognizing and giving feedback, in order to direct the change process of mental models. The interaction with other learners is also an important mechanism of feedback, which helps the learner to make the conceptual change.

The questions such "What will happen?" and "Why will it happen in that way?" were seen as tools to elicit and enhance students' own ideas, and the answers were considered as indicators of individual process of learning.

Judgments were supported by contrast of theoretical constructs explaining individual knowledge development.

ASSESSMENT FOR LEARNING ACTIVITY WITH A SOCIO-CULTURAL SENSIBILITY

As explained before, two kind of analysis guided my process of production. One was to make a different interpretation of what a child says, acts or writes as information for assessment purposes, having a socio-cultural perspective in mind. It implies to move from an interpretation focused on conceptual change and changes on mind structures, towards an interpretation considering the social activity in which the child is participating. In that sense the analysis is focalized on how child's ideas emerge and are possible in the classroom interactions, with the tools and artifacts that are used, as well as the language available, and child's experiences in other social settings.

In this first kind of analysis, I take socio-cultural assumptions in order to interpret the events in the story in a different way. For instance, when confirming her prediction while in the group, Anna said: "Yes! It is as I thought". One could imagine possible thoughts crossing Anna's mind when Rebeca asked what would happen to the containers when put into the water. Anna probably recalled that, when her mother puts potatoes in a pot full of water, the water pours out. When predicting what would happen with the containers, she imagined that the water could also pour out of the aquarium. She may not have thought about the capacity of objects to float or sink.

However, when the collective discussion took place and the different possible positions of the objects in the water were represented, she 'became aware' that she was thinking about another aspect of the relationship between objects and water, namely that the volume of an object displaces the same volume of water. Probably, she also remembered when her mother told her that when lentils are soaked in water, those that are in the surface have to be removed because they are not good. She may have thought that the same object can be at the bottom or on the surface, depending on how good or bad it is, as in the case of lentils.

Even though her expression may apparently indicate that she had an acceptable prediction, the reasoning that led her to such conclusion is not clear-cut. In Chapter seven, one of the examples of students' responses to the questions related to the mattress can be analyze in this way. The group students' answer "If he is laying or sitting on the mattress he may fall because the current moves the mattress" is un expression of the way as they made sense to the

question, for them, the mattress was in the water, as they or one of them have experienced with mattress, according to possible social meanings to the word "mattress".

The other analysis focuses assessment in the activity in which learning is happening and the way in which it is considered in the learning process. It is to move from a perspective that sees the socio-cultural conditions of teacher and learner as static and external to learning processes towards one that sees the social activity as framing and constituting the learning processes. The assessment judgments will be about individual participation, interactions, as well as link to the situation in which individuals are engaged. The evidence of learning is constructed looking at the individual and the joint activity with others —activity seen as social praxis in terms of Radford and Empey shaped for instance by norms and values shared in classroom, and meanings attributed by children and teacher to artifacts supporting thinking.

From a constructivist perspective, Ana's expression when confirming her prediction can be interpreted as possessing a knowledge structure, based on her previous experiences, that is appropriate for that situation. In this second kind of analysis, from a socio-cultural perspective, what Ana thought, was mediated by her history of interactions with water and objects in a particular social setting and activities, with particular artifacts and languages available: in the kitchen, in a cooking session, with her mother's language and knowledge. She learned from her mother that there is good and bad lentils, and that this may be recognized by the fact that some float and others sink. At the same time, in another social setting, the classroom, she was learning a new social approximation to the relation between water and objects, helped by the others' experiences in their family, with friends or in that particular social setting. Those different experiences allowed her to 'be aware' of different ways of arguing, reasoning and reflecting. An important point to highlight here is that a given expression indicating students' reflection cannot be isolated and de-contextualized, but rather needs to be seen in the complexity of the social immediate and evoked setting where it is produced.

Therefore, I propose to focus on the learning happening in the diversity of social spaces and situations in IBSE classrooms. I will use the different IBSE classroom moments described previously, where the teacher and the learners are engaging with each other in social and physical settings: talking, reflecting and doing with others, experimenting with different kinds of objects, using the languages they bring to the situation from out-of school experiences and the new ones that are available in the classroom, and making sense of the activities they are doing together. I assume that learning is rooted in the engagement among subjects and is happening in the shared activities and spaces, in a particular, socially structured setting. Knowledge emerges and can be found in the spaces of engagement among subjects. Knowledge and learning are not only an

individual matter happening to a learner, they are a complex social process happening among people.

CHANGING SEMIOTIC SYSTEM OF CULTURAL SIGNIFICATIONS

If the elements constituting the Semiotic System of Cultural Signification change in the way as were exposed above, the challenge is to imagine the consequences for assessment for learning classroom activity. If learning is not to be explained in terms of the accommodation and assimilation of mental structures in the individual, which set of concepts can help us talk about learning? What can we say about knowledge then?

Following Radford (2008), learning is "a social process through which students become progressively conversant with cultural forms of reflection. Arising in the course of sensuous mediated cultural praxes embedded in historically formed epistèmes and ontologies, learning, it is argued, *is not just about knowing something but also about becoming someone*" (p. 215, my emphasis). To be *conversant* with cultural forms of reflection, students appropriate and objectify the forms of talking and referring to objects, processes and artifacts of culture. *Objectification* is the term that Radford chooses to name the processes of appropriation of cultural forms of reflection and associated knowing. However, objectification is only one side of the coin in the dialectics of learning. *Subjectification*, naming the process of becoming related to the transformation of the self when engaging in the social and cultural forms of reflection, is also an essential component of learning.

In relation to the view of socio-constructivist theories of learning that privilege objectification as an individual matter, for socio-cultural views of learning the dialectics of objectification and subjectification imply the impossibility of separating the knowing subjects from his/her social, cultural, political and historical context. It is in the constitutive relationship between a knowing person and the context where the sources of sense making and becoming are found. Knowledge is not an existing Platonic entity, decontextualized from praxis and to be found in the mental structures of individuals, as constructivist theories suppose. Rather, it is partial, contextualized in praxis, objectified forms of reflection, made explicit with and through the artifacts of culture (Radford, 2008; Roth, 2006a).

This way of seeing learning has implications for conceptualizing and doing assessment for learning in IBSE classrooms. In assessment for learning, interpretations of learning evidences change from the focus on individual mental structures to a focus on the collective forms of reflection, reasoning, talking, writing and acting, as well as to how students become conversant with the forms of reflection present in the activity. Looking at formative assessments from a socio-cultural perspective, it is also relevant to take into account the child,

children and teacher relations, their languages and norms, values, institutional expectations, as well as epistemological considerations of knowledge. It is to identify the Forms of Social Relations, Forms of Production, and Cultural Knowledge with the purpose to guide assessment activities.

The purpose of assessment activity should be to provide language, meanings, artifacts and objects to the child and help her/him be engaged in activities where all those elements make sense for the teacher and students. The aim is to allow the student to produce ideas and reflections, which are adequate to the circumstances as well as support collective activities. I also consider that interactions involve more than cognitive dimensions, and are shaped by what is possible in the location where interaction is happening.

To illustrate the move towards assessment for learning considering the individual and the social activity in which he/she is involved, I retake the typical IBSE moments identified above and reformulate them. I call *Spaces of Learning-in-Otherness* those moments and spaces that are generated while students and teacher are engaging with each other, in the physical and social setting of each moment of the IBSE classroom. I construct the *Socio-cultural discourse in assessment for learning and IBSE* based on them. Those spaces support the move from looking at the child's own ideas in mind and individual inquiry skills, towards possibilities for the child to enunciate ideas during the engagement on social activities located in a specific culture, place and time; and with artifacts whose meaning is determined by the collectivity, the uses at the institution, the history of the individuals, and the culture in which the group is located.

I propose to move towards a representation of assessment activity including the relation between the child and the social activity. My assumption is that when a child is answering, all the artifacts (with the meanings shared by individuals when are engaged in such activity) present in the moment have an influence in what the child can say, write and do. For that, I take Radford's theory of objectification-subjectification and re-interpret it in terms of assessment.

With the term "learning-in-otherness" I want to grasp the characteristics of learning previously described. I emphasize the fact that individuals are inseparable from the whole social, cultural, political and even economic context constituted in the meeting with others (Radford, 2008). By re-formulating the spaces of learning in terms of *spaces of learning-in-otherness*, I am trying to focus on the reflections that take place in the moments of engagement among subjects, and not on each individual's psychological processes. At the same time, I make visible the fact that knowledge is situated, which results from the activity and the classroom praxis.

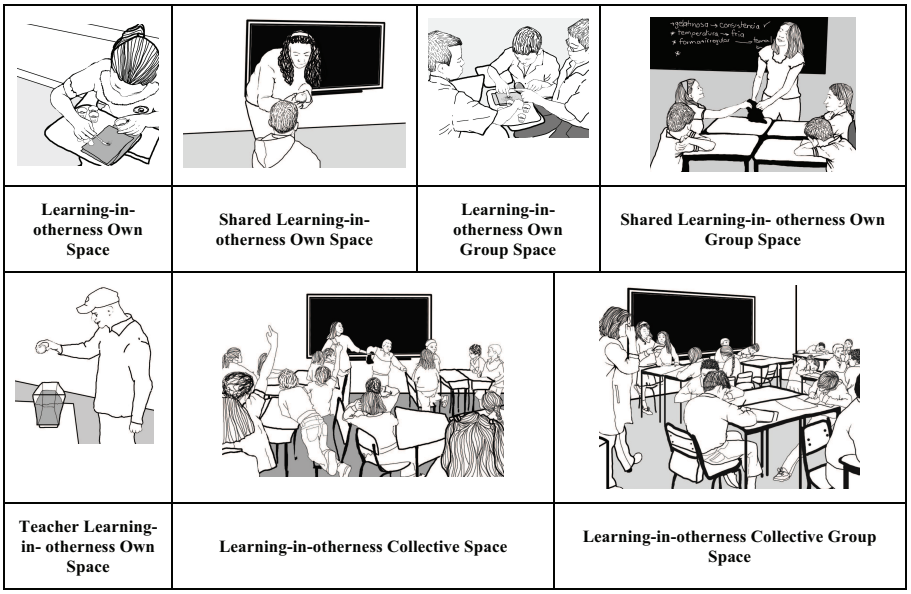


Table Nº 1. Assessment model focused on spaces of Learning in otherness

My aim is to focus the attention on the classroom activity which make possible that a certain kind of ideas can emerge during activities. It is then important to judge if children's ideas during classroom activities are produced with everyday language or with more specialized language. This means it is important to make visible and available a language that draws the phenomenon and to make available epistemic considerations about knowledge. The teacher in his /her assessment perspective needs to be clear that there are different interpretations and meanings shaping the activity. It became relevant to find ways and information to judge if children 'see' 'the object'. Then, in the interactional spaces, each individual appropriates those objects.

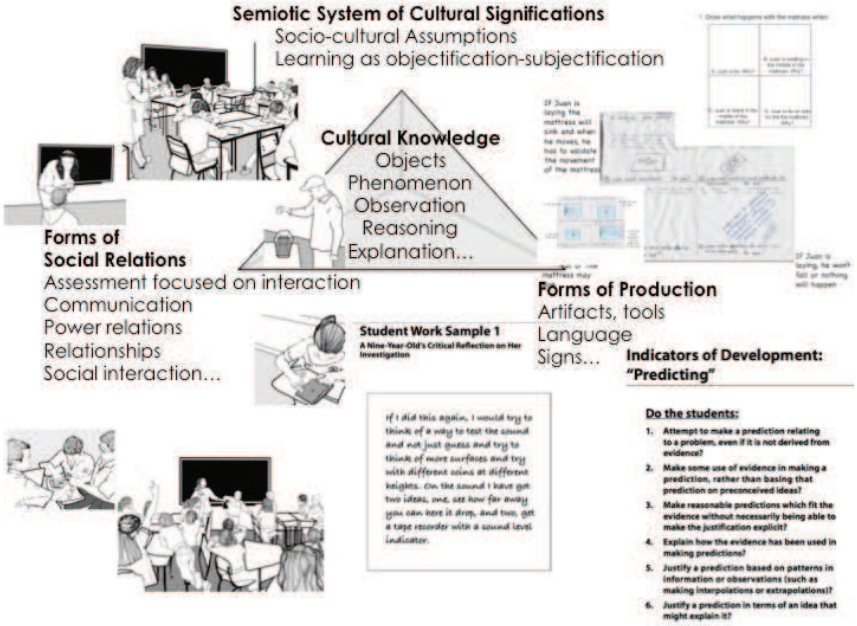
In graph Nº 2, I represent the elements constituting the assessment activity. First, there is the group of socio-cultural assumptions that guide the teacher in the interpretations and configuration of assessment activities. For instance, I presented in Chapter five the impact of the group of individualistic assumptions in the constitution of artifacts guiding classroom activities such as Harlen's (Harlen, 2006b, 2006c, 2006e) indicators and questions. Thus, by changing the Semiotic System of Cultural Significations, I am showing a change in the way the assessment activity should be conceived.

Second, I identified a need to constitute the set of Cultural Knowledge that is to be taught. I imagined that objects to be learn drive assessment activity in which students and teacher are engaged. The objective should be to make visible the objects and to learn to produce them. The objects to be learn in the inquiry-based classroom are a kind of explanations for observations, a kind of

reasoning, a cultural phenomenon and phenomena, ways to elaborate and produce a phenomenon and phenomena, objects such density, weight, or kilogram, and so on. My hypothesis is that if these objects are available and are part of the activity in which they are engaged, the students have the opportunity to notice them, produce them, and use them. However, in the activity the students bring other objects that they have learned in other social situations. The assessment activity makes a bridge between these objects and the others.

Third, there are Forms of Social Relations that are expected to be productive for learning, and the social relations that are validated in the place and the historical moment they are living. The flux of every day life at school materialized with power relationships, forms of social interactions, type of communications, uses of languages etc. A teacher with a socio-cultural sensibility should pay attention to creating spaces of interaction where students can trust, express, and interact acknowledging differences of interactions.

Finally, the Forms of Production should be constituted by artifacts, tools, languages, and signs, which materialize the Cultural Knowledge. Which kind of explanations are expected to be produced, how a phenomenon is made visible etc. The indicators produced by researchers are tools that help in this process. Thus artifacts such criteria, indicators, examples of good and no so good explanations, questions are forms of production for assessment activity aiming at objectify the learning process.



Graph N° 2. Assessment for learning in inquiry-based classroom viewed as social praxis.

In the Graph Nº 2, I recognize more than cognitive elements have to be considered. A child only appropriates the cultural objects and artifacts if he/she encounters them when engaged in the activity. Teachers must consider emotions, power relations, and the child's role in the classroom activity in their approach to assessment. The spaces of Learning in otherness are all those moments when assessment is done to produce valuation statements on the changes in individual and collective knowledge, as well as the development of concepts with shared meanings. Language is a key element as well as discourses that shape the classroom activities. The hypothesis is that if the collective knowledge develops in the expected direction, then the individual will have a high space for following.

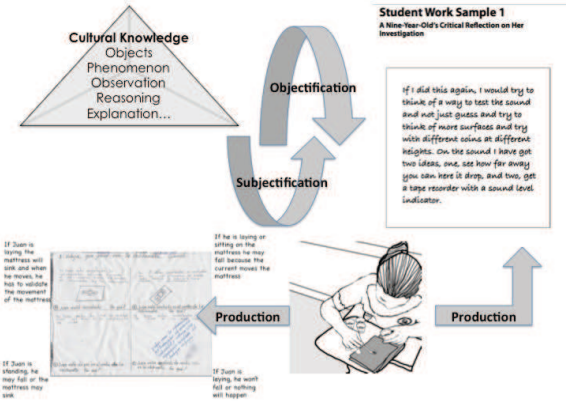
My intention with this model is to focus learning evidence on children's thinking emerging during the interaction with the cultural artifacts, activities, the teacher and the other children. It is to take distance from a perspective which is looking only for individual answers and actions towards one looking to the dialectic process between the subject, the collectivity and the activity. The teacher assesses if the interpretations, meanings and artifacts used during the interactions among children are shared and coherent with culturally determined meanings expected to be appropriate. The dimensions are interconnected; if a child does not notice the object, he/she cannot use cultural artifacts with meanings and uses shared by the group, and he/she does not appropriate them either. It is in those dialogues between the teacher and a child or between children, when the teacher tries to make sense of child's thinking and the child is engaged in a thinking process in the same direction than the teacher, or children are engage in a kind of conversation following the sense that the collectivity is giving to the situation.

In each space, the child is involved in a social activity where he/she encounters resources to think. The child's ideas emerge from there. For instance, the child will be confronted to use and appropriate artifacts or physical objects charged with local meanings —like notebooks, board, and posters, containers and the aquarium—, and other kind of artifacts —like semiotic symbols, concepts, and diversity of representations around concepts like density—. The children are engaged in a social activity determined by local meanings *to* inquire problems, challenges, and pedagogical situations. Both the teacher and the children give local meanings to the artifacts depending on the institutional meaning and the teacher's meaning.

As I showed, an artifact can have different meanings depending on the individual's experiences. In those spaces, it is not only school science knowledge that is emerging from the contact of the children with the resources, but also ways of being and acting in this kind of social circumstances. Those spaces will be different when moving from one culture to another. The ways of communication —like body language, verbal language, and written language—,

emotions —like happiness, and sadness—, and social relationships —like friendship, and power relations—, change. Those spaces are interconnected, and the teacher and students move between them while in class. Learning is occurring in each space with all those resources. Assessment is present all the time on those spaces as a tool to recognize what is going on and support changes on the 'everyday ways to make sense' towards a 'educated way to make sense' of the facts.

Graph Nª 4 represents the process of objectification-subjectification as assessment activity should consider. I represented as the dialectical process of objectification and subjectification.



Graph Nº 3. Assessment for learning focused in the process of objectification and subjectification.

With objectification I emphasize that during the assessment activity the teacher responsibility is to pay attention and judge if cultural objects are available to children. The teacher also ponders if the expected collective thinking occurs based on them. For instance, artifacts and tools such as rubrics and questions are useful to drive thinking and dialogues between the teacher and children. The configuration of reasoning with specific language such as why, where, and how in the communication processes of the teacher with children and between children are powerful tools to make visible scientific reasoning as well other forms of explaining (to differentiate and identify). Also, the use of representation tools, which are not specific to the every day representations, such as mathematic and others, need to be introduced and judged if the meanings given by the collectivity during the activities is the expected one.

I use Radfords' concept of subjectification to make explicit that assessment also pays attention to the individual appropriation of the object as well to becoming some one able to produce with the cultural objects that are

present in the collective spaces. It means to see if a child is engaged in a shared thinking with the collectivity and becomes fluent conversant with a new language. Finally, the triangle makes explicit the inseparability of child productions with the elements that constitute the social praxis. Each individual produces in an interactional space where children and teacher are immersed in a social setting with rules, norms, expectations, relationships, interests, and values. Assessment activity also pays attention to that, making them visible and using them to support learning.

PRODUCING AN ACTIVITY WITH SOCIO-CULTURAL CULTURAL SENSIBILITY

In order to move towards an assessment view based on socio-cultural assumptions, I propose to locate the described classroom event in a country, city, and institutional culture. The above classroom example is now located in *Bogotá, Colombia. José Celestino Mutis Comprehensive School is a State school that belongs to the Colombian IBSE Network. Primary and lower secondary teachers have participated in several professional development seminars with the intention of introducing and implementing IBSE in the school's science classes. Rebeca, the example teacher, had learnt to implement IBSE principles in that situation.*

For instance, in the example, Rebeca expects to introduce density as concept that will help students to construct a language configuration, different from every day, shaping the facts with this new tool and cultural artifact. She also will try to find out other possible language configuration in order to distinguish with children those different languages configurations that can be used to refer to the same facts. She thinks that children from that school have not the same kind of social experiences than her, then, she needs to explore their languages and ways to make sense to the observed facts. It is also the way she establishes a respect relationship with students —by listening to their experiences, taking them into consideration and giving a new sense to the situation.

Learning-in-otherness Own space is a classroom moment when the child is isolated from interaction with others. From a child alone with his/her own ideas, misconceptions, or naïve theories in mind independent from culture, as the Dominant discourse assumes, I propose to move towards a child with otherness reflection; situated in a specific social activity; with an artifact having local meanings, his/her own possibilities to make sense of a

situation, in an institution —school—, with his/her role as a student and peer and his/her way to relate to the world. The space is characterized by the connection of the child's actual possibilities of reflection, collective linguistic resources, collective ways to make sense of the situation, personal historical meaning making, and collective uses of artifacts. It is a moment in which the child is talking to him/herself with the cultural and social language appropriated. Learning is happening while the subject appropriates the thinking and reflection available in the collectivity, in that particular social situation, supported by his/her history of experiences. Knowledge is emerging in the interaction of the child with the artifacts and language and meanings shared by the collectivity, and also with the meanings that she/he attributes. Self-assessment can be expressed as the possibilities of the child to notice what he/she is doing and which meaning he/she is using in relation to others in the group.

For instance, Ana is concentrated answering some of Rebecas's questions (for instance, What will be happen in the water to containers A and B when they will be inside the sealer?) that guides her thinking. She listens carefully to children's remarks around her and notices that they were talking differently about containers in the water than in the way she was thinking. Trying to make sense of those remarks, She adapts her thinking to another way of talking about the containers in the water. She thought then that it was not the way she made sense to the question but the one the others did. She changes her idea from thinking water going out from the sealer, when containers were in, towards the idea of a containers floating or sinking. She did that because one of the children that did a remark was the smart one of the class, and Rebeca always says that he is right. She also saw that her best friend was following his remarks. Even thought she was alone during the activity, she was attentive to the environment and to adjusting her thinking to others ways of talking about water, containers and sealers. The criteria to change her thinking was not rational, it was more on the social configuration of the classroom and in the affective domain.

I call *Shared Learning-in- otherness Own Space* the moment in which the other is physically present. It is when the teacher or another child physically appears in the Own Space, becoming a new resource to reflect and produce ideas. It is a moment when new possibilities arise to give new meaning to the situation, to reflect with another based on those isolated reflections. The teacher's responsibility is to inquire and assess if the child is giving the expected sense to the activity. In that sense, by questions (why do you think the container goes to the bottom when I push it? Measure the weight. What do you observe when the other container is put in the water?), by showing other meanings, by connecting with the child's language, the teacher is

assessing and giving access to other meanings, languages, ways to do and make sense.

For example, Rebeca goes to Ana's own space and dialogue about something that she observed in her notebook. She asks her why did she change the representation of the situation of containers in the water. Ana answers that it was because she was not sure about the meaning of the question, and then she saw that she was wrong because the others' answers were different from her answer. Rebeca starts to ask about her first answer and pushes her to make a rational relation between her answer and other's answers —in that way, Rebeca tried to objectify the cultural knowledge and reasoning that Ana needed to support her thought, and she judged that Ana needed help to make her confident of her ideas and to show her that it was all right to have different interpretations of the question, but that she needed to support her thought with evidence from experience and investigations—.

Learning-in-otherness Own Group Space focuses on the group thinking that results from the engagement of each child in the social activity, with the individual and group way of making sense of the situation. Learning is happening in relation to what they are able to see and think in that particular moment. The activity, the meaning they are giving to what they are doing, and the artifacts determine possibilities for learning. From the idea that each individual is thinking with his/her own cognitive possibilities and sharing, I move towards a group of children engaged in an activity and thinking together. They can assess what they are doing by making sense and looking at others.

Looking at the example, we can imagine Carola, Rodriguez, Juliana and Contreras (Rebeca calls by their first name girls and boys by their last name, as it was made in the first place she worked as a teacher) were uncomfortable because Rodriguez said to Carola that he loves her, so they were not concentrated on what was going on with containers and water. Contreras and Rodriguez explained to Carola that they would answer Rebeca's questions if she accepted to be Rodriguez's girlfriend. Carola does not like the work in the classroom so she was exited with the situation. At one point of the discussion, they listened Rebeca say that the time to answer was about to finish. So they started the activity and Rodriguez wrote the answer to the questions.

Teacher Learning-in- otherness Own Space means that the teacher also thinks and produces ideas using his or her particular way of making sense and own meanings. What is possible there is what will drive the activities in the classroom. The artifact used and the way he/she uses it will be the way to refract a collective way of reasoning. If a teacher sees children's activity as a way of

showing the process to calculate a density, then the orientations during the classroom will be in that sense. If for the teacher the activity's goal is to show how the inquiry thinking is used to write argumentations using the facts, then the collectivity will follow. Assessment is mediated by his/her own way of making sense of the activity, meanings, expectations and possibilities. The values, emotions and norms are also part of his or her space.

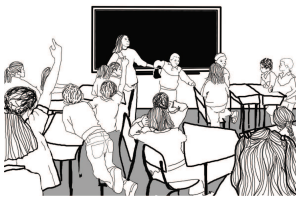
When Rebeca was listening the groups' discussions she was surprised because not all groups were working on the activity. She talked to herself and decided to help each group to engage in the activity. She thinks that it is not a good strategy to show them that she is uncomfortable with their attitude. For instance, she went towards Carola's group and choose to talk to Juliana because she knows that she always pays attention and tried to get involved the others —In this case, Rebeca assesses the way in which the groups are engaged and what the best way to solve the problem she is observing is, it is not a cognitive matter, it is related to social relationships, power and values.

Shared Learning-in- otherness Own Group is when the teacher arrives as a new resource to think and produce group ideas related to the situation and context. By showing new meanings to artifacts, words, sentences, ways of representing, the teacher is helping them learn. The teacher became engaged in what they are doing and opens doors to new ways of recognizing facts and talking about them. The phenomenon starts to be shaped by the teacher's language, establishing a bridge with their language around the facts and the others. A French teacher[81], reflecting about group work said that he observed that a group solved a challenge because of an idea that a child proposed. The interesting thing for him was that this child was in "echec scolaire" [school failure], which means that his grades were not good. This child was engaged in the process of thinking together and making sense of the situation, she was acquiring knowledge and reflecting. The child's grades and what the teacher observed were not aligned. When a teacher goes to the group, he/she can assess if the group is working and at the same time the participation of each child in the group.

Returning to the example, Rebeca perceived that the group was not concentrated, so she went to their own space and asked Juliana to imagine what

[81] Observed in a video from French IBSE project La main à la pâte.

will happen to the containers in the water —Rebeca noticed that they were talking about personal issues and not academic ones, she decided not to complain but to do something to engage them in the expected process of thinking— Juliana's answer that the container A will float and B will sink — Rebeca knows that Juliana is always paying attention and that she was not engaged in the others' conversation—. Rebeca asked Rodriguez if he agreed with her. Rodriguez needed to be very smart in front of Carola so he did his best effort to argue his answer. With the presence of the teacher they began to think and reason in the expected way. However, their engagement was guided by the emotional forces and not by their desire to learn.



I distinguish *Learning-in-otherness Collective Space* from *Learning-in-otherness Collective Group Space* by the fact that the first connects subjects' thinking with the collective thinking, and in the other case, the group thinking with the collective one. In both cases it is the moment of building a collective meaning of the activity in which they are engaged. Those spaces are essential for learning and assessment. What is accepted, valued and validated becomes what will be used frequently in those spaces. The subject follows those particular meanings to think and do.

During an inquiry-based session, in a collective group space, Rebeca[82] was inquiring about the children's ideas of flotation. She asked for characteristics of flotation. Different children expressed ideas about it and the teacher wrote on the blackboard some expressions making a summary of their interventions. She was not telling if what they said was wrong or right; she was listening and asking questions. A child was trying to explain something, moving his hands, and saying "Que el objeto como empuja hacia abajo y el líquido hacia arriba y entonces así se hace como una nivelación" —That the object pushes downwards and the liquid upwards and then there is a kind of nivelation. Looking at the situation, Rebeca felt that he could not find words to say what he wanted to say, and that it was difficult to follow his thinking. Gloria, another child, showing respect for him and his difficulties to express himself, uses a more elaborated language and said: "I think that what my friend wants to say is that when the object is put into the water, the liquid, there is a downward force of the object and an upward force of the water, called the Arquimedes law. This is, when the water pushes the object upwards and the object pushes downwards so that it does not sink". A new way of saying 'that' appeared but also a movement of Gloria to help the child. This is what I want to express by pointing that assessment must also recognize other dimensions beyond the cognitive ones.

[82] This part of the story is based on empirical material coming from a Video of Pequeños Científicos, a Colombian Inquiry-based project.

Assessment activity takes care of the others' thinking and invites them to another way of communicating and saying things.

In another moment, after the activity where the groups were making an hypothesis about the containers in the water, Rebeca asks each group to present their conclusions. She assessed different aspect during their presentation and also decided to verify if the different members of the groups agreed on the presented ideas. She assumed that it is important for children if their work is valuated in front of the others and is why she did not make visible that Carola's group did not work very well.

I use the classroom story to illustrate what the socio-cultural perspective offers for seeing the spaces of learning-in-otherness and assessment for learning. When prompted by Rebeca's question, Pablo engaged in a reflection. Pablo's verbalization takes place in the relationship between the question (What will happen to the container?), the presence of the *Containers A* and *B,* and his own social experiences in the past. Rebeca's question in that particular situation -in terms of space and activity- invites Pablo to reflect in a particular way, given the presence of the containers. His thoughts at the moment are possible because of the configuration of these elements. Pablo's reflections appear as a possibility in the *Learning-in-otherness Own Space,* given the configuration of the question and the other meanings and artifacts involved.

When Rebeca asks Pablo "What are you thinking?", he voices his hesitation about the answer. Rebeca gives him *Container A* and with her gestures invites him to put it in the aquarium. Rebeca's intention to make visible the significance of density for buoyancy guides her in pushing Pablo to realize the connection. She initiates and invites Pablo into another space: *Shared Learning-in-otherness Own Space*. In the meeting between Rebeca and Pablo, new possibilities for reflection emerge. In that way, Pablo deals with new information that came from the physical setting as well as from the social interaction.

With this example, I want to suggest that even if it is possible to identify different spaces of learning-in-otherness, there are no clear-cut boundaries between them. Actually, they can be activated and interconnected in different ways according to the situation. The central point here is that spaces affect each other. In this way, the resources that shape thinking and reflection in each space constitute a potential structuring resource for reflection in other spaces.

If I turn our attention to assessment for learning within the interconnectedness of spaces of learning-in-otherness, I can provide a new possible interpretation about Juan and Maria's case analyzed before from constructivist point of view. Juan and Maria had different explanations for the fact that *Container A* floats and *B* sinks: "because it is heavy" or because "it is heavier than *Container B"*. Their own history of experiences and the resources available in that precise moment prompted them to claim that. Maybe, at the

same moment, they could have expressed a different claim have they seen the material inside the containers, or got information about their weight. For Rebeca, in her activity of producing valuational statements in relation to the students' becoming conversant in the situation, it is not enough to take their answer as a reflection of Juan's and María's understanding. An assessment on the grounds of an answer to a question ignores the complexity of reflection at any given time.

In face of the difference in answers, Rebeca chooses to invite them to realize "something different". She says "How could you know who is right between the two of you?". Rebeca faces the pedagogical challenge to help them becoming aware of the "something else". She leads them through different experiences with the phenomena, revolving around the relationship between the density of objects and the density of water for floating. By weighing students' expressions, Rebeca realizes that she needs to make evident and introduce the idea of density as a new element in the spaces of *learning-in-otherness*. She makes the notion of density available to students and shows the expressions that make part of the culturally formed conversations about density in buoyancy. Rebeca needs to allow the students become fluently conversant with the new language resources introduced in the spaces. Rebeca hopes that expressions such as "an object floats because its density is lower that the water's density" will take time for the student to produce, but with a good guidance it will be possible.

I argued that, from a constructivist point of view, if a learner arrives to that kind of desired explanation after having showed a wrong initial explanation, then the teacher would have evidence to claim that the student's mental structures have changed. Individual conceptual change has been achieved and it can be "observed". The interpretation of an evidence of learning creates a statement about what happens in the learner's head. In contrast, from a socio-cultural point of view, the interpretation of evidence such as a student expressing an explanation for a phenomenon, accepted in a school's scientific culture, will be different. That kind of fluency in conversation can be taken as a sign of the student's appropriation of a particular cultural type of reasoning and of his/her attempt to use the available language in that particular social setting where it is accepted as socially meaningful.

Assessment for learning then becomes particularly attentive to the language resources that students articulate, the way in which artifacts modify the students' reflections, and the provision of new resources and artifacts for opening new possibilities of conversation in the spaces of *learning-in-otherness*. Each *space* of *learning-in-otherness* can be considered as an opportunity to make the participants aware of other cultural objects and artifacts, and to help them become comfortable in using those objects and artifacts, and their associated resources.

It is also important to be aware that interpretation is part of culture. Children and teachers are part of an institution where some meanings are

attributed to the artifacts available. Learning to perceive different interpretations must be part of the possibilities in the spaces. Assessment can be conceived as the process by which the teacher and the students become aware of different interpretations and meanings that circulate in the space of *Learning-in-otherness*. An expression does not contain the meaning in itself; it is the reader or the producer who interprets and gives a meaning to that, based on his or her participation in other social activities. Also, the relations and the possibilities of interaction are different for each child, making participation very different. A challenge for assessment activity is to know different interpretations or speech genders that may occur when facts are produced.

FINAL REMARKS

The production of the examples and the analytical process in this chapter was an attempt to appropriate the cultural knowledge fabricated by socio-cultural scholars and bring it in operation in thinking. However, what can be perceived is the cohabitation of my individualistic view with my new adopted theoretical perspective. Indeed, there is a tendency to explain changes by interpreting individuals actions and thoughts, as it is the case in the assessment activity from and individualistic perspective. At the same time, there is no clarity of the role-played by the large-scale social configurations in the construction of the example. That is, the meaning of the term context to denote the multiple influences of social, economic and political relations on which children and teachers live are not considered in this view. All these elements are assumed to be "present" in the mediation of cultural artifacts and of language, but are not identified and analyzed as part of my sensibility.

In my process of production of an example of assessment for learning activity with individualistic sensibility, I fabricated evidences of child learning by looking at naïve theories, misconceptions, and by considering the child as a little scientist constructing theories about natural phenomena by experimentation, and considering assessment activities that support conceptual change and changes in individual mental structures. In order to produce an example with a socio-cultural sensibility, I used the theory of obectification and subjectification to see the evidence of learning as the child appropriation of cultural forms of understanding to look at physical surroundings. I put an effort in making operational the idea that assessment activity should be envisioned to share and make visible collectively appropriation of existing cultural knowledge. I also gave relevance to the diversity of meanings of tools that can be created by the collectivity in the interactional spaces. Assessment activity should pay attention to that. It is also important to recognize that everyday assessment activity happens within the circumstances that emerge in the precise moment of

actions. In that sense, there is no way to have a predefined idea of what should happen in the classroom. The activity modifies thinking, reasoning as well as meanings of objects.

I also moved from assessment tools enhancing knowledge and providing indicators to fabricating evidence of learning based on those individual skills and theories, towards a view of assessment prompts, and indicators as cultural tools making visible to both the teacher and children the cultural reasoning, language and meaning in those spaces where learning is happening in a rich interactional environment.

I pointed that assessment must consider that phenomena are social constructions made by languages available and with cultural located meanings. In that sense, assessment with a socio-cultural view takes care of different speech genres that can shape facts. The facts are not the phenomena: it is the language configuration around the facts. Finally, I moved from learning evidence constructed by looking at individual information and in the basis of an existence of ideas in the child's mind, towards one that considers the child's ideas as mediated by artifacts, symbols and shared meanings located in that particular moment when the child is making the activity and interacting with others.

Linking this process with the problematique, I was interested on understanding how assessment for learning and IBSE principles were modified by considering teachers and students, as well as their interactions for teaching, learning and assessing, as participants in a social praxis. My analysis intended to show that the interactional spaces are more than simple cognitive exchanges between individuals. By producing the representation of assessment activity as social praxis, my intention was to communicate the elements that are relevant in the process of learning, and that have a source on the situation and activity in the classroom. For instance, the identification of different languages, the consideration of phenomenon as constituted by language, the awareness of the social relations and motivations for learning and the role of artifacts and tools to objectify the expected learning. The representations allows me to move from assessment in the interactional spaces focused on individual evidence of learning, towards a view that considers those interactional spaces as co-constitutive of learning evidence: learning evidence is in the collectivity and in the relation of subject with that collectivity, in the fact that a subject is participating in an activity, using tools and artifacts and being able to talk with others in the expected way for such social activity. In Chapter ten I will move by making some consideration from a cultural-historical activity theory.

However, I had difficulties to establish the representation of assessment for learning activity considering the educational culture of the teacher and students. Indeed, I move towards the use of socio-cultural assumptions in the

Semiotic System of Cultural Significations, but I did not consider the group of assumptions of the teacher and students in the diversity of social settings among countries, cities and neighborhoods. In the problematic, I identified that teacher and students could be near or far from the individualistic group of assumptions as well as the group of socio-cultural assumptions. In that sense, as in the case of Ines, the assessment activity should be considered differently, with the truth and reasoning of educational culture in which IBSE and assessment for learning have been arriving as foreigners. I expect that there are places where teachers' assumptions can be closed to those of the research perspective; however, the flux of every day can change the way as the activity is developed. Thus the moving characteristics of the activity should be represented.

In this chapter, I am arguing from the point of view of a researcher for whom the theoretical discussions on how to interpret evidences of learning in the everyday teaching and learning is meaningful. This discussion informs my practice as researcher and as teacher educator. However, I do not intend to claim that these reflections are to be taken as a prescriptive recipe for doing appropriate assessment for learning in IBSE setting. This is not a "method of assessment" that can and should be transferred to classroom settings and to the everyday work of teachers. Teachers' assessment practices are constituted in the complexity of schooling in science or any other classroom. I have put forward a different way of thinking and reasoning about such practice. I would simply like to invite teachers to consider the reasons and grounds on which they build valuational statements on their students' learning, considering that statements are not innocent portraits of their students' state of mind.

9. THE KNOWER AND THE KNOWN

[…] Car il me semblait que je pourrais rencontrer beaucoup plus de vérité dans les raisonnements que chacun fait touchant les affaires qui lui importent, et dont l'événement le doit punir bientôt après s'il a mal jugé, que dans ceux que fait un home de lettres dans son cabinet touchant des spéculations qui ne produisent aucun effet, et qui ne lui sont d'autres conséquence sinon que peut-être il en tirera d'autant plus de vanité qu'elles seront plus éloignées du sensé commun, a cause qu'il aura du employer d'autant plus d'esprit et d'artifice à tacher de le rendre vraisemblables. (Descartes, 2008, p. 14)

[…] For it seemed to me that I could arrive at considerably more truth in the reasoning that each man makes concerning the matters which are important to him and in which events could punish him soon afterwards if he judged badly, than in the reasoning made by a man of letters in his study concerning speculations which produce no effect and which are of no consequence to him, except perhaps that from them he can augment his vanity and all the more so, the further his speculations are from common sense, because he would have had to use that much more wit and artifice in the attempt to make them probable.[83]

[…] Mais après que j'eus employé quelques années à étudier ainsi dans le livre du monde et à tâcher d'acquérir quelque expérience, je pris un jour résolution d'étudier aussi en moi-même, et d'employer toutes les forces de mon esprit à choisir les chemins que je devais suivre. Ce qui me réussit beaucoup

[…] But after I had spent a few years studying in this way in the book of the world, attempting to acquire some experience, one day I resolved to study myself as well and to use all the powers of my mind to select paths which I should follow, a task which brought me considerably more success, it seems to me, than if

[83]Translated by Ian Johnston Vancouver from Island University Nanaimo, BC Canada. Take from http://records.viu.ca/~johnstoi/descartes/descartes1.htm.

> mieux, ce me semble, que si je ne me fusse jamais éloigné ni de mon pays ni de mes livres. (Descartes, 2008, p. 15)
>
> I had never gone away from my own country and my books.[1]

In his introduction to the Discourse on Method, Descartes (2008) in 1637, uses his personal experience to construct his research method that would become most influential in shaping Modern science and mathematics. The above words let me highlight the points discussed in this chapter. In the introduction of his book, Descartes recognized the relevance for his academic work of his experience travelling to other countries. After trying to learn observing to the "book of the world", he decided to turn his gaze to himself and his thinking. His subjectivity becomes present in his writing. This shows a strong link between the researcher and the emerging method. He explained that by looking at the consequences of his thoughts he could judge the truth of such reasoning. In this study the researcher's experience is considered as relevant for constructing knowledge, as well as for appropriating theoretical research approaches to produce new research objects. In the communication of this thesis, the reader also has access to the researcher's subjectivity, experience and relationship with knowledge.

Although Descartes's subjectivity is present in the above words, and in the description of his research method, the results of Descartes's strategy of knowing ended in a paradigm that separated the knower from the knowledge. Indeed, according to Roth (2005b), Descartes's thinking influenced natural science research and consolidated the assumption that observer-independent knowledge of the world is possible. The root of this assumption can be found in Descartes's words:

> Je connus de là que j'étais une substance dont toute l'essence ou la nature n'est que de penser, et qui pour être n'a besoin d'aucun lieu ni ne dépend d'aucune chose matérielle, en sorte que ce moi, c'est-à-dire l'âme par laquelle je suis ce que je suis, est entièrement distincte du corps, et même qu'elle est plus aisée à connaître que lui, et encore qu'il ne fût point elle ne laisserait pas d'être tout ce qu'elle est.[84] (Descartes, 2008, p. 36)

[84] I thence concluded that I was a substance whose whole essence or nature consists only in thinking, and which, that it may exist, has need of no place, nor is dependent on any material thing; so that " I," that is to say, the mind by which I am what I am, is wholly distinct from the body, and is even more easily known than the latter, and is such, that although the latter were not, it would still continue to be all that it is. (Translation from http://oregonstate.edu/instruct/phl302/texts/descartes/descartes_method.html)

Roth and Radford (2011) explained that Descartes conceived the mind, psychological processes, thinking, and consciousness as entities lodged in an individual's 'interior space'. Roth (2005b) recognized the influence of Descartes in the consolidation of the paradigm conceiving body and mind separately: "Within the Cartesian paradigm body and mind became separated, and therefore also the connection between knowledge, a subject of mind, and our being in and of this material world." (p. 7). Descartes confirms the differentiation of soul and body and the separation of thinking and body. Science and mathematics research were shaped by this cultural sensibility consolidating, through time, a research paradigm.

The methodology and analytical strategy of my study was built around the researcher's experience of learning, by questioning and changing assumptions, and adopting new forms of understanding both educational research and the very same object of my study. The research methodology framed a subjective movement from considering the subject and the knowledge as separated entities towards considering the knower —myself—, and the knowledge —the object emerging from my research activity— as inseparable units. The inspection and communication of the researcher's learning strategy is supported by collective forms of understanding and researching nowadays (Krieger, 1991; Roth, 2009). The subject making this study is becoming a researcher in another historical time and place than Descartes did, with other possibilities of thinking and being, but at the end, the problem pointed by Descartes has a continuity: how the researcher learns and knows, and how knowledge produced in that way is accepted as part of culturally accepted scientific knowledge.

The researcher's experience with IBSE and assessment for learning research, and the researcher's participation in IBSE Network were essential for the consolidation of the methodological strategy and the constitution of the object of research. The five analytical strategies —Sensibility spaces one, two, three, four and five— described in Chapters four, five, six, seven and eight were delimited by the researcher's possibilities of thought, mediated by the individualistic and the socio-cultural cultural sensibilities. This chapter presents the knowledge emerging out of the analytical exercise, by looking at the researcher's process of learning and actions materialized in the sensibility spaces.

In the first part of this chapter, the relation of the self and social praxis is discussed and linked with the research process. In particular, the reflection brings together the researcher self, the research praxis, and the knowledge produced by the researcher. In the second part, the link of the researcher and the process of researching are objectified. The researcher's change of cultural sensibility is described. The five processes of learning are objectified through three categories: Naturalizing, De-naturalizing and Producing. At the end, the

dialectic relationship between the researcher's subjectification and objectification is situated within the research field. The methodology is discussed in terms of the use of researcher's subjectivity, and the knowledge objectified is situated in relation to the production of knowledge of socio-cultural researchers. To finalize, the humble contributions of the study in this dimensions are made explicit.

THE SELF AND THE SOCIAL PRAXIS

This study was conducted within the cultural-historical research perspective. In that sense, the researcher was considered to be a subject involved in a social praxis investigating assessment for learning within IBSE, and was identified as a participant of the IBSE Network activity. The researcher's subjectivity had possibilities of research given by the collective forms of understanding research objects within this social activity. The study followed the critical research paradigm. In that sense, the research shed light on the complexity of research activity when looking at assumptions guiding different collectivities of researchers. In particular, the study focused on the researcher's subjective changes during the process of participation in the research activity.

THE RESEARCHER SUBJECTIVITY AND RESEARCH PRAXIS

In Chapter five a social activity named for this study as IBSE Network was identified and described. The existence of several artifacts used to disseminate the IBSE pedagogical strategy, such as curricular modules, frameworks, and principles, was documented. Some projects in the IBSE Network have used assessment for learning research objects presented in Chapter five. In this study, artifacts, such as research papers and workshops for teachers on assessment for learning were analyzed to identify the assumptions guiding researchers' formulations and possibilities to investigate assessment for learning within IBSE.

The analytical strategy was built with researching tendencies and producing knowledge within the educational field. In particular, scholars producing artifacts within IBSE and assessment for learning research activities were identified as shaped by the individualistic cultural sensibility. Assessment for learning objects are built considering learning from an individual cognitive perspective. The dominant individualistic research perspective was identified in Chapter four and named the *individualistic cultural sensitivity* by re-interpreting and contextualizing Radford and Empey's (2007) concept of 'cultural sensibility'.

The researcher started this study with possibilities to participate in research activities in the collectivity of scholars following an individualistic

cultural sensibility. Her interaction as teacher educator with other researchers, artifacts, and conducting workshops imitating the ideals presented in researchers' texts, gave her the set of meanings shared within the IBSE Network community. The researcher's experiences, within the IBSE Network, and Colombian and Latin American educational systems, had molded the researcher's possibilities to participate with an individualistic perspective in an assessment for learning research activity. The researcher's initial possibilities of thinking were shaped by thinking the assessment for learning activity in terms of the cognitive learning process of individuals, and leaving aside the everyday moment of social activities and changes emerging when looking at an individuals' culture.

The study was planned to explore tensions emerging when assessment for learning and IBSE research objects are expected to be adapted to different educational traditions. In particular, different difficulties were observed when teachers were learning and using assessment for learning and IBSE pedagogical perspectives during the researcher's teaching activities within the IBSE Network. Problems were established in Chapters six, seven and eight by looking at current conceptualization of assessment for learning and IBSE discourses, and recognizing assessment activity as situated within an educational culture and a historical period.

The recognition of these problems was possible by the engagement in this study of the researcher with socio-cultural and critical research perspectives. The researcher's adoption of this research perspective has implied a change in her subjectivity. As documented in Chapter four, research in education with a socio-cultural perspective is based on a different set of assumptions from the individualistic and dominant tendency in assessment research. The participation of the researcher in a socio-cultural research activity in order to explore the assessment for learning activity within IBSE were limited, since the researcher's cultural sensibility was shaped by the individualistic possibilities of understanding and forms of innovation.

Roth and Radford (2011) state that "the subjects of activity are not the Piagetian/constructivist individuals that make discoveries and construct knowledge on their own" rather, "subjects are subjects of collective activity" (p. 10). This study was structured to understand the researcher's subjective change when moving from being engaged in educational activities within an individualistic cultural sensibility towards being engaged in a research activity within a socio-cultural cultural sensibility. In Chapter four, it was argued that scholars researching within a socio-cultural cultural sensibility experience education research in a different way from scholars having an individualistic cultural sensibility. The analytical strategy was conceived to understand the socio-cultural research perspective in education, and to use such cultural knowledge to conceive assessment for learning within an IBSE activity research.

Following Roth and Radford's statement, from a cultural-historical perspective, the researcher's subjectivity is immersed in collective forms of understanding and doing research. In this study, collective forms of doing research, and constructing the object of research, supported the use of the researcher's subjectivity and experiences.

Furthermore, Roth and Radford (2011) describe the relation between the self and the social praxis. The subject's process of learning and becoming participative is organized within cultural-historical relations with others: "In the course of participation in cultural-historically formed relations with others" (p. 10) —the participation of the researcher as teacher educator in the IBSE Network, and in research activity with a socio-cultural perspective— "individuals become cultural-historical beings through unending processes of subjectification" (Radford, 2008, p. 10) —the researcher becomes a person with possibilities of researching with individualistic or socio-cultural cultural sensibilities in an unending process of subjectification— "that is to say, processes of becoming through cognitive, emotional, ethical, political reflexive and critical differentiations, and identifications. Of paramount importance in the making of the subject —in the formation of this unique in-flux subject that is continuously becoming— are those cultural-historical significations it engages in and in which it finds itself immersed." (p. 10)

During this study, the researcher became a socio-cultural researcher when being in contact with new forms of knowing possible in this historical moment. The research process can be considered as an example of how an individual participating in culturally-historically formed relations —the researcher and the socio-cultural scholars' research activity— become a new person, full of new forms of understanding and possibilities to innovate. The research process involved the researcher in a cognitive process producing all kinds of ideas and reasoning, an emotional engagement because of the researcher's desire to change and understand others' cultures, an ethical involvement by taking care of others' ideas and respecting their approaches, a political by being critical in a process of identification and differentiation. The research process can be described as the making of the subject —the researcher— this unique in-flux subject that is continuously becoming, immersed in those cultural-historical significations lived in the two different research activities —researching assessment for learning within an inquiry-based classroom with an individualistic or with a socio-cultural cultural sensibility.

This study presupposes that individual thinking exists because the cultural materialized world gives the individual the tools to think and "the individual and its society —which is the seat of the social and the cultural— mutually presuppose one another" (Roth, 2006a, p. 3). The historical researcher's experiences were considered essential to the production of knowledge. However, these experiences were not used to better explore the researcher's mind and

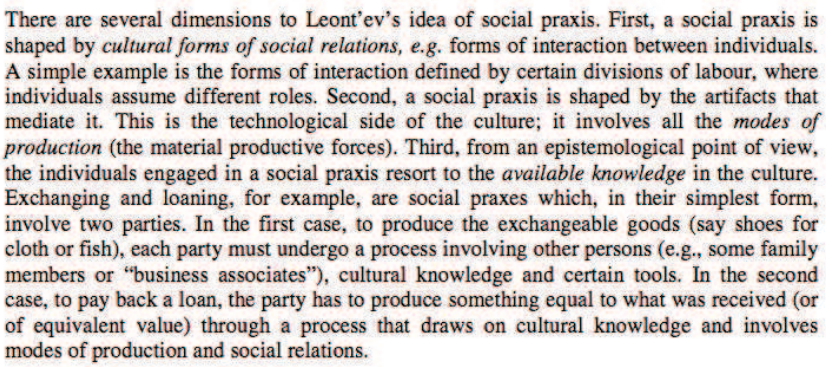
thinking. On the contrary, such experience was used to explore cultural objects —assessment for learning and IBSE conceptualizations, representations and signs— to find the collective roots of the researcher's own ideas and thinking. At the same time they were used to identify the learning process of the researcher and the identification of learning mechanisms to change the set of assumptions shaping a cultural sensibility.

Radford and Empey (2007) used the term cultural sensibility to conduct an analysis of how new mathematics emerge in history, changing the current possibilities of an individual's thinking. In this study, the term became a concept that allowed the researcher to capture the diversity of possibilities of thought in the research activity when experiencing research with one or another set of assumptions. It is argued that research objects and strategies are different when adopting assumptions from an individualistic sensibility or a socio-cultural cultural sensibility.

THE SELF AND THE PRODUCTION OF KNOWLEDGE

Since this research was produced by an individual participating in a social activity, it is important to see how the knowledge, and the process of learning during the research is produced and communicated, and how it finally ends being a culturally accepted knowledge. It is the intention to situate the knowledge produced in this study within forms of producing and communicating knowledge within the community of education researchers.

When reading several research papers, it can be noticed that the research subjectivity disappears, and some kind of cultural knowledge emerges from that fact. An example of that is in the next picture taken from Radford and Empey (2007), page number 234. In the text, the authors build knowledge by taking ideas of other scholars and transforming those cultural resources to understand and communicate the phenomenon they are looking at. For this study those ideas became essential to configure the research object. Those cultural resources were also transformed into tools to understand and to produce new knowledge:



There are several dimensions to Leont'ev's idea of social praxis. First, a social praxis is shaped by *cultural forms of social relations, e.g.* forms of interaction between individuals. A simple example is the forms of interaction defined by certain divisions of labour, where individuals assume different roles. Second, a social praxis is shaped by the artifacts that mediate it. This is the technological side of the culture; it involves all the *modes of production* (the material productive forces). Third, from an epistemological point of view, the individuals engaged in a social praxis resort to the *available knowledge* in the culture. Exchanging and loaning, for example, are social praxes which, in their simplest form, involve two parties. In the first case, to produce the exchangeable goods (say shoes for cloth or fish), each party must undergo a process involving other persons (e.g., some family members or "business associates"), cultural knowledge and certain tools. In the second case, to pay back a loan, the party has to produce something equal to what was received (or of equivalent value) through a process that draws on cultural knowledge and involves modes of production and social relations.

Picture of a text from Radford and Empey, (2007), p. 234

The authors introduced some of Leontyev's ideas, and exemplified them with practices of exchanging and lending. This presentation of Leontyev's thinking is used later by the authors to build a model that sees subjectivity as shaped by all those dimensions identified by Leontyev. They added to these dimensions the "*semiotic system of cultural significations* (Radford, 2006) —which is responsible for the views and beliefs that a culture holds about the good, the right, the beautiful, etc" (p. 234). Leontyev's, Radford's and Empey's ideas were fundamental to shape the methodology in this thesis. The researcher's subjectivity was considered to produce knowledge in relation to the existing cultural knowledge, cultural Forms of Social Relations, modes of production and semiotic system of cultural significations.

LINKING THE KNOWER AND THE KNOWLEDGE

Within the socio-cultural and critical research perspectives, the link between the knower and the knowledge is used. For instance, a paper materializing the research activity gives access to the researcher's subjectivity and experiences. The subjectivity and the everyday research activity became present as I am doing now, in this moment that I am writing this text: I took the book of Roth's book 'First person methods' (2012), and opened it on page 124 to take a picture with my I-pad scan, and send it to my computer to insert the picture in this text, and to illustrate what I am talking about. I disappear again in this text and the instance of the everyday researchers' activity will not be available for the reader.

The text in the next picture shows how the subject is involved in the research process, and how the descriptions of the researcher's experience are at the center of what is written and researched. As mentioned in Chapter three, from a cultural-historical research perspective, it is relevant to understand how individuals involved in any social activity live instances in daily life. Roth and

Radford (2011) mentioned how relevant it was in the line of Leontyev's cultural-historical activity theory to capture the permanent change of the everyday moment.

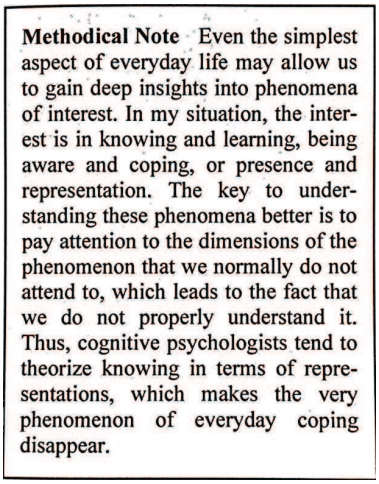
Being Absorbed

There are many instances in my daily life when I am completely absorbed in something. I am so completely involved that the personal pronoun 'I' and its pronominal forms 'my', 'mine', and 'me' no longer exist in the experience. In fact, I am not just absorbed on occasion but take it as an attitude: I deliberately allow myself to be absorbed. It is an attitude to life characteristic of Zen, which aims at presence rather than the making present of the presence. I do so across many, very different aspects of my daily life:

- 'I' am riding the bicycle for quite some time already and all of a sudden realize that a period of time has gone without 'my' 'noticing' 'the environs' or 'the time' 'passing' – 'I' can provoke the falling away of presence by focusing, for example, on the repetitive movement of my legs and feet pushing on the pedals;
- I have gone into the garden to weed. I pull a weed, pull a weed, pull a weed . . . and all of a sudden I realize that two hours have passed without 'my' 'noticing' the situation, *that* 'I' 'have been pulling' 'weeds', *where* 'I' 'have been pulling' 'the weeds', not even of an 'I' that has been the subject of the weeding;
- I am on a hiking trip. For the first couple of days, there are many thoughts racing through my mind. Later, I catch myself every now and then realizing that a long period of time has passed without 'my' 'noticing' 'anything' and that 'I' am unable to recall anything of the walk. If there has been anything at all, then it was a dim sense of 'walking';
- I sit at my desk, writing . . . until I suddenly

Picture of a text from Roth (2012), p. 124

From a cultural-historical perspective, capturing the flux of life is essential to understand social praxis. In this study, I did not pretended to use my experience in such way. However, each sensibility space was framed as those activities that the researcher did to understand and construct the phenomena. The use of Roth's instance experience in the methodology was supported by Roth's thinking with a Methodological Note in a box in page 125. Adopting another voice in the text, the subject's daily experience disappears and some meaning is given to what was made by doing such research methodology. However, the researcher's subjectivity continues to be present. There is a goal guiding the use of the researcher's experience.



Methodical Note Even the simplest aspect of everyday life may allow us to gain deep insights into phenomena of interest. In my situation, the interest is in knowing and learning, being aware and coping, or presence and representation. The key to understanding these phenomena better is to pay attention to the dimensions of the phenomenon that we normally do not attend to, which leads to the fact that we do not properly understand it. Thus, cognitive psychologists tend to theorize knowing in terms of representations, which makes the very phenomenon of everyday coping disappear.

Picture of a text from Roth (2012), p. 125

In the lines above, I presented Roth's texts with two purposes: one is to make the point that the experiences of the researcher are also used in the production of cultural knowledge; and the second is that the tendency in the academic form of communication research is to disappear everyday acting that makes possible the production of knowledge. The texts bring an idea of why Roth was communicating these personal experiences and using them to research phenomena. He connects his methodological perspective of looking his everyday life, in the instance that is happening, with his concern for their relevance for understanding social phenomena. Roth (2012) highlights the difference between what individualistic perspectives on researching learning do not consider. Indeed, they are missing the phenomenon that constitutes any social activity: the individual living and learning in everyday circumstances. It seems then that it is important, when a different way of constituting knowledge is presented, to be explicit to the reader about how the methodology adopted allowed the researcher to capture the phenomena under study.

In this study, the researcher's experience within social activities shaped by individualistic and socio-cultural cultural sensibilities was used to structure the analytical strategy. Some categories of the researcher's learning process were identified. Those categories describe the process of change from an individual perspective to a new educational culture. The categories emerged considering the researcher as participating in the research activity, in relation with other researchers following the socio-cultural perspective, and living an unending process of subjectification.

OBJECTIFICATION OF THE RESEARCHER'S PROCESS OF SUBJECTIFICATION

What is common in the exposed texts —Descartes's texts, Radford and Empey's text, and Roth's texts— is that subjects participating in the activity of researching communicate and objectify the researchers' learning and knowing processes. The research texts materialize learning and the strategies adopted by the individual during the activity as well as the objects and artifacts emerging from the process. Those materialized research objects are created within the social activity through the subject's contact with other people and artifacts (Leontyev, 2009; Radford & Empey, 2007). In their participation, they acquire historically produced and transformed cultural knowledge. By producing the text, the subject objectifies what was learned.

Finally, the knowledge produced and communicated becomes part of the cultural knowledge if other members of the community accept, appropriate and use it. A paper is accepted in a journal if the readers decide that it is relevant knowledge and the researcher's learning methodology follows the rules of the community. The researchers participating in researching activity use knowledge, objectified in papers, books, and dissertations. Such knowledge became part of the researchers' activity with more or less impact in every day researching activity. For instance, the knowledge produced by Vygotsky and Piaget has had enormous impact on the educational research activity, as was shown in Chapter four.

By looking at the analytical strategy presented in the five sensibility spaces, some actions with their respective goals can be identified (Leontyev, 2009), guiding the learning and preparing the self for understanding the assessment for learning activity in an inquiry-based classroom. Using the frame of cultural knowledge of Radford and Empey (2007) and Radford's theory of objectification-subjectification, three categories that objectify the process of the researcher's learning were identified: Naturalizing, De-naturalizing, and Producing. By objectifying the learning process it is intended to contribute to understanding educational change as a movement in cultural sensibility. In this case the movement was from an individual perspective, when the individual is immersed in one educational culture, and he/she is expected to learn from another educational culture, or a foreign culture —as was named, in Chapter two, 'assessment for learning within inquiry-based teaching'. In this case, the socio-cultural theoretical perspective was considered as 'foreign' to the researcher, and the individualistic perspective was the researcher's educational culture.

The researcher's actions —the analytical strategy of each sensibility space— were created with goals moving the researchers' subjectivity from the individualistic towards a socio-cultural cultural sensibility. This choice confronted the researcher's subjectivity to support her work with new cultural tools, signs and reasoning. Indeed, the methodology, the organization of the research process, and the results are not giving account of an objective world, as could be expected from the researcher's initial educational culture. Rather, it gave account of "this unique in-flux subject that is continuously becoming" within the research cultures (Roth & Radford, 2011, p. 10) as it is expected in the socio-cultural perspective.

The analytical strategy was deployed and communicated in Chapters four, five, six, seven, and eight. Those five sensibility spaces are the materialization of actions, in terms of Leontyev, with goals supporting transformational processes of the researcher's self. They objectify the daily inquiry in the researcher's journey. They reflect the involvement of the researcher's subjectivity, tending to disappear in research texts. The first two spaces allowed to identify and to make visible the researcher's own cultural sensibility, identified with an individualistic collective form of researching and based on the conceptualizations of individual cognition. The researcher subject differentiates her cultural sensibility from another cultural sensibility by being aware of the socio-cultural research thinking, as a different way to perceive the learning, knowledge and thinking. Thus, the researcher could identify the 'natural' thinking and reasoning of herself to belong to an individualistic cultural knowledge.

However, those processes did not allow the researcher to inquiry with a socio-cultural perspective. It was necessary to question her 'natural thinking' and to change her understanding towards new forms of understanding within socio-cultural cultural sensibility. The third sensibility space was identified as a process of 'de-naturalization'. The researcher's own ideas were questioned by making sense of socio-cultural assumptions. However, following the idea that it is only by living everyday instances that an individual can capture his/her own sensibility and possibilities to offer new cultural ways of being and thinking, the researcher visited a classroom and worked with a teacher. The fourth sensibility space make visible moments of noticing the everyday life in a classroom that did not coincide with her research based ideal. The process represents a conflict between those modes of cultural reasoning found in the individualistic cultural sensibility and the new socio-cultural tools when imagining a different assessment activity.

Finally, the process of producing a model of assessment for learning within IBSE by creating a hypothetical teaching assessment and learning scenario, showed the limitations of such change, the difficulties of capturing all the dimensions that becoming a socio-cultural researcher implies. How could any subject with an individualistic perspective on cognition do research

assessment for learning within IBSE with a socio-cultural perspective? Furthermore, if assessment for learning and IBSE are two pedagogical tools thought within an individualist perspective, how is it possible to research it with a socio-cultural perspective?

NATURALIZING

As a practitioner of assessment for learning within IBSE interacting with others in a complex social activity, the researcher developed the same 'cultural sensibility' as the researchers and practitioners of the IBSE Network. Everyday activities during several years in the Colombian IBSE project, and in the Latin American network activities, shaped individual possibilities of thought for the researcher. Then, it was not possible for a researcher embedded in the network to research assessment for learning within IBSE with a socio-cultural perspective. This can be supported following Radford and Empey's (2007) view of the social praxes. Indeed, for them, cognition and conception of the self only arise and develop through the interaction of four components: Cultural Knowledge, Forms of Production, Forms of Social Relations, and a Semiotic System of Cultural Significations. Those elements shape the initial cultural sensibility of the researcher. As expressed in the description of the problem in Chapter two, the process of objectification-subjectification aimed at changing such cultural sensibility within the researcher's subjectivity.

The researcher's *natural possibilities of thought* within the individualistic cultural sensibility were established by *identification*. Natural possibilities of thought are understood as the researcher's possibilities of thinking and acting with a group of assumptions. The word 'natural' captures the fact that the researcher was not aware of those assumptions. Researcher's natural possibilities of thought mean that the researcher was part of a social praxis in which thinking and producing with the group of assumptions become the common sense of the individuals immerse in IBSE and assessment for learning social activities. The natural thinking of the researcher is viewed as the ensemble of meanings given by the researcher to signs, words, ideas, and artifacts circulating in the IBSE Network, which are shaped by the individualistic assumptions. The *identification* mechanism of the researcher's learning process is defined here as the researcher's activity allowing her to notice groups of assumptions behind educational discourses, and in particular in assessment for learning and IBSE. This means that the researcher identified the cultural roots of her possibilities of thinking and acting within her educational practice.

Furthermore, the researcher identified the group of assumptions supporting the individualistic cultural sensibility by a mechanism of *differentiation*. This mechanism is the learning process by which the researcher identified the group of assumptions in contrast with another group of

assumptions behind socio-cultural educational discourses. The researcher noticed the socio-cultural group of assumptions that were often presented by researchers by differentiating it from the individualistic group. This noticing of other's assumptions is what is defined as the mechanism of *identification by differentiation*. This is what is materialized in the sensibility space one.

However, noticing both groups of assumptions and differentiating them was not enough to find the collective forms of understanding of practitioners within the IBSE Network, neither the researcher's individual forms of understanding. *Naturalizing* is the learning mechanism by which the researcher established the link between the assumptions behind the IBSE Network researchers' conceptualizations and those found in educational discourses. Naturalizing is a process by which the artifacts used in the IBSE Network were analyzed. The researcher's knowledge acquired during her experiences in the network, and her natural forms of thinking were used to identify the ideas shaping the IBSE Network social activity, and to link them with the individualistic group of assumptions. In that sense, naturalizing involved several mechanisms of the researcher's learning process: identifying assumptions, differentiating assumptions and linking assumptions with ideas found in assessment for learning and IBSE researchers' artifacts.

In Chapter four, the researcher was looking to delimitate the set of assumptions guiding IBSE and assessment for learning educational discourses. The decision was to look at those assumptions that have impact on the way the assessment activity could be conceptualized. In the process of identification, a set of assumptions shaping what in the literature is called the individualistic perspective was found. This perspective was linked with Piaget's work in cognitive psychology. It was also identified as guiding IBSE as well as assessment for learning within IBSE educational discourses. This perspective was called cultural sensibility, since it was found to be a line of thinking guiding different scholars' texts.

It was also found that scholars thinking with socio-cultural assumptions differentiate themselves from the individualistic forms of understanding and creating knowledge about learning. It was identified as another cultural sensibility, since it gave another possibility of researching in education. This line of thinking was associated with a particular interpretation of Vygotsky's work. The researcher starts by understanding that the individualistic perspective was different from the socio-cultural perspective, and that they give different possibilities of researching assessment for learning within IBSE.

It is argued that the researchers' subjective change was only possible by identifying the differences in those ways of constituting different scholars' thought about learning, knowledge and thinking. Understanding the differences was possible by reading the scholars' texts on socio-cultural cultural sensibility. As explained, they usually use the contrast between the individualistic and

socio-cultural assumptions to shed light on the different theoretical interpretations about learning. It was also important to see the same kind of ideas that shape the praxis of IBSE researchers. In Chapter ten, a description of each line of reasoning constituting those different cultural sensibilities in the field of assessment for learning will be presented.

As documented in Chapter five, the network is a social activity where texts materialize and guide such social activity. The texts analyzed in Chapter five represent Cultural Knowledge in the sense of Radford and Empey's (2007) model, shared by the individuals involved in such social activity. As presented in Chapter five, the Cultural Knowledge, produced by researchers and used by people during network activities, is constituted by a set of principles guiding the process of teaching and learning by inquiry. In such social praxis, knowledge is characterized by defined observable characteristics of classroom activities: the child asking questions about natural phenomena, the child experiencing a processes of inquiry to find answers, a child interacting with others supporting and listening their ideas and constructing explanations of phenomena supported by evidence. Assessment researchers produced knowledge merging IBSE principles and assessment for learning theoretical perspectives. The assessment research knowledge is characterized by a set of actions with the goal of identifying inquiry skills and individual content knowledge, to interpret information of student activity as evidence of learning and conceptual change in a child's mind, to produce feedback as a resource to produce the conceptual change in the individual's mind. The object/motive of such social activity was conceived as supporting and enhancing each child's learning. The actions of the activity have the goal of making visible the individual's learning goals, establishing how far the child's achievement is in relation to the goals, and providing feedback to close the gap in the mental models, and support conceptual change.

In Chapter five, artifacts, signs and objects used in the social activity of the IBSE Network were identified as Forms of Production, in the sense of Radford and Empey's perspective, characterizing the activity within the IBSE Network. The researcher highlighted recurrent terms such as conceptual change, misconceptions, child's own ideas, child's own questions, inquiry, investigation, phenomena, experimentation, and experience as part of the IBSE dominant discourse. On the other hand, some terms frequently used in assessment for learning research were identified, such as skills, concepts, inquiry skills, evidence of learning, interpretation, prompts, criteria, judgments, and learning goals. The researcher's meanings were shared in Chapter five. For instance, there are several artifacts such as criteria to identify learning with goals and to interpret the learners' answers. Another is the formative cycle (Harlen, 2006a) where all the assessment actions are represented. In different research texts theoretical representations of knowledge to be developed by learners were found

—e.g. conceptual knowledge, procedural knowledge, and strategic knowledge— (Ruiz-Primo, 2007). Those artifacts shape how assessment should be constructed in an IBSE environment.

As documented in Chapter five, in the texts of the network there are also prescriptions about the relations of the learners and the teacher or Forms of Social Relations, in terms of Radford and Empey's views. Teacher educators learn some principles and ways to act as a teacher educator. This shapes what the individuals of the network construct as possibilities of interaction during the activities in the network. For instance, the child is a learner inquiring by him or herself, and by being engaged with others in a process of discussion about natural and made phenomena. It is also determined that the child can participate in a process of peer and self-assessment by judging productions and constructing and interpreting criteria with others. The teacher is conceived as a leader encouraging such individual process by giving activities within which it is possible to be engaged as expected. The teacher establishes goals of learning, sets up activities to collect evidence of learning, interprets information, produces judgments, and changes teaching in function of the collected evidence. The teacher is in control of the assessment process.

Chapter five showed conceptions of truth, methods of teaching, ways of representing knowledge in classrooms, as well research products and elements that could be part of the Semiotic System of Cultural Significations in terms of Radford and Empey's model. A fundamental truth is that the learner arrives to the school full of ideas and theories about natural phenomena. The child's ideas are at the center of the assessment activities. The goal of actions in such praxis is to change possibilities of reasoning of the child through making visible their own theories and ideas. Teaching and learning activities are conceived to close the gap between scientific cultural reasoning and the kids' reasoning. Assessment research products are built around this idea, the production of indicators and activities looking for misconceptions, and the child's theories are essential in this kind of research.

The researcher's natural way of understanding learning and knowing was shaped by those different dimensions. In order to be able to identify this, it was necessary to differentiate this form of understanding from other cultural possibilities. First, by noticing this kind of reasoning and a group of assumptions in cognitive and psychological research, as well as in science education. Secondly, by finding another cultural reasoning, which is based on a different group of assumptions.

DE-NATURALIZING

This study found that subjects researching with an individualistic or socio-cultural cultural sensibility support their research activity on a different group of

assumptions (the results will be presented in the next chapter). Researchers from one or another cultural sensibility constitute research objects differently. This observation was supported by the conceptualization of the self in terms of social praxis (Radford and Empey 2007). It was claimed that the assumptions have impact on the researcher's views about conceptual objects, conceptions about truth, and methods of inquiry and legitimate ways of knowledge representations, or Semiotic System of Cultural Significations (Radford & Empey, 2007). Assumptions guide the researchers' conceptualizations of the assessment activity in classrooms. In that sense, the research established how the assumptions were instrumental in the constitution of different forms of understanding and knowing within the research activity.

Radford and Empey's (2007) conceptualization of social praxis and the relationship between culture, knowledge and the self helps to understand the problem faced by the researcher in the process of subjective change. Following their ideas, the researcher's participation in the social praxis of the IBSE Network involved much more than a simple space to interact and negotiate with other individuals' wills and interests. The researcher's subjectivity was conditioned by culturally defined Forms of Social Relations, and ideas of the self and the other; cultural technological Forms of Production through which actions and intentions become materialized; and a Supra-symbolic System of Beliefs shaping cultural understanding of what counts as legitimate.

This complex relationship enunciated by Radford and Empey could explain why the researcher changes by identification, differentiation and naturalization were not sufficient to become a socio-cultural researcher. When the researcher was participating in the research activity with a socio-cultural perspective, several tensions emerged. Indeed, the researcher's cultural sensibility was individualistic and the researcher used socio-cultural theories from outside of the research activity of socio-cultural researchers. In other words, the researcher did not have the socio-cultural cultural sensibility in her soul. In order to use the group of socio-cultural assumptions, and be able to re-conceptualize assessment for learning within IBSE, it was necessary to transform the researcher's views, ideas and truths shaped by the individualistic cultural sensibility. The researcher noticed that her ideas were not compatible with the socio-cultural assumptions; however, noticing it was not enough to develop a new perspective for the assessment activity within an IBSE framework.

De-naturalizing is the mechanism of the researcher's learning constituted by *naturalizing*, *questioning* and *disturbing*. Naturalizing allowed the researcher to objectify her own ideas; questioning was the mechanism by which the researcher linked these ideas with socio-cultural assumptions; and disturbing was the process of facing the flux of the individual's everyday activity and re-construct the events in the light of socio-cultural assumptions. By de-

naturalizing, the researcher noticed those cultural and societal dimensions that were hidden in the theoretical conceptualizations of the individualistic perspective.

Naturalizing was the learning mechanism by which the researcher objectified her ideas, linked them to texts used in the IBSE Network, and connected them with assumptions from the individualistic cultural sensibility. Two lines of reasoning were identified as strongly resistant to change: one linked to forms of knowing the natural and made worlds, and the other to the relation between learning activities and the context in which activities are experienced.

Some ideas were retained by the researcher from the analytical process described in Chapter five, and they were re-formulated in Chapter six as follows: 'the child is a little scientist full of theories and he or she is able to experiment and to prove his or her hypotheses', 'the child experiences are source for producing scientific theories and reasoning', and 'the child is able to plan and conceive experimentation and to observe phenomena in his/her daily life'. These ideas were considered as the researcher's 'own ideas', and the cultural roots were documented by looking at researcher's texts circulating in the IBSE Network. The term 'own ideas' refers to ideas that seem to be generated by the researcher, in his/her head, when adopting an individualistic cultural sensibility. However, when adopting a socio-cultural perspective, the ideas can be seen as linked to cultural forms of reasoning and knowing within the social praxis, as it was shown in Chapters five and six.

These 'own ideas' are part of objects conceived within the research activity with an individualistic perspective. As shown, learning activities in IBSE are planned to provide the child with new experiences as a little scientist. At the same time, the assessment for learning activity supports the child's observation of phenomena, construction of theories and explanations, and construction of evidences. These ideas where considered by the researcher as a truth. The analytical strategy in Chapter six aimed at changing these 'own ideas'. By being critical, the researcher questioned her ideas by exploring other cultural forms of knowing.

Another set of researcher's ideas based on her individualistic cultural sensibility were identified. These ideas were about her view of the socio-cultural context and educational culture. The context was a static recipient in which the assessment activity was experienced. The context was configured by identifiable factors that affected the learning processes. For instance, factors such as the socio-economical conditions of students and teachers, the material resources of the school, and the knowledge of teachers. The context was static because those factors were considered the same for a particular school. The researcher's exploration of socio-cultural assumptions generates questioning and tension

when looking at the relation of the self, the culture, the knowledge and the social praxis.

The second mechanism of learning was called *questioning* and it includes all those actions that the researcher did to change her view of the relation of the human being, the observation of the natural and made worlds, the experience, the language, phenomena and experiments. The aim was to establish different points of view about the relation of the child and his or her knowledge about the natural and made worlds. In Chapter six, some tensions were enunciated.

The analysis of the concepts of phenomena, reality, experimentation, experience, and views about human perception, reveals that theories, signs, and representations mediated the child's observation. In other words, the child experiences the natural and made worlds with cultural forms of understanding and knowing. The little scientist must learn to observe the nature with the artifacts generated by scientific cultural praxis in terms of the theory of social praxis (Radford & Empey, 2007). Following this idea, the object phenomenon is created with artifacts, signs and modes of production from the scientific culture, and experimentation is a scientific cultural form of understanding and knowing the world. A tension emerged in the researcher's point of view since the basic assumption that children, regardless of their culture, have ideas and theories about the world, and experienced reality as a little scientist, were questioned by adopting the other point of view. In terms of Radford and Empey's model of social praxis, the views of the researcher changed in the light of exchange of assumptions by participating in the socio-cultural research activity. This shows the researcher's intention to appropriate the other cultural sensibility, by questioning the fundamental assumptions of the individualistic perspective.

The third mechanism of learning was called *disturbing* and included the actions that the research did to move her ideas about the context and the relationship with the assessment activity. One action intended to disturb the researcher's understanding of the context by the re-construction of events related to the organization of the empirical work, and the researcher's understanding of the link between the assessment activity and the social and cultural dimensions. The second one was the analysis of the landing of the researcher in the flux of every day assessment activity, in a concrete school and classroom.

The theoretical representations of assessment for learning and IBSE, as well as the objects emerging from the research activity within the individualistic perspective, focused on the cognitive interaction between individualities in the classroom. The actions of the assessment activity aimed at recognizing and guiding the conceptual change of the learner. The assessment activity is conceptualized with a view of children's interaction as an exchange between cognitive individualities. The researcher was in this line of thinking. The socio-cultural perspective introduces a new element to be considered on the conceptualization: the individual living and experiencing education in the flux of

everyday school activity. The individual is viewed as part of a large-scale societal organization that is concretized in the social activities in which the individual is engaged. Assessment activity is considered as having object/motive, which is linked with institutional purposes. The researcher's re-construction of events in Chapter seven shows her change from one perspective to another. The analysis of the experience was the situation within which the researcher started to understand some of the theoretical tools used by socio-cultural researchers in their activity.

PRODUCING

Paraphrasing Radford's (2002) words, in this study, through a learning process, the researcher's subjective change was conceived not merely to acquire something or possessing it or mastering it. The mechanisms of learning reflect the intention of the researcher to go to culture to find "something" in it. The researcher went to the socio-cultural research field to find assumptions, ideas and forms of understanding. In that way, she found "something": a new theoretical conceptualization of the assessment for learning activity in inquiry-based teaching and learning sequences. Following Radford's (2002) words, "the act of learning was not the construction, re-construction, re-production, re-invention or mastering of concepts: its true outcome is to be found in the fact that, in this encounter with the other and cultural objects, the seeking individual *finds herself*." The naturalization and de-naturalization learning mechanism represents this encounter with the other and cultural objects; however, the researcher needed to find herself by creating, finding and noticing another assessment activity conceptualization for assessment for learning within IBSE. As Radford explains, finding this something is the process of objectification. The research activity aimed at objectifying the researcher's possibilities of conceiving the assessment activity within the socio-cultural research perspective.

Radford's (2008) presents learning as much more than objectifying something. Objectification is more than the connection of the researcher and the conceptualization of assessment for learning in inquiry-based classrooms. In the course of learning, the researcher had objectified cultural knowledge from the socio-cultural research field and, in doing so, had found itself objectified in a reflective move termed by Radford as *subjectification*. Thus, the making of the subject, the researcher with a socio-cultural perspective, the creation of a particular and unique subjectivity is what Radford calls a process of subjectification. This process was possible by the actions and analytical strategy of the researcher on whom objectification became possible.

The sensibility space five and the actions presented there had the goal of contrasting configurations of the assessment activity by using the different assumptions found in the individualistic and socio-cultural research activity. The

critical research perspective of the researcher was used to support the hypothetical classroom simulation. The researcher engaged herself with the possibilities of her individualistic and socio-cultural cultural sensibilities. The learning process did not change the individualistic sensibility of the researcher for a new one, the socio-cultural. The researcher became someone immerse in two different sensibilities that coexist, and continually exchange their possibilities of looking at the object.

Producing is the learning mechanism by which the researcher explored the implications of the assumptions in the configuration of assessment classroom activities. For the individualistic perspective, the dimensions of the individualistic social praxis were activated and contextualized in an example of classroom activity. In the case of the socio-cultural perspective, the contrast of the assumptions was used to change classroom activities and interpretations of learning for assessment purposes.

The focus of assessment activity was learning, knowledge and thinking in a classroom situation. In the individualistic perspective, the object/motive of the assessment activity was to support the conceptual change in the child's head. For the socio-cultural perspective, the object/motive was transformed in the encounter of children with cultural objects and the other to seek them and use them in a process of objectification and subjectification. From a simulation of assessment activity looking at the child as a little scientist, the researcher moved towards a simulation of assessment activity considering the child as seeking cultural scientific reasoning and cultural objects. Forms of relations between individuals participating in the assessment activity were also analyzed differently for the simulation.

SITUATING THE RESEARCH OBJECTS

I expounded some reflections and objects produced during my activity as a socio-cultural and critical researcher. In this section, I develop ideas that express the contributions of this dimension of my thesis to the field of research on education. The first reflection is about the analytical strategy and the use of the researcher's self in the research methodology. I argue that the methodology brings light to the link of the self, the objectification of research, and the research activity. The second reflection focuses on the overlap of different cultural sensibilities in conceptualizations about the assessment activity. The tendencies in educational research to follow one or another line of thinking and assumptions generate tensions, when the object studied has been approached by using languages from the dominant cultural sensibility.

REFLECTIONS ABOUT THE METHODOLOGY

As explained before, the methodology was constructed to change the researcher's subjectivity. Here, I explore the contribution of my research to the understanding of the link between the researcher's subjectivity, knowledge and social praxis. The relation of the knower and the known has different interpretations within research traditions. It can be different depending on the theoretical perspective the researcher is positioned in (Daston & Galison, 2010; Krieger, 1991; Roth, 2012, 2005b). For instance, Daston and Galison (2010) link knowledge, research and objectivity:

> To be objective is to aspire to knowledge that bears no trace of the knower –knowledge unmarked by prejudice or skill, fantasy or judgment, wishing or striving. Objectivity is blind sight, seeing without inference, interpretation, or intelligence. (Daston & Galison, 2010, p. 17)

In natural science, the researcher is trained to silence his or her subjectivity. When knowledge is detached from the researcher's subjectivity, then it is objective. As Daston and Galison (2010) documented, the subjectivity of the researcher in natural science was historically trained to disappear in some research practices. The dimensions that make subjectivity part of that knowledge such as prejudices, fantasy, etc. is let outside. The researcher's job is to produce knowledge that can be established as objective, because the individual process of learning is not delivered for the audience.

This view is in tension when considering different theories of human construction of reality. For instance, some researchers conducting studies about organizations, reality is seen as "that which works for us […] is to live and to make things happen, so if anything is real in this sense, it is because we can do things with it, we can make things happen, we can change things" and realities are conceived as "subjective in the sense that they are our private constructs" (Henriksen, et al., 2004, p. 17). In this sense, objectivity could be questioned and reinterpreted in the light of this theoretical perspective. Knowledge could be understood as being objectified by the researcher's private constructions. Apparently it is not possible to detach the knowledge from the researcher.

Furthermore, if the theoretical perspective of psychoanalysis about reality is considered, the construction of knowledge could be explored under this perspective. For Rojas-Urrego (2009a) and Rousillon (2002), psychic reality is defined as different from biological and material or external reality and as unique for each subject. This psychic reality designs things, which in their psychic character have the value of reality for the subject (Rojas-Urrego, 2009; Roussillon, 2002). What is the relationship of things that make part of the researcher psychic reality and the knowledge that is objectified during the

research process? How could such knowledge be detached from this unique psychic reality?

Paraphrasing Rojas-Urrego, the researcher gives sense and meaning to life and the world through this unique psychic reality. It determines to a great extent the way the researcher experiences the research activity, relationships, and own history. It also influences the shape the researcher gives to psychic contents, representations about him or herself and of the world. The researcher's psychic reality provides the individual a specific and unique sense of the things that happen and have happened to him or her; of what appears in front of the researcher and how he or she represents it; of the very personal way in which this researcher grasps external reality and transforms it, often distorting it, and sometimes even replacing it.

A tension emerges when looking at other researchers' constructs about reality. The psychic reality of the researcher is considered a noise for the knowledge configuration. In social science, Krieger (1991) explained the unpopularity of the expression of an individual perspective in two different senses:

> The expression of an individual perspective in social science is a difficult accomplishment in part because individuality is theoretically unpopular. The social science tends not only to view the self of a researcher as a contaminant, but they also view the selves of people studied as invisible (Krieger, 1991, p. 43)

The researcher is viewed as a contaminant and the individuality of people studied also tends to disappear. This fact has been also argued against and there are different research perspectives that acknowledge the researchers and participants' subjectivities as essential to understand social phenomena. Roth (2012) challenged himself to inquire about learning theories by being reflexive, describing the researcher's learning in the same way as the researcher intends to describe people's learning. The above text of Roth is an example of what he did.

In my research, the researcher's subjectivity is viewed as shaped by the social praxis of socio-cultural researchers. The research methodology was an attempt to train my subjectivity within the socio-cultural cultural sensibility. Daston and Galison (2010) used the word "training" to link practice and the self. They assume that the scientific self is forged and constituted by the practice:

> Training the senses in scientific observations, keeping lab notebooks, drawing specimens, habitually monitoring one's own beliefs and hypothesis, quieting the will, and channeling the attention. Like Foucault, we assume that this practice does not merely express the self; it forges and constitutes it. (Daston & Galison, 2010, p. 199)

My individual experience as academic at the university, participating in research and developmental projects, forged and constituted my self as a researcher. The methodology was built to be part of another social praxis, by participating. This assumption supported the choices and analytical strategy of my thesis. The contribution of my work can be positioned by considering that the researcher has a unique psychic reality that is at the same time shaped by his or her participation in a social praxis. The process of unending researcher's objectification-subjectification (Radford, 2002) and the categories of the learning mechanism objectify the experience of this unique psychic reality, forged and constituted by her participation in social praxis that were not compatible with her trained self.

My research accepts that understanding social phenomena and social change involves understanding the individuals' perspectives. Furthermore, by adopting a theoretical perspective of reality such as the psychoanalytical, I presuppose that understanding social change is to understand changes of the individual's psychic reality. My decision to be a critical researcher brought me problems, first by the contradiction of my psychic reality trained in the positivist paradigm that considers knowledge as an objective world, with the self-constructed by being a socio-cultural researcher. Secondly, because critical researchers in education acknowledge that the critical perspective is not understood and shared by researchers whose psychic reality does not consider such research as possible.

Valero and Zevenbergen (2004b), discussing about the relevance of this kind of research for mathematics education, acknowledge that critical research has questioned assumptions, interests and ways of proceeding within research paradigms such as positivism and hermeneutics. Valero and Zevenbergen are in favor of adopting a critical research perspective because it links the fields of research and practice. They claim that a critical perspective conceives the relationship between the researcher and the participants in research in a different way. They also point out that this becomes problematic because dominant cultural forms of researching are in conflict with this kind of research. On these grounds, my study adds a new element of discussion to this debate. It is the knowledge that emerges by objectifying the researcher's experience of change. The critical perspective viewed as how the researcher trained her or his subjectivity to produce cultural knowledge within a historical and determined praxis.

The methodologies developed to include the researcher's inner life are conceived to avoid the problems emerging by looking at an individual's psychic reality. Methodologies such as autobiography or auto ethnography are looking to control the inner life in such way that it is only used to understand others and social phenomena. Roth (Roth, 2012, 2005b) shows examples of these methodologies in the field of education as a systematic reflection of the inner

experience, and called attention to the possible problems emerging from this kind of research when it is not controlled. He trains his subjectivity to systematically observe his actions in the instance they are happening and registering them. He also links his observations with the social phenomena he is trying to capture.

I followed another approach in my methodological strategy: Rather than making an inspection of my inner life in a systematic way, I decided to inquire about a social praxis in which I was involved by following my inner reflections and ideas in the researchers' and practitioners' texts regulating the IBSE and the assessment activity. I used my trained psychic reality. In terms of Radford's and Empey's conceptualization of the self and the social praxis, I produced knowledge about the assumptions guiding my practice by understanding others, and at the same time, I questioned those collective forms of understanding by participating in a social activity based on a different set of assumptions. With the categories that emerge from the analytical strategy, the subjective change of a researcher from this unique psychic reality while researching can be understood. Since the dominant perspective in research is to hide this from the research process, I hope to contribute to understanding the role of the researcher's psychic reality in the process of objectification in a new way.

SUBJECTIVITY IN ASSESSMENT FOR LEARNING RESEARCH

The researcher's subjectivity immerse in the social praxis of researching from a socio-cultural perspective is not clearly framed within a socio-cultural cultural sensibility. Researchers focus on the teachers' problems when facing assessment for learning. The classroom assessment activity, as the focus of research, is an evolution of the initial socio-constructivist perspective (Shepard, 2000), in which the individualistic and the socio-cultural cultural sensibilities coexist. The studies explore the complexity of teacher assessment practice when ideas of assessment for learning are shared with researchers. The perspectives of researchers on learning are theoretically explained and theories build experiences in the field. Researchers also discuss the diversity of theoretical points of view such as constructivism, socio-constructivism and socio-cultural theories and the implications for assessment. However, I did not find texts discussing the researchers' subjectivity and assumptions about evidence of learning when the researcher adopts a theoretical perspective. Languages referring to the individualistic perspective on learning are usually used within the socio-cultural approaches. The researcher's subjectivity is not available for the reader. Knowledge is delivered as a disembodied package in which the problems of the teacher's practice are observed.

Shepard (2000) challenged assessment research looking through the history of assessment and curricula practices. She described an emerging

paradigm conflicting with the traditional scientific measuring, Hereditary Theory of IQ, Associationist and Behaviorist theories of learning. She described the emerging paradigm as socio-constructivist. She argued that the objective test dominating practices affected more than the subject-matter knowledge. This shaped "beliefs about the nature of evidence and principles of fairness" (p. 5). In a project in which teachers and researchers were working, they found that teachers had different beliefs from the researchers'. In particular, teachers wanted assessment to be objective, "they worried often about the subjectivity involved in making a more holistic evaluation of the students' work and preferred formula-based methods, such as counting miscues, because these techniques were more "impartial"" (p. 5). Shepard (2000) considered how the assessment practice should be conceptualized by borrowing ideas from cognitive, constructivism and socio-cultural theories. In her model, she recognizes Vygostky and Soviet psychologists' work using the idea that "what is taken into the mind is socially and culturally determined" (p. 7). In that sense, she considered that "cognitive abilities are "developed" through socially supported interactions", and that " development and learning are primarily social processes." (p. 7). For her, classroom assessment must change in two fundamentally important ways: form and content must represent important thinking and problem solving skills; teachers and students' views of assessment must change; and teachers need help in fending off the distorting and de-motivating effects of external assessments. She expressed the objects to be taught and assessed as thinking and problem skills. This perspective could be viewed as part of the individualistic cultural sensibility, since the focus of the assessment is on the individual's skills.

Black and William (2006) are researchers that have a long trajectory of researching assessment for learning and formative assessment. As documented in Chapter five, their publications (Black & Wiliam, 1998a, 1998b) had a great impact on the assessment for learning research field within IBSE (Harlen, 2006a; Ruiz-Primo, et al., 2007). Black, Harrison, Lee, Marshall, and William (2003) described some of their research on assessment for learning to review the research evidence, to make a case so that more attention would be paid to helping the practice into the classroom, to draw out implications for practical action, and to discuss policy and practice.

Their book "Assessment for learning, Putting it into practice" (Black, et al., 2003) aimed at highlighting some points of the review and to help the teacher to appropriate the assessment for learning principles. Especially, they conceived a program of development facing the teacher's change, the students' perspectives and, as they said, the central concept of assessment for learning: 'feedback'. The focus of assessment for learning on the individual's process of learning is clearly adopted during the project. For instance, they write that when teachers developed their capacity to listen more attentively to the students'

responses, teachers "appreciated more fully that learning was not a process of passive reception of knowledge, but one in which the learners were active in creating their own understandings" (Black, et al., 2003, p. 59). Black et al. noticed that teachers realized that they needed "better models of how their students thought if they were to make sense of their responses to tasks, activities and questions, and to respond in ways that supported learning" (p. 59); the teacher's role is to provide a framework of appropriate targets and to give support on the task of attaining them; and that teachers "needed to train their students to take responsibility for their own learning and assessment" (p. 59).

In 2006, in the book "Assessment and Learning", edited by John Gardner, Black and William proposed a theory of formative assessment supported by Engeström's (1987) 'activity system'. They suggest four key aspects as minimal elements of a theory of formative assessment. They discussed changes in "the relationship between the teacher's role and the nature of the subject's discipline" (p. 84); "changes in teachers' beliefs about their role in the regulation of the learning process (derived their implicit theories of learning)"; "the student-teacher interaction focusing specifically on the role of feedback, the 'fine-grain of feedback', and a brief discussion of the relevance of Vygotsky's notion of the 'zone of proximal development' (ZDP) to the regulation of learning" (p. 89); and the role of the student. In their description and analysis of these aspects, Black and William highlight a problem emerging when looking at the "teachers' needs to understand the way students think and the way in which they take in new messages both at general (subject-discipline) and specific (individual) levels" (p. 89). The problem enunciated was "this call for a theory relating to the mental processes of students which does not yet exist" (p. 89). They explain "for both the teacher, and any observer or researcher, it follows that they can only draw conclusions from situations observed in the light of theoretical models" (p. 89). Since the individualistic cultural sensibility has been dominant in assessment practices, it is easy to build models that use individual thinking and skills to connect the observed individual behavior with individual thinking. In that sense, the models could resonate with the perspective considering psychological processes, thinking and consciousness as being in the internal space of the individual.

Cowie (2005) adopted a socio-cultural perspective for researching assessment for learning. She explored students' experiences with formative assessment in the New Zealand context. Students experienced assessment as a meaning-making interactional activity shaping "what it meant to be a student and how individuals saw themselves as knowers and learners of science" (p. 209). It appears relevant to understand how assessment practices construct students' ideas of learning. Cowie (2005) found that students experience positively the one-one interactions with the teacher and to have feedback of their work. Some difficulties were expressed when assessment occurs in a public

space. It seems that assessment practice generates in students the idea that learning is something individual and that it contributes to their identity as learners as well as how the others perceive the student:

> The students indicated the public identities available were those of someone who is dumb, stupid, slow, a try-hard, brainy, 'sciency' and someone who is 'not recognized', essentially invisible. Individuals construed their own public identity as continually up for reconsideration and reconstruction on the basis of present actions and interactions but they referred to other students as 'brainy' in a way that suggested this identity was stable.

The dominant view of learning as a quality of an individual is what shapes the individual's experience of learning. The individual's mind possibilities are mentioned as part of the individual's identity as a learner: dumb, stupid, slow, a try-hard… There is not mention of learning as a collective process, as something that is possible because the individuals are engaged in a joint activity.

In their book "Expanding Notions of Assessment for leaning", Cowie, Moreland and Otrel-Cass (2013) work with teachers and students to develop assessment for learning with a socio-cultural perspective. They recognize that an effort is needed to construct an assessment activity in which teachers "need to believe and act in ways that suggest that all, and not only some, of their students want to and can learn", students "need to feel safe to take risks, to explore their ideas and to make mistakes" and "to feel safe to disclose what is to the edges of their understanding to make their ideas public and discussable" (p. 19). This can be viewed from an individualistic point of view that considers thinking as an individual matter, and the collective forms of thinking are not explored.

I would like to situate my work in relation to these scholars' research. The knowledge produced by them is based on their empirical work with teachers and students in their countries. Their reflections are built on the initial conceptualization of assessment for learning emphasizing the support of individual learning, and with a socio-constructivist theoretical perspective. My humble contribution is to point out the dominance of an individualistic perspective on the view of learning as an individual phenomenon. My individual process of learning and the recognition of assumptions guiding different theoretical perspectives help to recognize the difficulties for the researcher's subjectivity to move the idea of learning as logged in one individual space towards learning built in a collective space. The knowledge produced during my research is different since it is focused on the change of the individual's subjectivity when immerse in a dominant culture, and the difficulties to build a new subjectivity differentiated from the dominant cultural sensibility. Roth and Radford (2011) explained that "cultural-historical activity theory, as conceived

in the Vygostky-Leontyev-Holzkamp lineage of work, is incommensurable and irreconcilable with constructivist approaches to mathematical thinking". The difference is in the way the relation of the individual and the collectivity is approached. The knowledge, practices, and thoughts are considered as collective. In that sense, most of the theoretical conceptualizations of assessment for learning within a socio-cultural perspective conceive the relation of the individual and the collectivity more as interactions of individual minds within social or collective interactions. The emphasis is on the individuals and the inter-individual exchange, and not in the socio-cultural constitution of the self and the other as a fundamental socio-historic view of human beings.

I started my study thinking as a teacher educator. How is it possible that teachers had difficulties to adopt assessment for learning and IBSE principles in their praxis? The cultural-historical activity theory, and particularly Radford and Empey's theoretical constructions, allowed me to perceive assessment for learning and IBSE as a social praxis, with particular subjectivities shaped by this praxis. A teacher or a student in a classroom in Colombia, or Chile, or London, or New Zealand has a subjectivity immerse in a social praxis with specific Forms of Social Relations, beliefs about learning and teaching, ways of assessing and objectifying learning, signs and artifacts that constitute what is relevant to learn for the collectivity. If a model such inquiry based teaching and assessment for learning is expected to be a social praxis, then it implies to understand the kind of subjectivity that such model requires. Teachers and learners need to be transformed in their subjectivity. The problem is not if a teacher understands the concepts, the problem is that it implies a collective change.

10. OBJECTIFICATION OF THE RESEARCH PROCESSES

> In Western approaches to the mind, psychological processes, thinking, and consciousness have been generally conceived of as entities somehow lodged in an individual 'interior space'. This idea of an 'interior space' is not new. It was articualted by philosophers such as René Descartes and Gottfried Leibniz in the 17th and 18th centuries. To give but one example, […] Leibniz contended that our ideas, even those of sensible things, come from our soul' (Leibniz, 1705/1949, p. 15). (Roth & Radford, 2011, p. 1)
>
> Leont'ev found misleading in the individualistic approach the fact that it extracts consiousness, thinking, and psychological processes from the individual's mode of life and considers it abstractly. By referring to the individual's mode of life Leont'ev had in mind something that is much more than a collection of purely individual self-determining acts. His main point in fact was that our modes of life 'are built up in any set of sociocultural conditions' (Leont'ev, 1981, p. 224). (Roth & Radford, 2011, p. 1)

This thesis focuses on changing the current conceptualisations of assessment for learning activity within an inquiry-based teaching and learning sequence. The theoretical constructs of researchers used within the IBSE Network are supported by the approach to the mind illustrated by Roth and Radford in the above left text: the mind, psychological processes, thinking, and consciousness conceived as entities lodged in an individual 'interior space'. In Chapter five, it was documented that research activity used in the IBSE Network was ruled by this idea. It was stated that individualistic cultural sensibility forms of understanding and capacity to create with assumptions are coherent with this approach of the mind.

During the study it was identified a need to think assessment for learning within IBSE with a new learning theoretical perspective that recognizes elements such as social, cultural and situated characteristics of the human cognition. Another theoretical approach was observed considering the mind

linking human learning and cognition to the social and cultural elements involved in human activities. It was called socio-cultural cultural sensibility forms of understanding and creating with assumptions behind this other theoretical perspective.

The decision of such turn was supported on the fact that those current conceptualizations of assessment for learning activity within inquiry-based teaching and learning sequences arrived to teachers' practices, in diversity of places, and within different educational systems, as a foreign educational culture. In that sense, Leontyev's critique exposed by Roth and Radford, in the above right text, helps to understand why it was important to do it. In different educational systems, countries and cultures where a change in the educational culture is expected, there are modes of life differing from one place to another. In particular, there are different ways of classroom interactions and different forms of assessment activity.

As Roth and Radford explained in the above text, "Leontyev found misleading in the individualistic approach the fact that it extracts consiousness, thinking, and psychological processes from the individual's mode of life and considers it abstractly." Thus, to move conceptualizations of assessment for learning towards a socio-cultural approach implies finding assumptions that acknowledge the differences in modes of life in all those places where assessment for learning activity could be implemented. Furthermore, it is also considered in this approach the existence of socio-cultural conditions interfering in any individual's possibilities of thought. As Roth and Radford explained, for Leontyev the individual's mode of life "is much more than a collection of purely individual self-determining acts", and "that our modes of life 'are built up in any set of socio-cultural conditions'".

Three ideas are developed as the result of the analytical strategy. The first is the existence of two social research activities studying assessment for learning activity within teaching and learning sequences. In one of them, scholars have an individualistic approach to construct their conceptualization. In the other, the socio-cultural approach is used to define the theoretical tools. The second idea is that scholars from each approach support their conceptualizations in more or less explicit assumptions. Each approach is based on a different set of assumptions and shape conceptualizations of assessment for learning within inquiry-based sequences. The third idea is that assessment for learning within inquiry-based teaching and learning can be conceptualized following Roth's, Radford's, and Leontyev's cultural-historical activity research perspective. This implies to conceptualize linking the individuals and the social activity in which they are immerse at school.

This chapter is organized in six parts. In the first, the research process is objectified and the results are explained. In the second part, two studies on assessment for learning, identified as social activities, are presented, each one

based on a different cultural sensibility. In the third part, the socio-constructivism perspective used by scholars to build their objects of research is characterized. In particular, the impact of those ideas in scholars taught through assessment for learning activities in inquiry-based classrooms are considered. In a fourth part, scholars' ways of presenting their ideas based on the socio-cultural perspective are presented. In the fifth part, the assumption and the cultural-historical theory is used to reflect about the implications for the conceptualizations of assessment for learning activity within an inquiry-based classroom. Some final remarks are presented at the end.

OBJECTIFICATION OF THE RESEARCH PROCESS

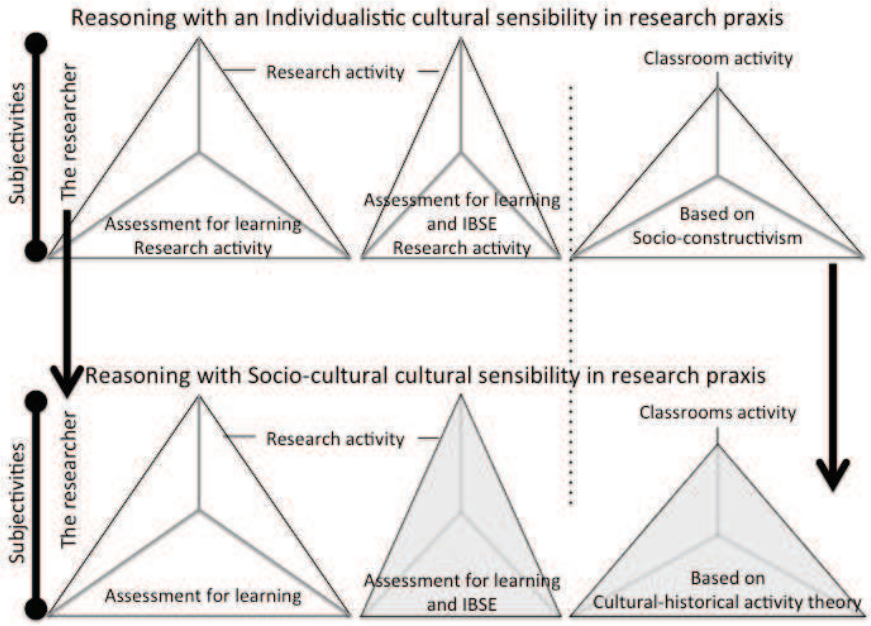
The adoption of a critical research perspective had impacted the way of constructing the research objects, the methodology and the results. As explained in the first chapter, to be critical implied to inquiry about the assumptions, truths and ideals of the praxis in which 'the researcher' —the researcher in this chapter is the individual that has made this study— was involved as teacher educator and researcher, as well the researcher's assumptions, truths and ideals. This questioning was envisioned as a way to understand the complexity of a social phenomenon of the researcher's practice. This is, to understand individuals' process of learning when adopting a foreign educational culture —foreign culture understood as a pedagogical or research activity that is different from what is the current activity of individuals—, such as IBSE, assessment for learning for teachers of the IBSE Network, and socio-cultural theories of learning for the researcher.

The analysis has been structured using Leontyev', Roth', Radford' and Empey's views of the links between social activity, cultural knowledge and the self. The research has followed three levels of analysis, one concerning researchers' social activity, another researchers' conceptualization of classrooms social activity, and finally the link between the researcher and the social activity of researching. In Chapter nine it was presented the researcher's process of learning as a change on researcher's subjectivity. It was showed as a movement of the individual from the individualistic forms of investigating classroom activities towards the socio-cultural forms of inquiry classroom activities. In this chapter the results are explicitly linking the social activity, cultural knowledge and the researcher. This means to see the researcher as immersed in the collectivity of researchers with possibilities of thinking mediated by cultural tools, assumptions, and modes of inquiry used by the collectivity of researchers. In other words, to considered the researcher being part of a social praxis with the Semiotic System of Cultural Significations, Forms of Production, Forms of Social Relations, and Cultural Knowledge.

The objectification of the research process is expressed around the notion of social activity. The link between the social activity, the cultural knowledge and the self has been represented by Radford' and Empey's (2007) triangle. Three different social activities have been identified: assessment for learning research activity, assessment for learning within IBSE research activity, and classroom activity. From the analytical process have emerged two forms of understanding and shape classroom activities within assessment for learning research. One following the individualistic cultural sensibility —cultural sensibility has been used in the thesis to capture 'ways of reasoning with assumptions' within educational research, which have an impact in the way as the research object is conceived: a different conceptualization of assessment for learning classroom activity. The other has been identified as following the socio-cultural cultural sensibility.

The object/motive of this study has been to build a conceptualization of assessment for learning inquiry-based classroom activity following a socio-cultural cultural sensibility. The study has been documenting that assessment for learning research activity within IBSE has been based on the individualistic cultural sensibility. It has been also showed that, at the beginning of the research process, the researcher's possibilities of thought were mediated by the individualistic cultural sensibility. The study has recognized that assessment for learning researchers' subjectivities are shape by a set of assumptions in resonance with "approaches to the mind, psychological processes, thinking, and consciousness conceived of as entities somehow lodged in an individual 'interior space'" (Roth & Radford, 2011, p. 10).

The observation and analysis of the IBSE Network and their artifacts revealed the existence of a dominant discourse shaping assessment for learning research within IBSE research activity. It was found that researchers have been following the 'way of reasoning with individualistic assumptions'. The first row of triangles in the Graph Nº1 represents researchers' subjectivities following the individualistic cultural sensibility. They are recognized as part of a collectivity researching assessment for learning —the first triangle represents research activity within the field of assessment for learning—; and at the same time, inquiring about assessment activity in inquiry-based classrooms —the second triangle represents the research activity within the field of assessment for learning and IBSE—; and producing conceptualizations about assessment for learning within inquiry-based teaching and learning activities —the third triangle represents the classroom activity considered as the object of study for researchers. The researcher is identified as part of that collectivity.



Graph Nº 1. The objectification of the research process

The black arrows represent the move of the researcher's subjectivity from participating in a collective research activity following individualistic cultural sensibility, towards another collective research activity following a socio-cultural cultural sensibility. The researcher is considered as being part of cultural forms of thinking and adapting to them in the process of objectification and subjectification.

The second row of triangles represents the other form of researching assessment for learning with socio-cultural cultural sensibility. The study identified a group of researchers studying assessment classroom activities with a socio-cultural cultural sensibility. Their modes of reasoning and built research objects will be illustrated in this chapter —the first triangle of the second row represents the research activity of socio-cultural researchers. However, we did not found a group of researchers investigating assessment for learning within IBSE with a socio-cultural perspective.

The second gray triangle represents the inexistence, and at the same time, the possibility to research within the field by the work that has been made in this study. The contribution of the thesis is to open the door for further inquiry by giving some concepts that could be used to think assessment for learning within inquiry-based classroom activities with a socio-cultural cultural sensibility. The

third triangle of the second row and the grey color represents the object of research, which has been constructed during this study, the classroom activity with a cultural-historical activity theory perspective. The researcher's subjectification is represented by the last triangle of the row, considering the object of research 'classroom social activity'. The researcher has proposed conceptualizations supported by cultural-historical activity theory. This will be presented in this chapter.

In Chapter three, the critical perspective of this research was linked to Skovsmose and Borba's (2004) proposal for critically researching the collaboration of researcher and teachers in thinking and producing new possibilities for classroom practice. The purpose of the research was to imagine a hypothetical situation in relation to the classrooms activities when considering the current situation. Thus, to imagine something that is possible. This was materialized in Chapter eight by the simulation of two assessment classroom activities using different knowledge of current situations.

However, the research process developed yet a new critical dimension. This is, the process of objectification and subjectification of the researcher implied to study the research itself on assessment for learning within IBSE. Researching research itself is not a new discovery of this thesis. Indeed, there are other researchers that found relevant to study the mechanisms by which researchers research and constitute their objects of study. This is to critically examine research as praxis and the production of its objects (e.g. Pais & Valero, 2012; T. S. Popkewitz & Brennan, 1997; Valero, 2004a, 2013).

For instance, Valero (2004a) supported this kind of critical approach in the field of mathematics Education:

> We need to undertake a critique of the constructs and guides for practice that mathematics education research has produced for two reasons. The first is to support a search for plausible, alternative understandings of the social practices of mathematics education in schools; the second is to break with the deeply entrenched modern systems of reason in which our discipline has built. [...] We are starting to take critique a step further by examining mathematics education research itself and by investigating how researchers engage in the production and reproduction of the mechanisms of power that have been central to the constitution of modernity. (p. 10)

She recognizes a need to critique the constructs and guides for practices produced by the activity of researchers. She identified two different reasons for that. One, to search for other forms of understanding social practice of mathematics education at school, and two, to break with the existing modes of reasoning that structure ways of researching in mathematics education. She

argues for a critical research perspective examining mathematics education research activity and their contribution to the reproduction of power.

Popkewitz and Brennan (1997) adopted a critical perspective to understand ways of reason that are behind social practices. In particular, their research perspective links the subject and the social praxis. The decentering of the subject strategy is presented as a form "to understand how the subject is constituted within a field that relates knowledge and power" (p. 296). This is considered as relevant since it is a road to understand individual change immersed in a historical network of relationships that constitutes the individual. They explained that the intention "is not to deny that actors are seeking to change their worlds but to give historical specificity to the systems of ideas that enclose and intern reason and the reasonable person." (p. 297) Furthermore, for them, the decentering of the subject, "focuses on systems of ideas as historical practices through which the objects of the world are constructed and become systems of action". (p. 297)

This study can is aligned within these critical perspectives that examine research itself. The intention was to situate the researcher subjective change within historical forms of truths and knowledge that, as Popkewitz and Brennan (1997) explained, "present themselves as having no origin or end" (p. 298). As explored in this thesis, the dominant individualistic cultural sensibility, reviewed in term of Popkewitz and Brennan as a systems of ideas that support the possibilities of thought of individuals, shaped the researcher possibilities to construct research objects. The research strategy supported the researcher's subjective change within another system of ideas, the socio-cultural cultural sensibility. Furthermore, paraphrasing Popkewitz and Brennan, this research and the objects being researched are product of the researcher's participation in historical practices through which the objects of the world are constructed and become system of action.

The results of the inquiry are objectified by:

1. Describing assessment for learning research as social activity, and interpreting researchers' conceptualizations as being supported by the individualistic cultural sensibility.
2. Describing assessment for learning research as social activity, and interpreting researchers' conceptualizations as being supported by socio-cultural cultural sensibility.
3. Describing the individualistic cultural sensibility, or 'ways of reasoning with individualistic assumptions', of scholars involved in the research activity of assessment for learning within IBSE.

4. Describing the differences of the socio-cultural sensibility, or 'ways of reasoning with socio-cultural cultural sensibility', of scholars involved in the research activity of assessment for learning.
5. Presenting assessment for learning within inquiry-based classroom activities with a cultural-historical activity theory perspective.

As explained before, the terms cultural sensibility was borrowed from Radford' and Empey's concept and transformed for the purpose of this study. The intention was to communicate the observations of researchers' texts, and the process of the researcher participation in the research social activity with socio-cultural assumptions. In Chapter four, the researcher identified two discourses in educational research shaping researchers' texts. Those discourses were named as individualistic cultural sensibility and socio-cultural cultural sensibility. In Chapter five, the IBSE discourse and the assessment for learning within IBSE discourses were considered as shape by researchers individualistic cultural sensibility. In Chapters six and seven, it was expressed as problematic this line of research since they assumed ideal learners and teachers with out considering them in they daily classroom activity, shaped by their socio-cultural conditions and historical possibilities. In Chapter eight some problems and tensions were expressed as the result of looking research social activity within assessment for learning and IBSE with a critical perspective. It was also presented two classroom activities simulations. The researcher uses her individualistic cultural sensibility and also her new possibilities of thought with a socio-cultural cultural sensibility. The intention in this chapter is to link all this findings in the expressed 'ways of reasoning with assumptions' that was called cultural sensibilities for researching.

ASSESSMENT FOR LEARNING RESEARCH AS A SOCIAL ACTIVITY

Assessment for learning research can be viewed as a social activity in terms of Leontyev's concepts of object/motive, actions, goals and operations. Scholars researching and acting in this social activity can do it by identifying themselves with one or another kind of cultural sensibility —understood as possibilities of thought within a frame of cultural knowledge in terms of Radford and Empey's (2007) perspective. Two cultural sensibilities were identified and documented in Chapter four. In one of them, the researchers followed assumptions within the individualistic perspective, and in the other, scholars reasoned with socio-cultural assumptions. Thus, the assessment for learning activity in the classroom is conceived differently by researchers immerse in one or another cultural

sensibility. I expound in this part some ideas characterizing each one of those cultural sensibilities.

IBSE and assessment for learning statements are built to provide an account of the learner's learning process and knowledge production on the natural and made worlds. One of the analyses in this study explored the connection established by scholars with individualistic or socio-cultural sensibility between the child's and social, made and natural worlds. It was inquired about forms of understanding and explaining such relation and the impact in assessment for learning research activity. The other analysis searched assumptions about the interactions of the child with others and the impact of that in conceptualizations about learning and knowing. It was expected to establish how different the conceptualizations were in assessment research and IBSE, when the interaction of the child with others and with the natural and made worlds is seen with individualistic or socio-cultural cultural sensibility. Such analysis makes visible different interpretations within scholars about the role of teacher and peers in the individual processes of learning, as well as the perception of the natural and made worlds. The study have described objects produced by researchers from one or another cultural sensibility about assessment for learning activity in classrooms.

PRODUCING WITH INDIVIDUALISTIC CULTURAL SENSIBILITY

Considering assessment in general, Roth and Radford (2011) explain how in the traditional testing and interviewing practices the purpose of obtaining and analyzing answers is to reveal what is going on in the student's head: thinking, psychological processes, self-appraisals, and even consciousness. This practice can be also perceived in the assessment for learning research. In assessment for learning discourses a need to collect evidences is emphasized during the instruction, giving an account of changes in the students' interior mind, and it is assumed that it is possible to establish a relation between the evidence collected and the intended learning goal. A judgment can be produced after interpreting the students' actions.

In a recent review of the assessment for learning research, Wiliam (2011) answered the question 'what is assessment for learning?'. This review reveals the characteristics shaping the individualistic cultural sensibility. William (2011) explains the appearance of assessment for learning and formative assessment as the recognition that each learner, under the same instructional characteristics, shows different understandings and learning achievements. He states that there is recognition that each learner arrives to the classroom with different knowledge, and that this impacts what each learner understands. In that sense, assessment for learning was conceived to recognize those differences and use them in teaching, and to focus the attention of learning in what was intended.

Wiliam (2011) acknowledges that "there has been an increasing tendency to seek to understand activities that are intended to guide learning towards the intended goal, and that takes place during the learning process, as forms of assessment" (p. 3). Furthermore, for Wiliam (2011), this explains a need of assessment embedded in instruction: "It is only through assessment that we can find out whether a particular sequence of instructional activities has resulted in the intended learning outcomes" (p. 3). According to those statements, the aim of the assessment for learning activity is to have information that clarifies if students achieve the intended goals. How could the learning outcome be interpreted? Does the learning outcome look as something that happens in the internal space of the learners' head? How is the entity 'intended goal' constituted? Furthermore, if it is acknowledged that the individual does not learn in the same way after the same instruction, is it possible to arrive to such 'intended goal'?

Wiliam (2011) reviewed the historical process of research on assessment for learning. He presents the results of several projects in which there are differences in the use of the term assessment for learning and formative assessment. Wiliam (2011) writes definitions clarifying the differences.

> Assessment for learning is any assessment for which the first priority in its design and practice is to serve the purpose of promoting students' learning. It thus differs from assessment designed primarily to serve the purposes of accountability, or of ranking, or of certifying competence. An assessment activity can help learning if it provides information that teachers and their students can use as feedback in assessing themselves and one another and in modifying the teaching and learning activities in which they are engaged. Such assessment becomes "formative assessment" when the evidence is actually used to adapt the teaching work to meet learning needs. (Black, Harrison, Lee, Marshall, and Wiliam, 2004, p. 10).
>
> Practice in a classroom is formative to the extent that evidence about student achievement is elicited, interpreted, and used by teachers, learners, or their peers, to make decisions about the next steps in instruction that are likely to be better, or better founded, than the decisions they would have taken in the absence of the evidence that was elicited. (Black & Wiliam, 2009, p. 9). (Wiliam, 2011, p. 11)

There are two different aspects involved in assessment activity. One is the process to construct evidence about learning that could be used by both learners and teacher, and second, the use of such information to modify teaching and learning activities. The central aspect for our analysis is to focus on 'evidence of learning' and the way this is interpreted. For the individualistic perspective,

learning is considered as something happening in the mind. This implies that this evidence can be studied and constructed independently of the activity that is being done. Individuals can be regarded as cognitive entities reacting to the environmental circumstances.

The object/motive of the assessment for learning activity could be established as 'promoting student's learning'. This becomes possible by providing information used by teachers and learners as feedback, to assess each other, and to modify teaching and learning activities. Assessment is formative when the evidence about student achievements is elicited, interpreted and used to make decisions in such way that it would be impossible to do without such information.

By using the information in the definitions, it can be identify actions with specific goals. One is to collect information with the goal to have evidence of students' achievements. Another is to share such information with individuals and decide following steps in learning. Here, there are some essential elements that will change depending on what theoretical perspective about learning is used. If the aim of assessment is to improve student's learning, so a theory of learning must give a tool to state what the student's learning is. The theory also helps to clarify and define a meaning for 'evidence about student achievement', to decide ways to elicit such 'thing' —learning—, and finally to interpret the information.

The next picture from Wiliam's (2011) review illustrates how forms of social relations and interactions are conceived with an individualistic perspective and the reasoning around it.

<table>
<tr><th></th><th>Where the learner is going</th><th>Where the learner is right now</th><th>How to get there</th></tr>
<tr><td>Teacher</td><td rowspan="2">Clarifying learning intentions and sharing and criteria for success</td><td>Engineering effective classroom discussions, activities and tasks that elicit evidence of learning</td><td>Providing feedback that moves learners forward</td></tr>
<tr><td>Peer</td><td colspan="2">Activating learners as instructional resources for one another</td></tr>
<tr><td>Learner</td><td>Understanding learning intentions and criteria for success</td><td colspan="2">Activating learners as the owners of their own learning</td></tr>
</table>

Fig. 1. Aspects of formative assessment (Wiliam & Thompson, 2008).

The focus is on the learner: where the learner is going, where the learner is right now, and how to get there. The form of social relations and interactions turn those statements around. The teacher clarifies the learning intentions and shares criteria for success, the learners —as peers or as the learner on focus— understand criteria and share learning intentions and success criteria. The teacher's activity is engineering effectively by designing classroom discussions, activities and tasks that elicit evidence of learning. The teacher also provides

feedback, moving learners forward. The learner is recognized as an instructional resource for the others and they are also expected to activate learners as the owners of their learning.

In Wiliam's definitions of assessment for learning and formative assessment there are no references of a particular meaning attached to learning. However, in his historical review in the field, he acknowledges some important theoretical positions. For instance, he acknowledges that feedback research has been relevant to the assessment field. Particularly, that feedback must be understood in the context where it is happening, it makes no sense to look it out of the contextual circumstances. What is important at the end is that the teacher, the learner and peers can use evidence to support future changes in learning. The author recognizes the development of the research field by using some results from research perspectives focused on understanding individual internal functioning. As a strategy to be taken into consideration in the formative assessment research, he suggests "activating students as owners of their own learning" (p. 348). He identifies fields of research such metacognition, motivation, attribution theory, interest, and self-regulated learning as influencing the conceptualizations of the assessment for learning activity.

> The final strategy, ''Activating students as owners of their own learning'' clearly draws together a number of related fields of research, such as metacognition (Hacker, Dunlosky, & Graesser, 1998), motivation (Deci & Ryan, 1994), attribution theory (Dweck, 2000), interest (Hidi & Harackiewicz, 2000) and, most importantly, self-regulated learning, defined by Boekaerts (2006) as ''a multilevel, multicomponent process that targets affect, cognitions, and actions, as well as features of the environment for modulation in the service of one's goals (p. 347).
>
> While much of the research on self-regulation has tended to prioritize either cognitive or motivational approaches, in recent years there have been several significant attempts to draw these two strands more closely together, because, as Boekaerts (2006) argues, self-regulated learning is both metacognitively governed and affectively charged. (p. 348)

Those texts illustrate the individualistic perspective on the assessment for learning research activity. Indeed, the study of the mental processes of the individual —metacognition, motivation, attribution theory, self regulated learning— is at the core of those theories that are used to describe the phenomena and to support theoretical conceptualizations.

Wiliam (2011) presented Boekaerts' theoretical perspective. As it can be appreciated, the psychological characteristics of the learner are at the center of such approach.

> […] Boekaerts has proposed a deceptively simple, but powerful, model for understanding self-regulated learning, termed the dual processing theory (Boekaerts, 1993). In the model:
>
> It is assumed that students who are invited to participate in a learning activity use three sources of information to form a mental representation of the task-in-context and to appraise it: (1) current perceptions of the task and the physical, social, and instructional context within which it is embedded; (2) activated domain-specific knowledge and (meta)cognitive strategies related to the task; and (3) motivational beliefs, including domain-specific capacity, interest and effort beliefs. (Boekaerts, 2006, p. 349). (William, 2011, p. 348)

Scholars researching in the assessment for learning field with an individualistic perspective use this kind of discourses. The individual mental representation is what is important at the end of the individual's learning activity. The context, meaning the task, the physical, social and instructional context, could be interpreted as how the individual adapts to the environment.

Language is also studied as shaping the assessment activity. Pryor and Crossouard (2008) reveal in their empirical work two kinds of assessment dialogues: convergent and divergent. While the first follows a conversation pattern Initiation-Responses-Feedback —A question or task with a possible response that needs to be as the teacher expects it to be, and the teacher's authoritative, judgmental or quantitative feedback—, which is associated to behaviorist learning theories —Stimulus-response, and feedback reinforcing correct answers—. The authors criticize this kind of conversations by saying that it was not clear to what extent the students were engaged on the task or were able to read with the expected meaning. What they observed was that the problems of the learners' misreading are often derived from social rather than cognitive issues.

The second kind of conversations found by Pryor and Crossouard (2008) was identified as dialogues. The starting point was a concern to establish what learners knew, understood or could do. The teacher's questions were different —helping questions rather than testing questions—. They connect this kind of conversations to a constructivist framework. These forms of dialogues are envisioned in assessment discourses within the IBSE frame (e.g. Harlen's, (2006b, 2006c) questions to enhance inquiry skills or science concepts presented in Chapter five). In the inquiry assessment field, some researchers consider assessment conversations as formatted instructional dialogue that embeds assessment into the activity structure of the classroom. The aim is to engage students in the considerations of different ideas and representations produced by

members of the classroom and to adapt them to scientific ways of knowing (Duschl, 2003; Duschl & Gitomer, 1997).

As shown in Chapter five, Ruiz-Primo and Furtak (2006) in an empirical research work within the IBSE frame, identified assessment conversations as allowing teachers to recognize student's conceptions, mental models, strategies, language use, or communication skills, and to use that information to guide the instruction. What is relevant in this framework is that through conversations the teacher finds out how students evaluate the quality of evidence and how students use evidence in their explanations. A best assessment cycle (ESRU) of conversation is recognized in this study: Teacher *Eliciting* trough a question, *Student* answering, teacher *Recognizing* and finally *Using* information. They found that when teachers use this kind of pattern repetitively, their students show better learning, than when the teacher does not recognize and uses the information for learning purposes.

James (2006) identifies this kind of discourse with views of learning requiring the active engagement of learners and determined by "what goes in the head" (p. 55). The meaning of learning is guided by theories of learning aiming at understanding the function of the brain, and "how people construct meaning and make sense of the world through organizing structures, concepts and principles in schemas" (p. 55). According to her, this perspective achievement is framed in terms of "understanding in relation to conceptual structures and competence in processing strategies" (p. 55). Furthermore, metacognition –self-monitoring and self-regulation- she argues, are also important dimensions of learning.

PRODUCING WITH THE SOCIO-CULTURAL CULTURAL SENSIBILITY

Researchers that challenge themselves to adopt a socio-cultural perspective in formative assessment acknowledge that still some work is needed to conceptualize formative assessment from a socio-cultural perspective. A need for a movement of dominant discourse is acknowledge by Pryor and Crossouard (2008). They appeal for a change enabling to go from a notion of learning as primarily a process of storing and reproducing knowledge, towards a conceptualization of learning as a process of 'coming to know in different situations' which is evidenced through 'accomplishment of action on the world' (Edwards, 2005). For instance, Pryor and Crossouard (2008) propose a definition of formative assessment that differed from the individualistic perspective:

> Formative assessment is seen as taking place when teachers and learners seek to respond to student work, making judgments about what is good learning. However, acknowledging learning as being bound up with identity construction (Lave & Wenger, 1991; Holland et al., 1998) implies that formative assessment

> interactions involve enabling learners first to engage with new ways of being and acting associated with new, aspirational identities; and second to have these recognized as legitimate, where what counts as legitimate is strongly framed by institutional discourses and assessment demands. (p. 3)

In their statement, Pryor and Crossouard use a definition of learning as 'being bound up with identity construction'. As they said, such conceptualization of learning implies some possibilities to define formative assessment. Such definition starts by acknowledging that a response of students work, making judgments about what is good learning, is fundamental in the constitution of any formative assessment activity. It appears also that in such activity there are some interactions that, according to the identity perspective on learning, have strong implications in classroom activities. There is also the recognition of institutional discourses and assessment demands as an essential part of the formative assessment conceptualization.

Assessment for learning and formative assessment from a socio-cultural perspective have attracted increasing attention from researchers in the last years (Black & Wiliam, 2006; Cowie, 2005; Cowie, et al., 2013; Gipps, 1999; M. James, 2006; Magnusson, et al., 1997; Pryor & Crossouard, 2008; Schoultz, Säljö, & Wydhamn, 2001; Schoultz, Säljö, & Wyndhamn, 2001). Some scholars provide theorizations based on their empirical experiences with assessment for learning at schools and Universities (Black, et al., 2003; Black & Wiliam, 2006; Cowie, et al., 2013; Pryor & Crossouard, 2008), while others show connections between learning theories and assessment (Gipps, 1999; M. James, 2006; Shepard, 2000), considering Vygotsky's ZPD from an assessment perspective (Magnusson, et al., 1997), analyzing consequences of language on assessment (Gipps, 1999; Schoultz, Säljö, & Wyndhamn, 2001), and showing students and teacher's perspectives (Black, et al., 2003; Cowie, 2005; Cowie, et al., 2013; Wiliam, et al., 2004).

Pryor and Crossouard (2008) recognize that formative assessment theorization from a socio-cultural perspective assume assessment as a discursive social practice involving dialectical and sometimes conflictual processes. To adopt a discursive perspective on assessment implies considering talking as a concrete social and situated practice with different aims: "opinions, attitudes, understandings, managing social situations, creating and managing social relationships, fulfilling communicative obligations and so on" (Schoultz, Säljö, & Wydhamn, 2001, p. 109). Dialogues with assessment purposes are also viewed as a process of negotiation that involves changes in identities in a collaborative space (Pryor & Crossouard, 2008).

In order to move assessment discursive practice towards a socio-cultural frame, Pryor and Crossouard (2008) propose to consider assessment criteria as

discursively produced, constituting a regime of truth; formative assessment as "a site where both the teacher and the student's identities are constructed and performed" (p. 9); issues of power in formative assessment; and agency in learning and assessment. While in the constructivist perspective, conversations focus on cognitive aspects, knowledge production and improvement of skills, in a socio-cultural perspective consider social dimensions of knowing. Duschl (2003), using an IBSE constructivist frame, also identified a social dimension to be considered in assessment conversations. However, he referred to cognitive processes as communicating research findings, arguing and debating and following some norms and rules of the scientific community's production of knowledge. Aspects such as power relations, identity issues, social relationships are not mentioned as a relevant part of the learning process.

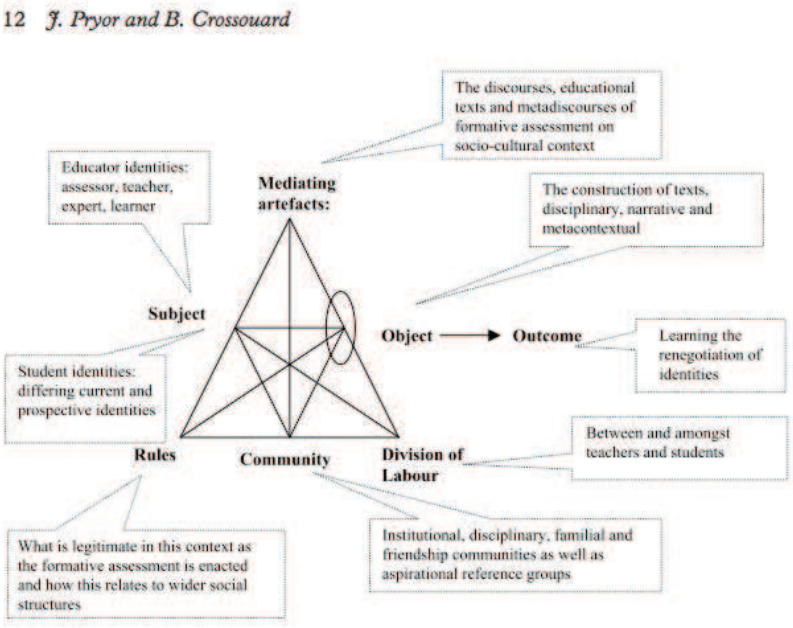
Shoultz, et al. (2001) differentiate communicative formats in assessment school settings. They challenge the dominant tendency to consider writing the answers to a test individually as "an unbiased indicator of what people know or understand" (p. 214). They explored the mediation of an adult in the process of answering. What they show is that communication is not an exchange of transparent messages, where decoding a question is a direct process. They consider that academic tests presuppose a "specific attitude to language and to objects and events" (p. 215), which requires formal and explicit definitions formulated within a discursive tradition. They argue that languages in everyday settings differ from that kind of discursive tradition. They also show a diversity of conceptual constructions used in different social settings and appropriated in various situated practices. In their study, they move from the "traditional focus on seeing differences in performances as something that happens as a natural consequence of students' abilities and knowledge", towards "seeing them as produced by, and trough, concrete communicative practice" (p. 216). They showed that students in test situations considered of low performance could be seeing differently when an adult interacted with them during testing. The meanings of words and the expectation can be discussed and shared, so the student makes a different sense of the test. A new interpretation and sense making is done by the student. Taking their finding into consideration implies that assessment with socio-cultural perspective must pay attention to differences between forms of language and the diversity of interpretations that can arise in a communicative process.

Tools, artifacts and mediation are central concepts of socio-cultural theories, as I showed in Chapter four. Adopting a socio-cultural perspective in assessment for learning or formative assessment implies thinking about the role of artifacts and tools in the assessment process. Gipps (1999) identifies the use of external supports as a key element in the development of mental functions, and Schoultz, Säljö, and Wydhamn (2001) support the claim that artifacts modify children's possibilities of thinking. Gipps (1999) identifies assessment in

traditional examination and psychometrics model as denying the pupil's uses of external tools because it reduces assessment usefulness and ecological validity. She proposes that assessment with a socio-cultural perspective should consider the use of auxiliary tools, such as adults, to achieve a better performance in that way. Schoultz, et al. (2001) show the impact of tools on thinking, particularly how the misconceptions or mental models did not appear in children's expressions when artifacts where used and a different language — closer to the child's experiences— than the typical used —more formal and abstract— in interviews where naïve conceptions appear.

Magnusson, Templin, and Boyle (1997) presented a socio-cultural perspective by referring to Vygotsky's ZPD. The term Dynamic assessment focuses on what children are capable of learning —their potential development— rather than on what a learner has already learnt. Similarly, Shoultz, et al. (2001), identify the relevance of an adult to help a child to develop their potentialities during assessment tasks. As I showed in Chapter three, Vygotsky thought that what a child can do with the help of an adult shows his developmental possibilities.

Pryor and Crossouard (2008) propose a model that considers a questioning process —helping as well as testing questions—, observation of processes and products, feedback and judgment, and making task and quality criteria explicit. They follow Lave and Wenger's (1991) definition of learning as inseparable of identity and the negotiation of the understanding process. They propose a negotiation of understanding of the task and quality criteria as well as a collaborative process using metacontextual reflection —seen as dialogues "considering issues of power and control, the criteria may not just be clarified but deconstructed" (p. 16)—. They also explain the complexity of assessment from a socio-cultural perspective using the triangle of Cultural Historical Activity Theory (Engeström, 1987). The Graph Nº 2 illustrates their representation:



Picture N° 2. Pryor and Crossouard's formative assessment activity theory model (p. 12)

The diagram shows the complexity involved when a socio-cultural perspective is assumed. The discourses, educational texts and metadiscourses of formative assessment on a socio-cultural context are recognized as Mediating artifacts. The subjects' identities (Educator and Student) and renegotiation of identities are at the core of the outcome. Rules are viewed as what is legitimate in the context as formative assessment and a relation is established with a wider social structure. Community includes institutional, disciplinary, family and friends' communities as well as aspirational reference groups. Finally, they considered the Division of Labour between and amongst teacher and students.

Black & Wiliam (2006) also used the Activity Theory framework to elaborate their model based on their empirical work on assessment for learning. They used three dimensions of the triangle: Tools —Pedagogical content knowledge and nature of the subject, interaction methods, feedback and learning analysis—, Subjects —Role of the teacher, role of the student in a group and role of student as an individual—, and Objects, outcomes —teacher's expectations and teacher's own test.

Scholars that adopt a socio-cultural perspective in formative assessment emphasize that around the assessment activity there is more than a cognitive

evaluation process. Pryor and Crossouard (2008), presenting Rogoff's (1990) argumentations, argue that culture plays a strong role in the assessment activity. For instance, cultural values about intelligence and valued behaviors affect the understanding of assessment. Cultural variations appear in value judgments about the expectation of an intellectual process such as desirability of speed, abstraction and memory skills, and also the cultural conception of relationships in that particular situation.

To consider assessment for learning in the IBSE territory from a socio-cultural perspective implies seeing the complexity behind the classroom communication; the role of artifacts, adults and tools mediations; and norms, values, relationships and social dimensions involved in subjects' interactions. It is to construct theoretical assessment tools that take into account the collective learning and thinking processes in different interactional moments, in a way that goes beyond the sum of individual performances.

DIFFERENTIATING CULTURAL SENSIBILITIES

As mentioned before, there are two cultural sensibilities shaping scholars' possibilities of thought in the assessment for learning research field: The individualistic and the socio-cultural perspectives. In that sense, such social activity —researching assessment for learning— has a different object/motive. In the case of the individualistic perspective, the object/motive is to move the individual's learning by understanding how he/her thinking works and how he/she uses their surroundings to modify their internal functioning. The socio-cultural sensibility emphasizes in the role-played by the surrounding in the individual's possibilities of learning. The individual, interactions and the activity are a unit from which learning is analyzed.

The following sections expound the way in which a specific cultural sensibility supports individual researchers making assessment research activity —when the researcher assumes an individualistic or a socio-cultural perspective—. The reader must expect to find some elements of such research activities; however, it is not intended to detail processes and methodologies that characterize these ways of knowing. The aim is to show how specific vocabulary, reasoning and ideas appear as the way in which thinking is developed by scholars following one or another perspective. The final purpose is to point that individuals conducting assessment research, within one or another cultural sensibility, offer different tools to conceptualize assessment for learning and formative assessment knowledge within the IBSE. Supported by those differences, there is a reflection about the assessment activity in inquiry-based classrooms.

ASSESSMENT FOR LEARNING WITHIN IBSE WITH INDIVIDUALISTIC CULTURAL SENSIBILITY

As said before, to research with an individualistic cultural sensibility means that scholars conceive the activity of assessment for learning in a classroom as an exchange of objects between individuals, isolating those individuals, teacher and learners, from their everyday life and activity. Somehow, ideals of the individuals' exchanges can be as foreseen by research independently from everyday social and environmental circumstances. The individual self and his/her emotions disappear to focus the attention on his/her cognition, and the construction of knowledge by the individual in his/her activity within the world. In addition, the social forms of relations shaping social activities with their collective object/motive also disappear. Assessment relations of individuals are reduced to an exchange of things between individuals —such as learning goals, criteria, judgments of good work, and feedback, to support the individual learning.

As documented in Chapters four and five, the individualistic cultural sensibility is driven by assumptions. The thesis focuses on the impact of those assumptions on assessment for learning discourses. A relation was established between IBSE and assessment for learning with socio-constructivist discourses. This section presents the connections emerging from this study. The analysis started by connecting Piaget's and Vygotsky's developmental theories with discourses in education and science education. The attention was driven towards the relation of the child and the environment. The analysis looked assumptions about the relation of the child with phenomena and with others. This study established links between those assumptions, assessment for learning conceptualizations, and inquiry-based teaching and learning.

The first assumption considered as essential for research activity was that the development of the child is internally determined and influenced by his/her experience within the environment. In other words, the child's internal development follows a natural law of growing and is adapted to the environment during the child's interaction with the social, made and natural worlds. This assumption has consequences in the way assessment for learning within IBSE is conceived. During the analysis were tracked and found the following reasoning shaping discourse associated to a socio-constructivist epistemology.

A first line of reasoning in the assessment for learning and IBSE research is the recognition that a child in his/her experiences and interactions with the world adapts and develops a kind of scientific reasoning. Such reasoning is not always coherent with the scientific thought but it allows children to build

explanations about natural phenomena. Those ideas and possibilities of reasoning are identified as one kind of personal knowledge.

PIAGET (2004)

> [...] THIS VERBAL ACTIVITY IS NOT SOCIAL; EACH CHILD CARRIES IT ON BY HIMSELF. EACH CHILD HAS HIS OWN WORLD OF HYPOTHESES AND SOLUTIONS WHICH HE HAS NEVER COMMUNICATED TO ANYONE, EITHER BECAUSE OF HIS EGO-CENTRISM, OR FOR LACK OF THE MEANS OF EXPRESSION –WHICH COMES TO THE SAME THING, IF [...] LANGUAGE IS MOULDED ON HABITS OF THOUGHT. (P. 79)

This idea of a child full of hypothesis never communicated to others, evolved in educational research. Scholars in science education determine their investigations to reveal those ideas deeply rooted in the internal body of the child as growing and internally developing. The hypothesis is that the child has some theories and ways of reasoning about the natural phenomena that are not compatible with scientific hypothesis, but in the everyday life they work for the individual. According to this line of thinking those children's theories are found in all children independently of the culture. Scholars researching assessment for learning within IBSE adhered to this kind of reasoning.

YIN ET AL. (2008)

> MOST STUDENTS HAVE RICH EXPERIENCES AND PERSONAL THEORIES OR MENTAL MODELS FOR EXPLAINING SINKING AND FLOATING.
>
> UNFORTUNATELY, MANY OF THEIR THEORIES ARE EITHER MISCONCEPTIONS OR CONCEPTIONS THAT ARE ONLY VALID UNDER CERTAIN CIRCUMSTANCES.
>
> THOSE CONCEPTIONS ARE SO DEEPLY ROOTED IN STUDENTS' MINDS THAT IT IS DIFFICULT TO CHANGE THEM, EVEN AFTER STUDENTS HAVE BEEN INTENSIVELY EXPOSED TO SCIENTIFIC CONCEPTIONS SUCH AS, "IF AN OBJECT'S DENSITY IS LESS THAN A LIQUID'S DENSITY, THE OBJECT WILL FLOAT IN THE LIQUID REGARDLESS OF THE SIZE OR MASS OF THE OBJECT" (P. 338)

Researchers following this reasoning and hypothesis recognize two kinds of knowledge in children. The knowledge that depends on this internal development of the child and another that is offered by and external knowledge learned by humanity. Pellegrino, Chudowsky and Glaser explain that as follows:

PELLEGRINO, CHUDOWSKY, AND GLASER, (2002)

> Some types of knowledge are universally acquired in the course of normal development, while other types are learned only with intervention of deliberate teaching (which includes teaching by any means, such as apprenticeship, formal school, or self-study). For example, all normal children learn to walk whether or not their caretakers make any special efforts to teach them to do so, but most do not learn to ride a bicycle or play the piano without intervention.
>
> Thus in mathematics, the fundamentals of ordinality and cardinality appear to develop in all normal human infants without instruction. In contrast, however, such concepts as mathematical notation, algebra, and Cartesian graphing representations must be taught. (p. 29)

Researchers in science education with individualistic perspective made empirical research to document the hypothesis. The children's internal ideas are made visible. The idea behind this kind of research is to build a repertoire. For assessment purposes, it is relevant to know this kind of ideas since they explain children's statements in the classroom, and help to plan new teaching activities with formative purposes. The repertoire could be used by practitioners to assess learning. Vosniadou and Brewer are scholars producing such kind of evidence as their research activity in science education.

Vosniadou and Brewer, (1992)

> For example, many children said that the earth is round but also stated that it has an end or edge from which people could fall. A great deal of this apparent inconsistency could be explained by assuming that the children used, in a consistent fashion, mental models of the earth other than the spherical earth model. Five alternative mental models of the earth were identified: The rectangular earth, the disc earth, the hollow sphere, and the flattened sphere. It is argued that these models are constrained by certain presuppositions which children form based on interpretations of their everyday experience. Some of these models (the rectangular earth and the disc earth) seem to be initial models children construct before they are exposed to the culturally accepted information that the earth is a sphere. (p. 535)

Those researchers' statements had a great impact in the way scholars from assessment within IBSE elaborate theoretical support to the inquiry-based

teaching and learning. Indeed, IBSE and assessment researchers elaborate tools and produce knowledge to support changes of the child's ideas and reasoning. In a guide for IBSE teachers, Satiel explains how important it is to follow the child's ideas when teaching through inquiry.

SATIEL, (2006)

> WHATEVER THEIR CULTURE AND AGE, STUDENTS GENERALLY HAVE MANY IDEAS ABOUT THE PHENOMENA THEY ENCOUNTER IN THEIR PERSONAL EXPERIENCE, REGARDLESS OF THE WORK THEY MAY HAVE DONE IN SCHOOL. IT IS IMPORTANT TO BE FAMILIAR WITH THOSE IDEAS, REFERRED TO AS STUDENTS' "PRECONCEPTIONS" OR "INITIAL CONCEPTIONS", AS THIS HELPS TEACHERS, FIRST OF ALL, BECOME FAMILIAR WITH THE STUDENTS' REASONING, THEN ASK CERTAIN QUESTIONS TO GUIDE CLASSROOM ACTIVITIES AND, ULTIMATELY, CHECK THAT THEY HAVE EFFECTIVELY UNDERSTOOD THE CONCEPTS INTRODUCED.
>
> BY TAKING THE STUDENTS' IDEAS SERIOUSLY AND TAKING INTO ACCOUNT THEIR QUESTIONS, THE TEACHER ENSURES THAT THE STUDENTS HAVE THE OPPORTUNITY TO SEE THAT THERE EXIST IDEAS OTHER THAN THEIR OWN, AND THAT THE SAID IDEAS CAN BE ROOTED IN FACTS THAT THEY HAD NOT CONSIDERED (P. 14)

The recognition of some facts that do not coincide with children's reasoning is important for inquiry-based activities. Harlen explains the impact of those statements for teaching and assessment.

HARLEN, (2006A)

> EXPERIENCE AND RESEARCH SHOW THAT MERELY TEACHING "CORRECT" SCIENTIFIC IDEAS DOES NOT NECESSARILY CHANGE STUDENTS' UNDERSTANDING. CHANGE IS MORE LIKELY TO HAPPEN WHEN STUDENTS TEST THEIR SCIENTIFIC IDEAS FOR THEM SELVES. TEACHING THROUGH INQUIRY HELP STUDENTS TEST THEIR EXISTING IDEAS ABOUT SCIENTIFIC PHENOMENA, CONSIDER ALTERNATIVE IDEAS, AND GRADUALLY DEVELOP AN UNDERSTANDING THAT IS MORE CONSISTENT WITH EVIDENCE AND WITH THE SCIENTIFIC VIEW OF HOW THINGS WORK. BUT STUDENTS OFTEN NEED HELP WITH THIS PROCESS. FORMATIVE ASSESSMENT GIVES TEACHERS THE MEANS TO HELP STUDENTS EXPRESS THEIR IDEAS AND RIGOROUSLY TEST THEM (P. 10)

HARLEN, (2006A)

> USING ASSESSMENT TO INFORM TEACHING IS IMPORTANT IN ANY INSTRUCTIONAL APPROACH. HOWEVER, IT IS CRITICAL TO INQUIRY, IN WHICH STUDENTS ARE RAISING QUESTIONS AND

> DESIGNING INVESTIGATIONS TO TEST THEIR OWN IDEAS. TEACHERS MUST ASSESS PROGRESS AT EVERY STEP OF THE INVESTIGATION IN ORDER TO ENSURE THAT THEIR INVESTIGATIONS ARE SOUND ENOUGH FOR STUDENTS TO DRAW USEFUL CONCLUSIONS THAT HELP THEM MORE FULLY DEVELOP THEIR SCIENTIFIC IDEAS. (P. 11)

Shavelson et al., producing knowledge about assessment for learning for inquiry-based teaching and learning settings also explained the consequences of this reasoning for the field. Children's ideas, justifications and reasoning are considered in the assessment activity.

SHAVELSON ET AL., (2008)

> THEIR JUSTIFICATIONS AND EXPLANATIONS REVEAL THEIR SCHEMATIC KNOWLEDGE (KNOWING AND REASONING WHY) AND BECOME THE FOCUS OF THE CLASSROOM DISCUSSION WITH THE GOAL OF CLOSING THE GAP "IN MENTAL MODELS" FOR EXPLAINING WHAT THEY SAW, BASED ON EMPIRICAL DATA. (P. 304)

FURTAK AND RUIZ-PRIMO, (2007)

> FOR A PROMPT TO BE CONSIDERED EFFECTIVE TOOL FOR FORMATIVE PURPOSES, IT MUST ELICIT STUDENTS' MULTIPLE UNDERSTANDINGS, ESPECIALLY THE INAPPROPRIATE CONCEPTIONS, SINCE THIS IS THE INFORMATION TEACHERS NEED TO MAKE APPROPRIATE INSTRUCTIONAL DECISIONS TO REDUCE THE GAP. (P. 3)

Those texts take from different research papers reflect the researchers' subjective way of making sense of the knowledge constructed by the child in their daily interaction with the natural made and social worlds. The constructivist epistemology is behind this line of reasoning. Scholars following this epistemology conceive knowledge as an individual's construction and adaptation to the surroundings. The child's experience and activity in the world are a source for him or her to construct knowledge. Knowledge is considered the result of the individual's activity in the world (Jonnaert, 2002). The child's theories are tentative constructions and activities in classroom are thought see if they are viable.

DUIT, (1996)

> *ALL KNOWLEDGE OR IDEAS CONSTRUCTED BY THE INDIVIDUAL ABOUT TRAITS OF THE WORLD OUTSIDE OR ABOUT IDEAS ANOTHER MAY HAVE IS TENTATIVE IN NATURE. IT IS*

> *HYPOTHETICAL AND MAY NEED MINOR OR MAJOR CHANGES WHEN OTHER EVIDENCES BECOME AVAILABLE. (P. 44)*
>
> KNOWLEDGE AND IDEAS THAT HAVE BEEN CONSTRUCTED NEED TO BE VIABLE, I.E., USEFUL FOR THE INDIVIDUAL (OR A GROUP OF INDIVIDUALS RESPECTIVELY) […] ONLY CONSTRUCTS THAT STAND THE TEST OF BEING VIABLE SURVIVE SO TO SPEAK. (P. 44)

This line is what constitutes the first reasoning of what was called before the individualistic cultural sensibility in assessment for learning research within IBSE.

A second line of reasoning in the assessment for learning and IBSE research is the recognition of the interaction between the child with peers and adults to learn. This dimension of individualistic thinking can be identified with Vygotsky's ideas about the relation of the child and the social world. Although Vygotsky is recognized as a scholar with a socio-cultural cultural sensibility, the researchers' interpretation of his work follow an individualistic sensibility. The Zone of Proximal Development of Vygotsky is one of the conceptualizations impacting educational research. He expresses the Zone of Proximal Development –ZPD as follows:

VYGOTSKY, (1978)

> WE PROPOSE THAT AN ESSENTIAL FEATURE OF LEARNING IS THAT IT CREATES THE ZONE OF PROXIMAL DEVELOPMENT; THAT IS, LEARNING AWAKENS A VARIETY OF INTERNAL DEVELOPMENTAL PROCESSES THAT ARE ABLE TO OPERATE ONLY WHEN THE CHILD IS INTERACTING WITH PEOPLE IN HIS ENVIRONMENT AND IN COOPERATION WITH PEERS.
>
> ONCE THESE PROCESSES ARE INTERNALIZED, THEY BECOME PART OF THE CHILD'S INDEPENDENT DEVELOPMENTAL ACHIEVEMENT. (P. 35)
>
> THE ZONE OF PROXIMAL DEVELOPMENT […] IS THE DISTANCE BETWEEN THE ACTUAL DEVELOPMENTAL LEVEL AS DETERMINED BY INDEPENDENT PROBLEM SOLVING AND THE LEVEL OF POTENTIAL DEVELOPMENT AS DETERMINED THROUGH PROBLEM SOLVING UNDER ADULT GUIDANCE OR IN COLLABORATION WITH MORE CAPABLE PEERS. (P. 86)

There are three elements in Vygotsky's approach. First, learning awakes the internal development of the child only when the child is interacting with people in their environment and when cooperating with peers. Second, the process of learning with peers is internalized and becomes part of the child's independent development achievement. And third, the existence of a Zone of Proximal Development is recognized; this zone is the difference between what the child is

capable of doing on his or her own and what he/ she can do under adult guidance or in collaboration with a more capable peer.

Some socio-cultural researchers see an individualistic interpretation of Vygotsky's statements. Indeed, Roth and Radford see this as:

ROTH AND RADFORD, (2010)

> THE NOTION OF ZONE OF PROXIMAL DEVELOPMENT HAS COME TO BE USED WIDELY TO THEORIZE LEARNING AND LEARNING OPPORTUNITIES. UNFORTUNATELY, FOLLOWING A SIMPLIFIED READING OF ITS ORIGINAL DEFINITION AND PRIMARY SENSE [...] THE CONCEPT TENDS TO BE THOUGHT OF IN TERMS OF THE *OPPOSITION* OF INDIVIDUALS. ONE OF THESE INDIVIDUALS, A TEACHER OR PEER, IS MORE CAPABLE THAN ANOTHER INDIVIDUAL, THE LEARNER. SOMEHOW THEY ENGAGE IN AN "INTER-MENTAL" OR "INTER-PSYCHOLOGICAL" PLANE FROM WHERE THE LEARNER CONSTRUCTS KNOWLEDGE FROM HIM- OR HERSELF ON AN "INTRA-MENTAL" OR "INTRA- PSYCHOLOGICAL" PLANE. (P. 199)

Scholars within IBSE and assessment for learning recognize the relevance of others for the individual process of learning. See for instance Harlen's, IAP and Ruiz-Primo's reasoning:

HARLEN, (2004)

> WHEN INQUIRY-BASED TEACHING IS PRACTICED, TEACHERS AND STUDENTS ARE INVOLVED IN WELL-DEFINED ACTIONS, WHICH DIFFER IN SEVERAL RESPECTS FROM CURRENT CLASSROOM PRACTICE. THIS PAPER ARGUES THAT INTERACTIONS AMONG STUDENTS AND BETWEEN STUDENTS AND TEACHERS ARE NEEDED FOR INQUIRY-BASED LEARNING, WITH THE TEACHER HAVING A KEY ROLE.

IAP WORKING GROUP (2006)

> STUDENTS DEVELOP CONCEPTS THAT ENABLE THEM TO UNDERSTAND THE SCIENTIFIC ASPECTS OF THE WORLD AROUND THEM THROUGH THEIR OWN THINKING USING CRITICAL AND LOGICAL REASONING ABOUT EVIDENCE THAT THEY HAVE GATHERED. THEY WILL BE INVOLVED IN [...]
>
> [...] COLLABORATING WITH OTHERS, SHARING THEIR IDEAS, PLANS AND CONCLUSIONS; ADVANCING THEIR OWN UNDERSTANDING THROUGH DIALOGUE WITH OTHERS.
>
> [...] TEACHERS LEAD STUDENTS TO DEVELOP THE SKILLS OF INQUIRY AND THE UNDERSTANDING OF SCIENCE CONCEPTS

> through the students' own activity and reasoning. This involves facilitating group work, argumentation, dialogue and debate, as well as providing for direct exploration of and experimentation with materials and access to information sources. (p. 10)

RUIZ-PRIMO AND FURTAK, (2006)

> Ongoing formative assessment occurs in a classroom learning environment that helps teachers acquire information on a continuing and informal basis, such as within the course of daily classroom talk. This type of classroom talk has been termed an assessment conversation (Duschl, 2003; Duschl & Gitomer, 1997), or an instructional dialogue that embeds assessment into an activity already occurring in the classroom. Assessment conversations permit teachers to recognize students' conceptions, mental models, strategies, language use, or communication skills, and allow them to use this information to guide instruction. (p. 60)

The use of these statements by researchers in IBSE and assessment for learning and IBSE could be seen as an individualistic interpretation of Vygotsky's words. Following the constructivism epistemological view, it means the learner constructs knowledge by him/herself, engages with others' psychological individuality. The Scholars with a socio-cultural perspective see this conception of the role of interactions in a classroom as an individualistic interpretation of ZPD. Using Roth and Radford (2010) argument, those scholars ideas can be seen as a representation of such interpretation in terms of the opposition of individuals when they are engaged in an inter-mental or inter-psychological plane.

In the next example, extracted from the classroom simulation designed in Chapter eight, the socio-constructivist with the individualistic cultural sensibility shaped the Carulla's possibilities to imagine interactions and assessment activity in an inquiry-based teaching and learning situation.

CARULLA, (2011)

> In the story, for example, Rebeca brings to the classroom 11 aquaria, 11 sealed containers with something inside (*Container A*), and 11 sealed containers that are smaller and thinner than the first ones (*Container B*), filled with the same material as containers A. In order to assess, she expects children to talk and write about their explanation to the behavior of *Containers A* and *B* when they are placed in the

> aquaria filled with water. Rebeca decided to use the same material inside the containers in order to reduce the number of variables to consider in the experience, but she managed to make the bigger containers less dense so that the bigger ones would float while the smaller ones would sink. She expects children to have different responses and to observe different ideas and explanations. Particularly, she expects children to hypothesize that the heavy, big containers will sink and the lighter, smaller containers will float, due to their mass. (p. 297)

The text was conceived to illustrate the role of the teacher in the assessment activity, as being aware about the children's conceptions and theories. At the same time, the teacher is planning an activity that takes this into account. The teacher is also recognizing a tendency in children's reasoning, as those misconceptions observed in the literature research: "the heavy, big containers will sink and the lighter, smaller containers will float, due to their mass".

In one of the interaction examples in Chapter eight, the teacher is asking questions to learners. The learners behave as expected, showing their ideas about the sinking and floating phenomena. The teacher is in control of the assessment situation by looking at the distance between what she expected as explanation and what the children answer. She gives feedback to make them aware that their explanation does not work if they pay attention to the facts.

Carulla, (2011)

> Rebeca goes back to Maria, Juan, Pablo and Ana's table and points to *Container B* (the smaller one) that is on the right side of the aquarium, asking: "Why do you think this container is at the bottom?" Juan answers: "Because it is heavy". Maria interjects: "No, it is because it is heavier than the other one." "How could you know who is right between the two of you?" Rebeca asks. Pablo proposes to find out the weight of each object to see which one is the heaviest. They find out that the *Container A* is heavier than the *Container B*. Juan says: "I do not understand". Maria asks Rebeca: "But why?" The teacher, by questioning and considering the answers of group members, assesses their thinking about the relationship between the characteristics of the objects and the floating/sinking phenomena. She does not say what is right or wrong; she helps them to be aware of other aspects involved in floating that they were not aware of before. (p. 301)

In the construction of the assessment activity simulation, it was expected to have classroom interactions generating cognitive exchanges between learners and the teacher. The focus was the ideas of each child in relation to the phenomena. This is an example of the use of research ideals to imagine classroom interactions of individuals experiencing activities shaped by the individualistic cultural sensibility.

The constructivism presented before, and the individualistic interpretation of the ZPD is what in education is called the socio-constructivist perspective. Scholars define the key elements of socio-constructivism as follow:

JONNAERT, (2002)

> UNE APPROCHE CONSTRUCTIVISTE QUI PREND EN CONSIDÉRATION LA DIMENSION INTERACTIVE, DANS LE SENS PIAGÉTIEN DU TERME (MISE EN INTERACTION DES CONNAISSANCES ANCIENNES AVEC DES OBJETS NOUVEAUX EN SITUATION) NE FAIT PAS L'IMPASSE SUR LES « SAVOIR CODIFIÉS », BIEN AU CONTRAIRE ! PAR CETTE DIMENSION INTERACTIVE, NOUS ÉVOQUONS ESSENTIELLEMENT LE FAIT QUE LE SUJET CONSTRUIT DE NOUVELLES CONNAISSANCES ET MODIFIE D'ANCIENNES CONNAISSANCES PARCE QU'IL SE TROUVE EN INTERACTION AVEC SON MILIEU PHYSIQUE ET SOCIAL.
>
> […] CES INTERACTIONS SOCIALES SONT FAITES, D'UNE PART, DES ÉCHANGES AVEC LES PAIRS, ET D'AUTRE PART, DES ÉCHANGES AVEC L'ADULTE[85] (P. 18)

RADFORD[86]

> […] EL CONOCIMIENTO NO ES RECIBIDO PASIVAMENTE POR EL SUJETO SINO CONSTRUIDO POR ÉSTE.
>
> […] LA FUNCIÓN DE LA COGNICIÓN ES ADAPTATIVA Y SIRVE A LA ORGANIZACIÓN DE LA EXPERIENCIA DEL MUNDO, NO AL DESCUBRIMIENTO DE UNA REALIDAD ONTOLÓGICA (VER VON GLASERSFELD, 1995, P. 18).[87] (P. 39)

---

[85] A constructivist approach that takes into account the interactive dimension, in the perspective of Piaget (interaction of ancient knowledge with new objects in situation) does not ignore the "codified knowledge", quite the contrary. Through this interactive dimension, we refer mainly to the fact that the subject constructs new knowledge and old knowledge changes because it is interacting with its physical and social environment.

[...] These social interactions are on the one hand with peers and in the other with adults.

[86] Girona paper with no date, taken from Radford's web page. Radford, L. La evolución de paradigmas y perspectivas en la investigación. El caso de la didáctica de las matemáticas.

[87] […] knowledge is not received passively by the subject but constructed by him/her

Those Scholars' statements represent the assumptions supporting what IBSE is and the assessment for learning epistemological view. This is, assessment for learning research within IBSE following the socio-constructivist epistemology with its individualistic cultural sensibility. Our hypothesis is that scholars researching assessment in IBSE recognize Vygotsky's ZPD. However, there is also the view of Piaget and the role of social interaction in the development recognized as explained by Jonnaert (2002) from the socio-constructivist perspective.

The analysis reveals that scholars from individualistic cultural sensibility create research objects considering child reasoning and explanations of natural and made worlds deep rooted in the student's mind. The role of the assessment activity is to follow the development of those ideas and give support to change mental structures, as the source of such theories. Supporting learning means to support a conceptual change in the student's mind. To change the existing student's idea for another based on evidence. Scholars within this perspective present their conceptualizations without questioning their assumptions. It was identified a difference between scholars in this cultural sensibility and those from the socio-cultural one. Indeed, scholars from a socio-cultural cultural sensibility normally differentiate themselves from the individualistic by contrasting the assumptions from one or another perspective. Contrasting the individualistic scholars' statements with those selected in the next section reveal such difference.

ASSESSMENT FOR LEARNING WITHIN IBSE WITH SOCIO-CULTURAL CULTURAL SENSIBILITY

Assessment for learning within IBSE researching activity with a Socio-cultural cultural sensibility should follows another line of reasoning. The assumption, differentiating the researchers' work from that of those who follow the individualistic cultural sensibility, is that the child's development is guided by culture. In both cases, it is recognized that the interaction of the child with the environment produces learning but it is different since in the first one, there is a mechanism of adaptation of the living child, and in the second one, the development is guided by an appropriation of the cultural ways of experience. As showed in Chapter four, this line of thinking is often presented by

---

[…] the function of cognition is adaptative and it serves the organization of the experience of the world, not the discovery of an ontologic reality (see von Glasersfeld, 1995, p. 18).[87]

differentiation of the individualistic perspective. Let us start by reviewing Vygotzky's thoughts.

VYGOTSKY, (1978)

> TO SUMMARIZE, THE MOST ESSENTIAL FEATURE OF OUR HYPOTHESIS IS THE NOTION THAT DEVELOPMENTAL PROCESSES DO NOT COINCIDE WITH LEARNING PROCESSES. RATHER, THE DEVELOPMENTAL PROCESS LAGS BEHIND THE LEARNING PROCESS; THIS SEQUENCE THEN RESULTS IN THE ZONE OF PROXIMAL DEVELOPMENT. (P. 35).

VYGOTSKY, (1978)

> WE PROPOSE THAT AN ESSENTIAL FEATURE OF LEARNING IS THAT IT CREATES THE ZONE OF PROXIMAL DEVELOPMENT; THAT IS, LEARNING AWAKENS A VARIETY OF INTERNAL DEVELOPMENTAL PROCESSES THAT ARE ABLE TO OPERATE ONLY WHEN THE CHILD IS INTERACTING WITH PEOPLE IN HIS ENVIRONMENT AND IN COOPERATION WITH PEERS.
>
> ONCE THESE PROCESSES ARE INTERNALIZED, THEY BECOME PART OF THE CHILD'S INDEPENDENT DEVELOPMENTAL ACHIEVEMENT. (P. 35)
>
> THE ZONE OF PROXIMAL DEVELOPMENT [...] IS THE DISTANCE BETWEEN THE ACTUAL DEVELOPMENTAL LEVEL AS DETERMINED BY INDEPENDENT PROBLEM SOLVING AND THE LEVEL OF POTENTIAL DEVELOPMENT AS DETERMINED THROUGH PROBLEM SOLVING UNDER ADULT GUIDANCE OR IN COLLABORATION WITH MORE CAPABLE PEERS. (P. 86)

Scholars following this line of reasoning usually emphasize the difference of their interpretation from that made by socio-constructivists. For instance, it is apparently necessary to distinguish between the dominant individualistic interpretation of Vygotsky's ZPD from the cultural-historical interpretation. Roth and Radford criticized the individualistic perspective and at the end explained the other interpretation.

ROTH AND RADFORD, (2010)

> THAT IS, SUCH CONCEPTUALIZATIONS CONVEY A SUBSTANTIALIST APPROACH THAT THINKS LEARNING AS KNOWLEDGE ASSIMILATION AND COLLECTIVITY IN TERMS OF ENSEMBLES OF INDIVIDUAL ACTORS INTERACTING UNPROBLEMATICALLY. THEIR INTERACTION IS THEMATIZED THROUGH THE DUBIOUS PRISM OF THE DIFFERENCES OF WHAT HAPPENS WITHIN THE INDIVIDUAL CONSCIOUSNESS AND WHAT HAPPENS IN COLLECTIVE CONSCIOUSNESS —AS IF THEY COULD EXIST SEPARATELY.

> SPEAKING IS REDUCED TO THE INDIVIDUAL, SUBJECTIVE INTENTION OF THE SPEAKER, WHO, IN SPEAKING, IS CONSIDERED TO EXTERNALIZE IDEAS THAT HAVE PREVIOUSLY FORMED ON THE INSIDE. THE APPROACH IS SUBSTANTIALIST IN THAT IT TAKES SOME PRIOR SITUATION, INCLUDING THE INSTITUTIONAL POSITIONS OF THE PARTICIPANTS IN AN INTERACTION (I.E., TEACHER, STUDENT), AND USES IT TO MAKE CAUSAL ATTRIBUTION ABOUT THE EVENTS THAT ENSUE. BUT SUCH APPROACHES ARE UNSATISFACTORY GIVEN THAT THERE IS INSUFFICIENT ATTENTION TO THE CO-CONSTITUTIVE NATURE OF SUBJECTIVE CONSCIOUSNESS AND COLLECTIVE CONSCIOUSNESS. (P. 199)

Their criticism is that the individualistic approach does not pay attention to the co-constitutive nature of subjective consciousness and collective consciousness.

One of the researchers making a difference between cultural-historical perspective and Piaget's theoretical perspective is Vygotsky. His explanation helps to understand Roth and Radford's criticism. For him, Piaget's view of learning and development is different from his view:

VYGOTSKY, (1978)

> WE CONSIDER THAT THE TOTAL DEVELOPMENT RUNS AS FOLLOWS: THE PRIMARY FUNCTION OF SPEECH, IN BOTH CHILDREN AND ADULTS, IS COMMUNICATION, SOCIAL CONTACT. THE EARLIEST SPEECH OF THE CHILD IS THEREFORE ESSENTIALLY SOCIAL [...] EGOCENTRIC SPEECH EMERGES WHEN THE CHILD TRANSFERS SOCIAL, COLLABORATIVE FORMS OF BEHAVIOR TO THE SPHERE OF INNER-PERSONAL PSYCHIC FUNCTIONS. EGOCENTRIC SPEECH EMERGES WHEN THE CHILD TRANSFERS SOCIAL, COLLABORATIVE FORMS OF BEHAVIOR TO THE SPHERE OF INNER-PERSONAL PSYCHIC FUNCTIONS. (P. 35)

VYGOTSKY, (1978)

> THE DEVELOPMENTAL UNIFORMITIES ESTABLISHED BY PIAGET APPLY TO THE GIVEN MILIEU, UNDER THE CONDITIONS OF PIAGET'S STUDY. THEY ARE NOT LAWS OF NATURE, BUT ARE HISTORICALLY AND SOCIALLY DETERMINED. (P. 55)

The scholars' reasoning within the socio-cultural cultural sensibility is attached to this assertion. In each interactional moment, in a particular place, with circumstances determined historically and socially, the child transfers to the sphere of inner-personal psychic functions, those that he/she encounters in his/her social life. Researchers use this reasoning in their conceptualizations.

WERTSCH, MINICK, ARNS, (1999)

> EXPLANATION OF THE INDIVIDUAL'S ONTOGENESIS MUST BEGIN WITH AN EXAMINATION OF SOCIAL PHENOMENA (P. 152).
>
> […] SOCIAL PHENOMENA ARE GOVERNED BY A UNIQUE SET OF EXPLANATORY PRINCIPLES (P. 152),
>
> […] SOCIAL PHENOMENA CANNOT BE REDUCED TO THE SUM OF INDIVIDUAL PSYCHOLOGICAL PHENOMENA (P. 152),
>
> […] AT LEAST CERTAIN ASPECTS OF THE INDIVIDUAL'S PSYCHOLOGICAL FUNCTIONING ARE DETERMINED BY THESE SOCIAL PHENOMENA (P. 152).

In this kind of reasoning, it is recognized that it is relevant to understand social phenomena to follow the individual ontogenesis. The social realm is considered as governed by a unique set of explanatory principles. This is opposed to the individualistic thinking that reduces the social to the sum of individual psychological phenomena. It is emphasized that at least certain aspects of the individual's psychological functioning are determined by these social phenomena.

The interactions of individuals are in consequence conceived differently. The collective thinking emerges as relevant for understanding learning. Researchers within this line of reasoning see interaction as follows.

ROGOFF AND TOMA, (1997)

> SOCIAL INTERACTION AIDS COGNITIVE DEVELOPMENT WHEN PARTNERS ACTUALLY ENGAGE IN SHARED THINKING PROCESSES, NOT SIMPLY WHEN INDIVIDUALS ARE IN THE PRESENCE OF OTHER PEOPLE (P. 471).

JAMES, (2006)

> LEARNING IS BY DEFINITION A SOCIAL AND COLLABORATIVE ACTIVITY IN WHICH PEOPLE DEVELOP THEIR THINKING TOGETHER (P. 57)
>
> THINKING IS CONDUCTED THROUGH ACTIONS THAT ALTER THE SITUATION AND THE SITUATION CHANGES THE THINKING; THE TWO CONSTANTLY INTERACT.
>
> LEARNING IS A MEDIATED ACTIVITY IN WHICH THE CULTURAL ARTIFACTS HAVE A CRUCIAL ROLE (P. 57)

Interactions are viewed as helping cognitive development when partners are actually engaged in a shared thinking process. There is a collective activity in which people develop thinking together. Thinking and actions are connected in

such way that both are modified by the activity. The mediation characteristic of artifacts is part of this transformative process.

This is condensed in the following scholars' reasoning:

LAVE, (1996)

> THEORIES OF SITUATED ACTIVITY DO NOT SEPARATE ACTION, THOUGHT, FEELING, AND VALUE AND THEIR COLLECTIVE, CULTURAL-HISTORICAL FORMS OF LOCATED, INTERESTED, CONFLICTUAL, MEANINGFUL ACTIVITY. (P. 7)

RADFORD, (2008)

> THINKING IS A RE-FLECTION, THAT IS, A DIALECTICAL MOVEMENT BETWEEN A HISTORICALLY AND CULTURALLY CONSTITUTED REALITY AND AN INDIVIDUAL WHO REFRACTS IT (AS WELL AS MODIFIES IT) ACCORDING TO HIS/HER OWN SUBJECTIVE INTERPRETATIONS, ACTIONS AND FEELINGS. (P. 219)

Furthermore, the historically constituted reality is important in this collective thinking activity. The individual refracts such reality according to his or her interpretations, actions and feelings. This is, there is not only the social and collective thinking implicated in the interaction; the individual interpretation also alters the situation.

Within this panorama, scholars also use this reasoning to characterize the individuals' experiences.

SÄLJÖ, (1997)

> [...] CULTURE IN ITS MATERIAL AND DISCURSIVE COMPONENTS, MUST BE REGARDED AS GENETICALLY PRIOR TO INDIVIDUAL EXPERIENCE. BUT, EVEN MORE FUNDAMENTALLY, [...] COMMUNICATION—I.E., TALK (AND OTHER MEANS OF SYMBOLIC COMMUNICATION)—HAS PRIMACY OVER EXPERIENCE IN SOME CENTRAL RESPECTS: FOR THE INDIVIDUAL IT IS THE TOOL THROUGH WHICH WE LEARN TO "EXPERIENCE" AND TO CHARACTERIZE AND COMMUNICATE OUR EXPERIENCES. (P. 177)

Following the same line of thinking, culture is constituted by material as well as discursive components. The individual finds in the culture the resources to experience the world. That reasoning is used to make another interpretation about the ideas expressed by children in the interaction with natural and made worlds. Scholars differentiate their interpretation from the individualistic perspective.

SCHOULTZ, SÄLJÖ, AND WYDHAMN, (2001)

> INSTEAD OF VIEWING UNDERSTANDING AS THE OVERT EXPRESSION OF UNDERLYING MENTAL MODELS, CHILDREN'S RESPONSES IN INTERVIEW STUDIES SHOULD BE REGARDED AS SITUATED AND AS DEPENDENT ON THE TOOLS AVAILABLE AS RESOURCES FOR REASONING. BY MODIFYING THE INTERVIEW SITUATION THROUGH THE INTRODUCTION OF A GLOBE AS A TOOL FOR THINKING, THE OUTCOMES ARE RADICALLY DIFFERENT FROM THOSE REPORTED EARLIER. NONE OF THE PROBLEMS THAT HAVE BEEN REPORTED, WHERE CHILDREN, FOR INSTANCE, CLAIM THAT PEOPLE CAN FALL OFF THE EARTH, CAN BE DETECTED. EVEN AMONG THE YOUNGEST PARTICIPANTS GRAVITATION IS OFTEN INVOKED AS AN EXPLANATORY CONCEPT. IT IS ARGUED THAT THE GLOBE IN THIS CASE SERVES AS AN EFFICIENT PROSTHETIC DEVICE FOR THINKING, AND THIS ILLUSTRATES THE TOOL-DEPENDENT NATURE OF HUMAN REASONING. (P. 103)

As it is explained, the tools and available resources, as part of the culture in which the individuals are interacting, alter the situation. The traditional interpretation and modes of inquiry in the individualistic perspective are questioned. This idea is also used in the context of science teaching. Roth (2007) questioned the possibility of children having a scientific reasoning in their inner psyche.

ROTH, (2007)

> […] BECAUSE INTERPRETATION ARISES FROM THE INTERPLAY OF EXISTING UNDERSTANDINGS AND EXPERIENCED WORLD, WHAT ONE OBSERVES DEPENDS ON WHAT ONE ALREADY KNOWS. THIS MEANS THAT STUDENTS WHO DO NOT YET KNOW THE SCIENTIFIC PRINCIPLES WILL BE UNLIKELY TO SEE JUST WHAT THEIR INVESTIGATION IS TO SHOW, FOR THE VERY PRINCIPLES THAT ARE TO BE EXHIBITED ARE PREREQUISITE TO SEEING THE PHENOMENON THAT IS TO BE SEEN. AS A RESULT, STUDENTS PERCEIVE DIFFERENT WORLDS THAN TEACHERS MAKING SCIENCE LEARNING THROUGH DISCOVERY NEXT TO IMPOSSIBLE (P. 140)

ROTH, (2007)

> […] THE PHENOMENA STUDENTS CONSTRUCTED EMERGED FROM THE INTERTWINING OF DISCURSIVE AND PRACTICAL ACTIVITY, INTERACTIONS WITH OTHERS AND THE MATERIAL WORLD THAT WAS THE FOCUS OF THEIR ACTIVITIES. SEE THUS, IT IS NOT SURPRISING THAT STUDENTS' PHENOMENA OFTEN DID NOT CORRESPOND TO THOSE THE TEACHER WANTED THEM TO CONSTRUCT. (P. 166)

The different reasoning characterizing the socio-cultural cultural sensibility is found in those words. First, the construction of phenomenon is possible if during the activity participants know the scientific principles. Learners involved in investigations not necessarily observe a phenomenon expected to be seen. In that sense, principles and scientific reasoning are considered as part of cultural resources for thinking and knowing. The students' activity is constituted by the discursive and practical activity, the interaction with others and the material world, with the possibilities that those resources give in the living moment. In that sense, the child's existing ideas claimed in the individualistic perspective is questioned.

This line of thinking can also be found to look at assessment activity.

VYGOTSKY, (1986)

> [...] WE GIVE CHILDREN A BATTERY OF TESTS OR A VARIETY OF TASKS OF VARYING DEGREES OF DIFFICULTY, AND WE JUDGE THE EXTENT OF THEIR MENTAL DEVELOPMENT ON THE BASIS OF HOW THEY SOLVE THEM AND AT WHAT LEVEL OF DIFFICULTY. ON THE OTHER HAND, IF WE OFFER LEADING QUESTIONS OR SHOW HOW THE PROBLEM IS TO BE SOLVED AND THE CHILD THEN SOLVES IT, OR IF THE TEACHER INITIATES THE SOLUTION AND THE CHILD COMPLETES IT OR SOLVES IT IN COLLABORATION WITH OTHER CHILDREN-IN SHORT, IF THE CHILD BARELY MISSES AN INDEPENDENT SOLUTION OF THE PROBLEM- THE SOLUTION IS NOT REGARDED AS INDICATIVE OF HIS MENTAL DEVELOPMENT. THIS "TRUTH" WAS FAMILIAR AND REINFORCED BY COMMON SENSE. OVER A DECADE EVEN THE PROFOUNDEST THINKERS NEVER QUESTIONED THE ASSUMPTION; THEY NEVER ENTERTAINED THE NOTION THAT WHAT CHILDREN CAN DO WITH THE ASSISTANCE OF OTHERS MIGHT BE IN SOME SENSE EVEN MORE INDICATIVE OF THEIR MENTAL DEVELOPMENT THAN WHAT THEY CAN DO ALONE. (P. 32)

Vygotsky recognizes a tendency in psychology to give tests to the child in order to see the development of the child. For him, the development can be regarded as the possibilities of the child to participate with another, the adult, in the resolution of a task.

Scholars recognize a new tendency in assessment discourses considering socio-cultural learning theories as

JAMES, (2006)

> [...] NO LONGER SEEN AS PRIVATE ACTIVITY DEPENDENT LARGELY, IF NOT WHOLLY, ON AN INDIVIDUAL'S POSSESSION OF INNATE AND USUALLY STABLE CHARACTERISTICS SUCH AS

> GENERAL INTELLIGENCE. INTERACTION BETWEEN PEOPLE, AND MEDIATING TOOLS SUCH AS LANGUAGE, ARE NOW SEEN TO HAVE CRUCIAL ROLES IN LEARNING. THUS THE ASSESSMENT OF LEARNING OUTCOMES NEEDS TO TAKE MORE ACCOUNT OF THE SOCIAL AS WELL AS THE INDIVIDUAL PROCESSES THROUGH WHICH LEARNING OCCURS. (P. 48)

Scholars with a socio-cultural sensibility recognize more than the private activity dependent on individuals intelligence. Scholars use the word identity to move from this tendency and give an account of learning as a process that change individual's subjectivity. The needs for a social, as well as the individual processes, are approach by recognizing classroom everyday situation as social practice.

PRYOR AND CROSSOUARD (2008)

> FORMATIVE ASSESSMENT IS SEEN AS TAKING PLACE WHEN TEACHERS AND LEARNERS SEEK TO RESPOND TO STUDENT WORK, MAKING JUDGMENTS ABOUT WHAT IS GOOD LEARNING. HOWEVER, ACKNOWLEDGING LEARNING AS BEING BOUND UP WITH IDENTITY CONSTRUCTION (LAVE & WENGER, 1991; HOLLAND ET AL., 1998) IMPLIES THAT FORMATIVE ASSESSMENT INTERACTIONS INVOLVE ENABLING LEARNERS FIRST TO ENGAGE WITH NEW WAYS OF BEING AND ACTING ASSOCIATED WITH NEW, ASPIRATIONAL IDENTITIES; AND SECOND TO HAVE THESE RECOGNIZED AS LEGITIMATE, WHERE WHAT COUNTS AS LEGITIMATE IS STRONGLY FRAMED BY INSTITUTIONAL DISCOURSES AND ASSESSMENT DEMANDS. (P. 3)

COWIE, MORELAND AND OTREL-CASS (2013)

> ASSESSMENT FOR LEARNING ENCOMPASSES THOSE EVERYDAY CLASSROOM PRACTICES THROUGH WHICH TEACHERS, PEERS AND LEARNERS SEEK/NOTICE, RECOGNIZE AND RESPOND TO STUDENT LEARNING, THROUGH THE LEARNING, IN WAYS THAT AIM TO ENHANCE STUDENT LEARNING AND STUDENT LEARNING CAPACITY AND AUTONOMY. ASSESSMENT FOR LEARNING ALSO NEEDS TO BE REFLECTIVE OF, RESPONSIVE TO, AND BUILD ON FROM, HOW PARTICULAR DISCIPLINES GENERATE AND LEGITIMIZE MEANING. (P. 147)

Assessment for learning conceived from a socio-cultural perspective should move the focus from looking at individual possession of innate and usually stable characteristics of intelligence, towards a view considering interaction between people and mediating characteristics of tools as central in the assessment activity. There is a need to conceive assessment activity involving

social and individual activity through which learning is occurring. Furthermore, if learning is linked with the construction of identities, formative assessment should promote the engagement of children with new aspirational identities. The institutional discourse and assessment demands are expected to be part of the assessment activity with a socio-cultural perspective. There are also an emphasis on the differences among the disciplines generate and legitimize meaning.

Black and Wiliam (2006) developed a theory of formative assessment based on a socio-cultural view. They recognize two groups of elements:

BLACK AND WILIAM, (2006)

> THE FIRST GROUP CONSTITUTES THE SPHERE OF PRODUCTION – THE VISIBLE ACTIONS UNDERTAKEN WITHIN THE SYSTEM DIRECTED TOWARDS ACHIEVING THE DESIRED GOALS- BUT THESE ARE MERELY THE 'TIP OF THE ICEBERG'. UNDERLYING THESE ELEMENTS ARE THE *SOCIAL, CULTURAL AND HISTORIC* CONDITIONS WITHIN WHICH THE GOALS ARE SOUGHT, AND THESE TWO GROUPS OF ELEMENTS AND THE DIALECTIC BETWEEN THEM TOGETHER CONSTITUTE AN ACTIVITY SYSTEM. (P. 83)
>
> THE OVERALL MESSAGE SEEMS TO BE THAT IN ORDER TO UNDERSTAND THE DETERMINANTS OF EFFECTIVE FEEDBACK, OR BROADEN THE PERSPECTIVE WHILST DETECTING AND INTERPRETING INDICATORS OF EFFECTIVE REGULATION, WE WILL NEED THEORETICAL MODELS THAT ACKNOWLEDGE THE SITUATED NATURE OF LEARNING. (P. 91)

Scholars identify the actions undertaken within the system with desired goals. Those actions and respective goals need to be linked to social, cultural and historic conditions. These conditions and the existing dialectic with the goals of actions are identified as constituting an activity system. Furthermore, scholars acknowledge that to understand assessment activities such as effective feedback, or detecting and interpreting indicators of effective regulation, the construction of theoretical models that acknowledge the situated nature of learning is necessary.

Cowie, Moreland and Otrel-Cass (2013) contributed to the field of assessment for learning research. By exploring with teachers assessment for learning interactions, they claimed and documented three ideas.

COWIE, MORELAND AND OTREL-CASS (2013)

> "STUDENT LEARNING AUTONOMY IS PROMOTED WHEN TEACHERS DELIBERATELY PROVIDE OPPORTUNITIES FOR STUDENTS TO EXERCISE AGENCY WITHIN A SYSTEM OF ACCOUNTABILITIES TO PEOPLE AND THE DISCIPLINE". (P. 139)

> PRODUCTIVE ASSESSMENT FOR LEARNING INTERACTIONS "ARE SHAPED BY AND ARE REFLEXIVE OF THE WAY A PARTICULAR DISCIPLINE GENERATES AND WARRANTS KNOWLEDGE". (P. 139)
>
> PRODUCTIVE ASSESSMENT FOR LEARNING "IS EMBEDDED IN INTERACTIONS THAT ARE MULTIFACETED, MULTIMODAL AND TAKE PLACE OVER MULTIPLE TIME SCALES". (P. 139)

They identified several challenges for assessment research from a socio-cultural perspective. In particular, they found problematic to trace and document an individual's learning over time and across contexts. This challenge could be transformed in a research agenda that built a different view of learning where the collectivity of students is conceived as the unity of analysis, and the individual process of objectification-subjectivity framed within the social praxis.

During this study it was found those different attempts to change assessment for learning conceptualizations with a socio-cultural cultural sensibility. However it was not found a line of thinking developed for inquiry-based classroom. In the collaboration with teachers and students in New Zealand, Cowie, Moreland and Otrel-Cass (2013) conceptualized assessment for learning. The classrooms assessment activities were planed in science and technology subject matters. Their book has been published recently and there is not time to deeply analyze their ideas and incorporate them in a model for IBSE. It was not explored in their work if teachers, involved in this research, teach science and technology with IBSE principles. In the first version of the thesis, in Chapter eight, Carulla designed a simulation of an assessment classroom activity using socio-cultural cultural sensibility. There is a first attempt to understand assessment within an inquiry-based classroom.

CARULLA, (2011)

> FOR INSTANCE, IN THE EXAMPLE, REBECA EXPECTS TO INTRODUCE DENSITY AS A CONCEPT THAT WILL HELP STUDENTS TO CONSTRUCT A LANGUAGE CONFIGURATION, DIFFERENT FROM THE EVERYDAY LANGUAGE, SHAPING THE FACTS WITH THIS NEW TOOL AND CULTURAL ARTIFACT. SHE ALSO WILL TRY TO FIND OUT OTHER POSSIBLE LANGUAGE CONFIGURATIONS IN ORDER TO DISTINGUISH WITH THE CHILDREN HOW THOSE DIFFERENT LANGUAGES CAN BE USED TO REFER TO THE SAME FACTS. SHE THINKS THAT CHILDREN FROM THAT SCHOOL HAVE NOT THE SAME KIND OF SOCIAL EXPERIENCES THAN HER, THEN, SHE NEEDS TO EXPLORE THEIR LANGUAGES AND WAYS OF MAKING SENSE TO THE OBSERVED FACTS. IT IS ALSO THE WAY SHE ESTABLISHES A RESPECT RELATIONSHIP WITH STUDENTS —BY LISTENING THEIR EXPERIENCES, TAKING THEM INTO CONSIDERATION AND GIVING A NEW SENSE TO THE SITUATION. (P. 314)

In this example, Carulla recognized the diversity of languages that students encounter in their social activities. The meanings attributed in different social praxis to signs and things are considered as part of the assessment activity. Density is considered as a cultural artifact. This means that the meaning of this word changes from one social activity to other. It is also paying attention to the fact that there are different speech genders constituting social activities.

In the next section the implications of considering the socio-cultural cultural sensibility for conceptualize assessment for learning within IBSE are considered. The research problematique of this thesis aimed to understand the role played by socio-cultural conditions and theories of learning in the configuration of classroom assessment activities. This is to conceive teacher and students everyday activities as a social praxis. .

DISCUSSING A CULTURAL-HISTORICAL VIEW OF ASSESSMENT FOR LEARNING WITHIN IBSE

When adopting a socio-cultural cultural sensibility, and re-thinking the principles and ideas of assessment for learning within IBSE, three aspects should be considered. First, the focus of the assessment activity on the conceptualizations about assessment activity should change. In the IBSE individualistic perspective, as documented in Chapters five and eight, there is a tendency to focus learning as inner psychological changes. The theoretical constructs such skills, attitudes, and child ideas, and the indicators and questions characterizing these constructs support assessment activity and the observation of inner psychological changes. A cultural-historical perspective on assessment for learning within IBSE should change the focus towards the unity individual-activity-collectivity to recognize the link between the collective and the individual consciousness.

Second, assessment activity conceptualizations must consider the characteristics of everyday life of individuals. There are no static meanings and interpretations of learning and teaching situations across the classrooms, schools, districts, countries and continents. There are differences in forms of social relations, considerations and beliefs about knowledge, learning, thinking, diversity of perspectives and feelings. In that sense there is not an ideal model. Black and Wiliam in their review of 1998 explained that assessment for learning should be seen as a collection of principles, rather than steps to follow or a model of an ideal practice. The challenge is to capture the differences that are hidden when a cognitive approach is used. Assessment activity should be understood in connection with the school's educational system. Individuals in the classroom are located in an institution, living at the same time other

classroom situations, where the individual learns about forms of interactions and relations, and also diverse uses of artifacts. Skovsmose (2005) suggested a perspective on meaning that move from consider meaning of mathematical concepts towards a meaning linked to the task in the sphere of practice at school. In that sense, he recognizes meaning as a product of a social space where individuals' experience everyday social life.

In Chapter eight, a classroom assessment activity in an inquiry-based classroom was imagined having in mind socio-cultural assumptions, and the mentioned aspects. It was represented dimensions involved in the assessment activity. Here, the cultural-historical activity theory and the cultural knowledge representation of Radford and Empey (2007) were used to discuss further possibilities of investigating assessment for learning. First some reflections around the research problematique are developed. After that, some theoretical devices are presented and some implications of this research are discussed.

UNDERSTANDING THE PROBLEMATIQUE

During the last three years the Fibonacci IBSME (Inquiry Based Science and Mathematics Education) project developed several resources for teachers and teacher educators. These resources objectify what is expected from classroom activity that could be denominated as inquiry-based. As it is explained, the tools are constructed by people from several countries and were considered as successful to be used in different cultural environments:

> The *Tools for Enhancing Inquiry in Science Education* were designed to support the effective implementation of an inquiry-based approach to science teaching. The tools result from three years of collaborative work among science education researchers, science teacher trainers, and science teachers with different levels of experience in implementing inquiry-based science education. The production of these tools involved partners from six different European countries: France, Greece, Italy, Slovakia, Sweden, and the United Kingdom. The tools were trialled on four different occasions in classrooms and with teachers from the first five countries mentioned. These trials have shown that the tools are flexible enough to be adapted for use in various cultural and social contexts, and within various educational systems. [88](Borda-Carulla, 2012, p. 3)

The research problematique led me to question the ideal classroom representations presented in the artifacts of IBSE Network. Indeed, it was

88

questioned the every day of a classroom intending to follow the individualistic perspective when the educational culture of teacher and students has been in contradiction with these ideals. This point will be explained by looking at this collective effort to bring inquiry-based classroom activity to different educational cultures.

From a cultural-historical activity theory perspective, the assessment for learning activity within the inquiry-based classroom should be conceived as having an object/motive. Individuals immersed in the classroom practice construct collectively the object/motive. If this is objectified, it will be clearer for individuals how to contribute to the collective activity. The object/motive for individuals involved in the assessment for learning activity should be to objectify the quality of learning. It can be also the construction of meaning to the tasks in the way as Skovsmose (2005) proposes. The representation of activities should be explained in terms of artifacts and the use of them to construct reasoning and phenomena.

As documented in several chapters, in the individualistic perspective researchers objectify learning as a change of an individual's internal psychological processes —skills, science content, attitudes, declarative knowledge, procedural knowledge, or strategic knowledge. Thus, the object/motive is to make visible for individuals the expected change. This is for instance, to objectify changes of an individual's inquiry skills and knowledge content while the child is producing an explanation about phenomena supported by evidence. Each individuals' assessment actions have a specific goal: the individual answering a prompt with the goal of showing that he/she knows, the teacher representing criteria to judge the individual's performances and answers, feedback to move the internal psychological processes, or peers evaluating others' work with some shared indicators to understand the purpose of the activity. The students construct their identities as learners within this panorama (Cowie, 2005).

In that sense, researchers with an individualistic cultural sensibility produce artifacts to objectify the entities such as the individual's skills, content knowledge and attitudes. As documented in Chapter five, skills such 'raising questions' are declined in a set of indicators for following the individuals' learning changes: a student that is inquiring should ask questions during an inquiry activity —for instance, indicators such 'readily ask a variety of questions that can and cannot be investigated', 'participate effectively in discussing how their answers can be answered' (Harlen, 2006b), etc.

When assuming a cultural-historical activity theory perspective, learning could be objectified differently. The unity is not the internal subject's psychological space where intellectual processes are evolving. Instead, it is the *social space* where the individual is interacting with others and cultural objects. What is relevant is his or her engagement in those actions and the interactional

processes that are lived by the individual in those spaces. Thus, it is to objectify learning as a change in the social space where the individual is involved in a joint activity. The proposal here is to consider the social spaces of the individual in the inquiry-based classroom as the unity around which the assessment activity is conceived.

One of the tools conceived in the Fibonacci project brings information that lets imagine ideal interactions characterizing any classroom activity across countries. In order to support the reflections about assessment for learning activity within IBSE, it will be presented their description of skills. Our intention is to use them for looking at a socio-cultural perspective. Indeed, as part of our socio-cultural sensibility, based on the idea that that transformations and change in life is always based in what exist already. In order to do that, it was made a link between the expected individual's learning outcomes with interactions. It is take advantage of the situation that the skills are described in relation to the expected social interactions between children. In their tool, they present the skills developed through inquiry-based teaching:

Borda-Carulla (2012),

Group A: Skills concerned with social interaction

Collaboration with others means readiness to work together towards a common goal. In a restricted sense it means sharing materials, working in harmony beside others but not with them. In a fuller sense it involves a discourse among equals, the pooling of ideas, talents and abilities to achieve something which would not have been possible without a combined effort. It is important to pupils' cognitive as well as their social education to encourage them to work with, as opposed to only beside, others. Learning from others is a skill that is needed throughout life and involves developing willingness to listen and respond to others and to share ideas, attention and responsibility. (p. 17)

Borda-Carulla (2012),

Children in the early years tend to see things from one point of view – their own – and only gradually come to appreciate that others may see and interpret things differently. The ability to see a situation from several points of view is important in developing a more complete picture of what is happening; it is fostered if children work together and have to understand each others' ideas. In kindergarten this requires some structure set by the teachers to encourage children to listen to and respond to what others say. In the lower primary years children may take assigned roles in a shared activity. Gradually a more mature form of collaboration develops when the children see for themselves the value of working with others. Collaboration then comes from within the child rather than from an external requirement. They organise, negotiate and seek agreed solutions in relation to the process and outcomes of their activities. (p. 17)

An inquiry-based classroom activity should promote interaction of children working towards a common goal. Children should interact to achieve 'something' that is possible because of the collective work. There is an explicit intention to differentiate the individual work to the collective one. Furthermore the interactions are conceived to differentiate children's point of views about a situation. To work collectively towards a common goal as is declared in the IBSE document, it is important that children see such thing and understand the challenge, as well that see which kind of interaction is valued.

As explained, the focus of assessment for learning within IBSE is to support children development of skills and scientific ideas. To move from this perspective towards a cultural-historical perspective, it could be possible to

transform skill language and focus the attention on interactions. Rather than see individuals capacities or skills to interact with things and others in the world, it is proposed to objectify different language configurations to talk collectively about things in the world and social relations.

Borda-Carulla (2012),

Group B: Skills concerned with gathering information about the surrounding world

These are skills that are involved in interacting with things in the real world in order to question, explore and find out about them. This interaction is part of scientific inquiry, which is not complete until the information revealed is analysed, interpreted and explained, using skills considered in Group C below. Questioning is relevant at all stages of conducting an investigation, but particularly at the start. Young children ask all kinds of questions and, by being encouraged to do something to try to answer them, they will come to realise that many questions need to be reformulated so that they can be answered through investigation. Further development leads to recognition that different kinds of questions require different kinds of investigation. (p. 17)

Borda-Carulla (2012),

Skills of collecting evidence through observation gradually become more refined as children increasingly pay attention to relevant detail and use measuring instruments and other equipment to refine their observations. They realise when controls are needed in an investigation and can set up a fair test where appropriate – at first using a framework of questions and later through their own planning. They also progress in taking steps to ensure that results are as accurate as possible and repeat measurements where appropriate. (p. 17)

The challenge for a conceptualization of the assessment activity with a socio-cultural cultural sensibility is to transform skills language. The effort to describe the activity in which the individual is showing his or her skills should be transformed in a social activity which involve children and teacher making certain kind of questions, by using instruments to measure objects, to organize numbers in tables to observe patterns, to differentiate one kind of observation from other and so on. This implies also a different kind of social relations that should be part of the objectification, as well as forms of production.

A new perspective on assessment for learning should recognize that phenomenon, investigations, evidences, and all the artifacts constituting the classroom practice should be objectified in classroom as the constitution of collective thinking and meaning.

Borda-Carulla (2012),

Group C: Skills concerned with analysing and reasoning

These skills are used in making sense of what is found as a result of questioning, planning and collecting evidence. Analysing and concluding are often neglected, with activities terminating after a statement of 'results' rather than proceeding to trying to explain and understand what was found in terms of scientific ideas. In the early stages of developing these skills children may make predictions about what they expect to happen and then compare what they find with their prediction. They may notice patterns in their observations from which they draw simple conclusions.

Borda-Carulla (2012),

Group D: Skills concerned with communicating

These skills are grouped together because it is through attempting to make things understandable to others, or defending a point of view using evidence, that learners examine their ideas critically. Communication is two-way: on one hand, pupils using speech, writing, drawing or modelling to share their ideas; on the other hand, paying attention to information or arguments from others. Effective communication requires the use of appropriate vocabulary and knowledge of conventions for communicating information such as through symbols, graphs and tables.

During the time that they are learning to read and

The skills gradually become more developed as children's investigations become more varied and they use patterns and other data to draw conclusions. Explaining findings in terms of scientific ideas has a key role in using inquiry to develop children's understanding. They may use words or drawings to represent, or model, their ideas about what explains the events or phenomena under study. Progression shows in the care taken to ensure that conclusions are consistent with all the data and in recognising that there may be more than one explanation that fits the data. (p. 18)

write, children in the early years communicate their observations and findings in science through drawing and talking, gradually beginning to use appropriate words and annotating their drawings with the help of the teacher. Once able to read they can find information from simple texts as well as from illustrations. They progress to recording their observations and data systematically, becoming more able to select the most suitable form. They show understanding of scientific terms and use these in explaining their conclusions. They question each other about their conclusions and identify weaknesses in their own and others' arguments. (p. 18)

As explored in the thesis, phenomenon is not something that can be see by interacting with the natural and made worlds. For that it is needed particular trained subjectivity. Individuals reasoning, analyzing and communicating with cultural forms of language configure the phenomenon. The subjectivity must change in order to see phenomena and use all those cultural artifacts that make visible such thing.

Keitel and Kilpatrick (2005) recognize that communications are central in assessment processes:

> One type of communication occurs in the classroom when teachers attempt to assess what students have learned, either formally or informally. Any assessment activity involves communication between teacher and students about what is expected; what sorts of response constitute superior, acceptable, or unacceptable performance; and what the consequences are likely to be. Assessments tell students what mathematics learning is valued. They show the mathematics that the teacher or others think is important for the students to know and remember. They give students information and judgements about mathematics itself and about the students themselves as mathematics learners. (p. 114)

The assessment communication is recognized as those formal and informal interactions that shape subjectivity in a mathematics classroom. This kind of communication gives information to the participants in the activity of mathematical objects and about what means to be learner of mathematics. Further more, Cowie et al. (2013) recognized in the interactional assessment process that teacher and students "shared understanding of learning, as both an individual and collective responsibility and act are central to change" (p. 144).

Radford and Roth (2010) acknowledge that interaction should be conceptualized differently when a cultural-historical perspective is adopted.

> As may be expected, this sociocultural view of the social and the individual results in a different conception of interaction. Far from being a space of subjective experience, interaction constitutes for sociocultural theorists the social fabric of consciousness and thought. This is why the individual's cognition and the social realm are *coterminous.* For socioculturalists, the specifically human form of the psyche develops in interaction with others, interactions that change their form in the course of history, and, in so doing, change the very form and content of cognition. Cognition is historical and cultural (Radford, 2008b). (p. 5)

This different conception of interaction is what should be added to a socio-cultural view of assessment in IBSE. Assessment interactions shape the object/motive for a collectivity of students and teacher in the everyday life. The subjectivity is shape by this interaction in the classroom. Lets see two examples that can illustrate one interpretation of Radford and Roth (2010) ideas. Cowie (2005) presented some students comments about assessment interactions. In students comments it can be perceived a tendency to link understanding of concepts with characteristics of the individual:

A GIRL WITH 10 YEARS OLD

> THE WORST THING IS WHEN YOU ASK A QUESTION AND THEY [THE TEACHER] BELITTLES YOU IN FRONT OF EVERYONE AND GOES 'WEREN'T YOU LISTENING?' OR 'DON'T YOU UNDERSTAND THAT BY NOW? (P. 207)

A GIRL WITH 10 YEARS OLD

> I KEPT ON THINKING THAT I WOULD PUT UP MY HAND [AND ASK A QUESTION] BUT THEN SOMEONE ELSE WOULD PUT UP THEIR HAND AND THEY WOULD UNDERSTAND IT [THE DIFFERENCE BETWEEN MASS AND WEIGHT] PERFECTLY AND I THOUGHT 'WELL, EVERYONE ELSE PROBABLY UNDERSTANDS IT AND I DON'T'. THEN I'D LOOK STUPID IF I PUT UP MY HAND AND ASKED HER TO REPEAT IT. SHE [THE TEACHER] COULD HAVE ALREADY GONE OVER IT TEN TIMES SINCE I DIDN'T UNDERSTAND IT. I'D LOOK LIKE A [EXPLETIVE] FOR MAKING HER EXPLAIN IT ONCE AGAIN BECAUSE EVERYONE UNDERSTOOD IT.

A BOY WITH 9 YEARS OLD

> YOU NEED TO BE ABLE TO TRUST OTHERS, TO BE SURE THEIR REACTIONS WON'T BE TO MAKE FUN, TALK ABOUT OR THINK I AM STUPID. (P. 207)

The perception of those children let imagine the kind of assessment interactions that shape the classroom activity. The subjectivity of children is built up on that. In that sense, the individual can feel as lacking capacities to see what others are looking at. The last comment shows the social value give to make what is considered as mistakes for the boy in that classroom. If you do not see and you make a comment out of what the collectivity is looking at, then you seem to be stupid.

In another classroom, it can be perceived another kind of subjectivity shaped by the interactions in the classroom. In Chapter eight, it was use an event observed in a video of an inquiry-based classroom in Colombia. In the video, the teacher is asking questions to children and writing their answers in the blackboard. She was not telling if what they said was wrong or right; she was listening, asking questions, looking for their perspectives on the correctness or not of reasoning, and writing their answers. At least 15 children answered teacher's questions. One interaction in the collective activity called our attention. As presented in Chapter eight, a child tried to objectify an idea but he couldn't found the words to explain what he sees about an object floating in water. A girl support him:

A BOY WAS TRYING TO EXPLAIN SOMETHING, MOVING HIS HANDS, AND SAYING THAT

> THE OBJECT PUSHES DOWNWARDS AND THE LIQUID UP AND THEN THERE IS A KIND OF NIVELATION.

ANOTHER GIRL SUPPORTED HIM

> I THINK THAT WHAT HE WANTS TO SAY IS THAT WHEN THE OBJECT IS PUT INTO THE WATER, THE LIQUID, THERE IS A DOWNWARD FORCE OF THE OBJECT AND AN UPWARD FORCE OF THE WATER, CALLED THE ARQUIMEDES LAW, THIS IS, WHEN THE WATER PUSHES THE OBJECT UPWARDS AND THE OBJECT PUSHES DOWNWARDS SO THAT IT DOES NOT SINK.

This example can be seeing as another kind of collective interaction where the boy feels safe to speak and express with out feeling as an idiot or stupid. The girl was paying attention to what he was trying to communicate and transformed what he was expressing with a more sophisticated language. In the video it can be observed that the teacher was aware of and constantly objectified with children this kind of interaction. She often said to respects other ideas, or ways to speak.

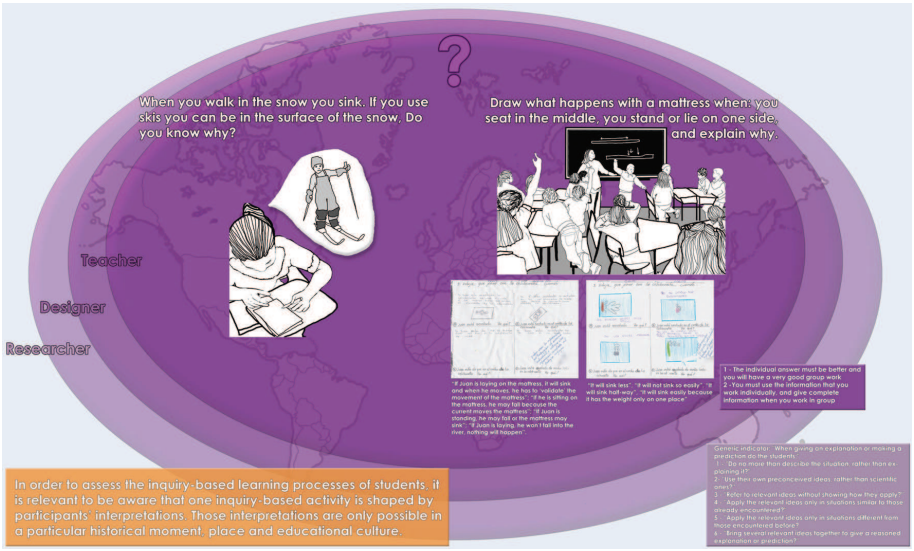
In Chapter seven, it was presented some events that called our attention when trying to make sense of society and culture in learning situations. What it was found was that the utilization of artifacts and tools in the everyday activity

of a classroom reveals the transformation of ideal models in the movement of everyday life. By becoming a socio-cultural researcher, it becomes possible to observe other things that are hidden when the subjectivity is shaped by the individualistic cultural sensibility.

From a socio-cultural perspective, the interaction and communication among the students and the teacher is considered as an interpretative process shaping and creating in situ the context for learning (Arvajal, 2012). Arvajal (2012) studied the role of students' experiences in the construction of meaning in the flux of everyday interactions. She used the notion of context as discursively constructed and direct the attention to the dynamic and interpretative nature of activities in the classroom, and considered that learners and teacher in a classroom situation shape and are shaped by the context being constructed in the flux of every day life. She mentions the implication of this considering the teacher and students as creators of the context "through discourse by reflecting and relying on the contextual resources" (p. 88). A cultural-historical perspective on assessment for learning within IBSE should consider contextual resources, viewed as the concrete activity, with the material, the learning activity, semiotic resources and socio-cultural conditions in which the learners are involved, and the background knowledge (see Arvajal, 2012).

Therefore, the tools and artifacts can be interpreted and transformed differently by individuals immersed in specific school practice. The question conceived by the teacher for a child in a country with seasons have not the same possibilities in Colombia where children never have contact with snow and skis. As illustrated in Chapter seven, the Colombian teacher transformed the question by using a mattress and by asking students to answer the question first in groups and then by observing the effects of being seating or lie in the middle of the mattress. Students' answers reveal different interpretations of the questions, and the interactions in the classroom made visible the differences between the ideal model interpreted by the researcher and interpreted by the teacher. These differences were only possible to perceive by this everyday experience in daily interaction and conversations. It is in these everyday interactions that subjectivity is constituted and transformed. To think assessment for learning within an inquiry based classroom should consider this flux of life changing meanings and interpretations of artifacts, and generating contextual resources as well as the context of learning.

The following picture is an attempt to communicate the complexity shaping the problematique. Teachers, students, researchers, teacher educators and curricula designers sharing artifacts that are used and transformed differently in those places were are introduced in the IBSE Network.



The historical moment, place and educational culture should be considered in any conceptualization of assessment for learning within IBSE. There is a need to understand how individuals involved in a process of subjectivity change can transform their initial subjectivity in another that open a door to a new cultural sensibility such IBSE. IBSE should also be modified, since the way is conceptualize is oriented with the individualistic perspective. It is proposed to see assessment for learning and IBSE focused on those social spaces that have been identified in Chapter eight. It is also relevant to consider the contextual resources that shape possibilities of discursive interactions.

EVERYDAY EXPERIENCE IN ASSESSMENT CONCEPTUALIZATIONS

Radford and Roth (2010) created the notion of joint action to represent the complexity of everyday life in the classroom. For them

> The *space of joint action* is more than a spatial notion where interaction would occur. It is a space of relations and embodied reciprocated tunings occurring in the concrete space of interaction. It is based on the *inseparability* of "consciousness-for-others" and "consciousness-for-myself" (Vygotsky, 1986, p. 256). This inseparability results from the possibilities for action, reflection, and emotion that language and other sensuous multimodal forms of communication, like touching, eye-contact, gesturing, and other embodied acts embed. (p. 5)

Communication and interaction in a classroom involves speech and also the body languages, the gestures, and the way at looking. The examples of students' perception in Cowie (2005) article illustrate this. For instance, it could be imagined the teacher stand up behind the child. The child interpreted this body gesture as follow:

> IT'S KIND OF NERVE WRACKING. CAUSE SHE'S LOOKING AT YOUR SHOULDER, AND YOU'RE GOING 'OH, NO, SHE'S READING THIS. OH NO, IT'S WRONG. IT'S WRONG. I'M WAY OFF. OH, NO, OH NO.'. AND WHEN SHE GOES AWAY YOU CAN GO 'YES'. IT'S LIKE SHE'S LOOKING AT YOUR WORK WHEN IT'S JUST HALF FINISHED. SHE'S NOT SEEING IT WHEN IT'S FINISHED. (GIRL, YEAR 8) (COWIE, 2005, P. 204)

The girl sensation and interpretation does not occur in her individuality, she learned that in her interactions with others in the classroom. For Radford and Roth (2010), the concept of *space of joint action* draws on the idea of the inseparability of consciousness and "stresses the fact that interaction is based on an evolving, tuning, and reciprocating of the participants' perspectives, making thinking a *collective* phenomenon". They conceive this space of joint action as a fabric "made up of bodily resonance and intercorporeal coordination accomplished at different levels: speech, posture, gestures, artifact- and sign-mediated actions, joint perception, etc." (p. 6)

The *social spaces of learning-in-otherness* were presented in Chapter eight as those interactional moments of the IBSE classroom environment where individuals are involved in a joint action with their object/motive: to learn something. *Subjective-learning-in-otherness-activity* is proposed as a construct to objectify the social space as the unity for assessment activity. This concept encloses several dimensions. First, it contains the movement of the subject in several interactional spaces during his/her process of learning —one example of such movement is presented in Chapter eight. Indeed, during the activity in which learning is happening, the subject realizes joint actions interacting with others and with artifacts. The individual has access to the contextual resources with the meanings that is collectively constructed. As Lave (1996) explained, socio-cultural theories of situated activity "do not separate action, thought, feeling, and value and their collective, cultural-historical forms of located, interested, conflictual, meaningful activity". The Learning-in-otherness interactional spaces can be defined as actions with goals aiming at the end the object/motive of the learning activity. Assessment activity should objectify what quality of learning participants envision in those spaces. What is relevant for the assessment activity is to objectify the individual's participation, as well as the collective thinking, during the actions in those different social spaces.

Second, it makes the institutional characteristics of the learning activity concrete. Indeed, any activity in the inquiry-based classroom is constrained by

the institutional setting in the historical moment when individuals are acting. For instance, in Chapter seven curricula decisions made by school administrators to follow a particular subject matter are shown. Inés could not use the assessment design with the researcher for the garbage curricula unity, since there were institutional needs that the teacher must be following: every 15 days there is an institutional test focused on the institutional curricula needs. At the same time, there are institutional forms of social relations as well as forms of production. Individuals interpret the situation based on their experience in school settings.

Third, it represents those interactional and dialogical spaces during the teaching and inquiry-based learning activity where individuals are constructing a joint meaning for the learning activity, the goals of actions and sharing the object/motive. In that sense, the assessment activity is such that individuals involved in the activity should be able to objectify the quality of learning.

Subjective-Learning-in-otherness-activity concept focuses the assessment for learning activity on the individual interaction in joint actions. Then, participants of the assessment activity must objectify the object/motive of the learning activity and the goals of actions. Inquiry activities in which the subject is involved can be defined as cultural activity where all the dimensions of cultural knowledge, defined by Radford and Empey, are awake. The subject is embedded in a classroom activity. The ideal of teaching by inquiry promotes forms of production —mathematical signs, argumentations, hypothesis, explanations, evidence, facts, phenomena, experimentation, investigation etc.—; forms of social relations —teacher, teacher-questioning, teacher showing the cultural knowledge, learner, leader of a group—; semiotic system of cultural significations —the epistemology of knowledge based on evidences, hypotheses and facts, communications using the accepted signs and reasoning—; and cultural knowledge —density, floating, sinking, quality of objects, forms of measuring—.

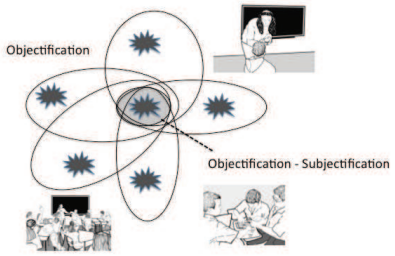
It is proposed here to see assessment activity with two purposes. First, the teacher should bring the Cultural Knowledge, Forms of Social Relation, Forms of Production, and Semiotic System of Cultural Significations into those spaces. The teacher is responsible of creating activities in which the individuals transform their subjectivity through these different dimensions. Second, the learners and the teacher should build forms of looking at the quality of those activities. Quality should be the object/motive guiding the assessment for learning activity. For that, it is important to bring to the social spaces differences of quality —for instance, by differentiating one or another work, by looking how things are expressed in books, etc. But quality is also the relations between the others, the respect and trust in others. The language and body communication should be part of this joint activity.

IMAGINIG A THEORETICAL CONSTRUCT

The construct of 'competence' has been used in education to bring the idea of learning as the possibilities of the individual to use knowledge in context (Jonnaert, 2002). Somehow, the term captures partially the idea of looking at the individual learning and the activity. However, it is separated of forms of social relations, from the constant changing of everyday life, and the institutional circumstances. It is used to build standards and to assess, example PISA. Accepting that the competence can measure by a test such PISA implies to deny all the dimensions involved in a social praxis.

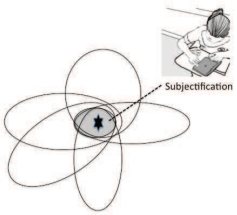
In this study it is proposed another idea: The term *subjective-Learning-in-otherness.* This object represents the movement of the individual from one to another learning-in-otherness space, the individual's participation in activities, the changes that emerge during the interaction, and the appropriation by the individual of novel forms of understanding. It is conceived as a constant epistemological movement of the individual while acting. Since assessment for learning is related to the classroom activity, there is not interest here on the transferability outside the classroom. The aim was to understand the everyday life in the classroom.

Let us see a representation of what could be the meaning for such object. Learners' joint action in each Learning-in-otherness space is represented by one ellipse. The intersection of the ellipses represents the movement from one to another space as something not clearly delimited. In the intersection of all spaces is the space-in-otherness own space, represented by a grey ellipse. This is to communicate the fact that the subject moves from one to another space. From participating in each joint action, learning of cultural knowledge emerges and the subjectivity change. The grey object represents the cultural knowledge (in the sense of Radford and Empey) circulating in those spaces.



Graph Nº 1. Representation of the individual process of objectification and subjectification

The grey object represents the cultural knowledge that should be objectified during the joint actions, but also those other things that shape the assessment interactions, such how to use others ideas, the possibilities or not to understand as different from being idiot or stupid. The objectification dimension appears as essential for the assessment activity. It is how individuals notice the cultural knowledge to be learnt and also the forms of production and forms of social relation. But noticing is not enough. It is relevant that the activity helps individuals to appropriate such cultural knowledge, forms of social relations, and forms of production. It is then how the subject is able to participate in the activity, and create something new with a new understanding. Assessment activity should pay attention to that. For instance, the individual understands the type of questions that are envisioned for inquiry, and also, understands the type of experimentations that give evidence to answer such question. At the same time, to understand the type of relations with other learners that is useful for knowing. In that sense, by all those interactions, finally the subject is subjectified. This is, the child is able to participate in a cultural determined form of acting in the classroom.



Graph 2. Representation of the construct subjective-learning-in-otherness

In conclusion, the concept 'subjective-learning-in-otherness', as represented above, involves different elements: diversity of spaces of joint action — individuals working together in different actions with goals aiming at the object to be learn—; a subject participating in joint actions and moving in those social spaces of inquiry-based classroom; cultural knowledge available in those spaces and contextual resources; and the subject being creative with such cultural knowledge —subjectification. Assessment for learning activity in an inquiry-based classroom should be conceived to support the process of objectification-subjectification of individuals.

FINAL REMARKS

The process of subjective change has opened different possibilities to think the assessment for learning activity in inquiry-based teaching with a cultural-historical activity theory perspective. In Chapter nine, some categories of the researcher's process of learning expressed the complexity involved in the change of subjectivity. In this chapter, assessment research has been objectified as a social activity that can be shaped by different cultural sensibilities. These different sensitivities constitute two distinct ways of reasoning in research about assessment for learning. Each way of reasoning becomes a particular epistemological form constructed by the researchers in their research activity.

The work in this thesis was located within the research field of assessment for learning. The present study is different from others in the sense that empirical research was not used with the purpose of describing and studying a reality. A critical perspective was adopted, where the researcher's practice was questioned from inside her individual experience. This is the humble contribution of the thesis to the field of practice of Inquiry Based Science Education and the projects that continue to grow in diversity of educational cultures. The challenge is how to transform the individualistic way of reasoning into a socio-cultural one. This is a big challenge since the researcher's subjectivity change has being a long process, that the researcher decided to accept, and that the researcher has been aware that style the individualistic sensibility is part of the researcher subjectivity. In that sense, the difficulties for practitioners to change their subjectivities must be understood as driven by socio-cultural and historical conditions of their social practice. It is suggested further empirical research that explores inquiry-based activities and assessment for learning considering alternatives that acknowledge the socio-cultural conditions of individuals and the historical conditions of social practices. The study also presents some bases to understand teachers' subjectivity change from the participation in current practices toward participating in IBSE practice.

REFERENCES

Abadi, S. (2007). *Pensamiento en Red. Una nueva disciplina para crear, realizar y vivir*. Buenos Aires: Editorial Temas.

Artigue, M. (1995). Ingenería didáctica. In M. Artigue, R. Douady, L. Moreno & P. Gómez (Eds.), *Ingeniería didáctica en educación matemática*. Bogotá.

Arvajal, M. (2012). Personal and shared experiences as resources for meaning making in a philosophy of science course. *Computer-Supported Collaborative Learning, 7*, 85-108.

Assessment-Reform-Group (2002). Research-based principles to guide classroom practice, 10 principles.

Atkin, J. M., Black, P., & Coffey, J. (Eds.). (2001). *Classroom assessment and the National Science Education Standards*. Washington, DC: National Academy Press.

Atweh, B. (2004). Understanding for Changing and Changing for Understanding. Praxis between Practice and Theory trough Action research in Mathematics Education. In P. Valero & R. Zevenbergen (Eds.), *Researching the Socio-Political Dimensions of Mathematics Education* (pp. 187-205). Boston: Kluwer Academic Publishers.

Bachelard, G. (1968). *The philosophy of no*. New York: Oriol.

Baquero, J. T., Blandón, C. R., Martinez, R., Castelblanco, Y., Cárdenas, F., Granés, J., et al. (2007). Fundamentación conceptual área de ciencias naturales. from Instituto Colombiano parea el Fomento de la Educación Superiror - ICFES -: http://www.colombiaaprende.edu.co/html/competencias/1746/articles-292351_recurso_1.pdf

Biggs, J. (2003). *Teaching for Quality Learning at University*. Buckingham: Open University Press.

Binet, A. (1857). *Mind and Body*. London: k. Paul, Trench, Trübner & co. ltd.

Birnbaum, J. (2010). Mon Zombie et moi. La philosophie comme Fiction. *Le monde,* p. 350,

Black, P., Harrison, C., Lee, C., Marshall, B., & Wiliam, D. (2003). *Assessment for Learning. Putting it into practice*. New York: Open University Press.

Black, P., & Wiliam, D. (1998a). Assessment and classroom learning. *Assessment in Education, 5*(1), 7-71.

Black, P., & Wiliam, D. (1998b). *Inside the Black Box: Raising standards through classroom assessment*. London: King's College.

Black, P., & Wiliam, D. (2006). Developing a theory of Formative Assessment. In J. Gardner (Ed.), *Assessment and Learning*. London: SAGE Publications Ltd.

Bloom, B. S., Hastings, J. T., & madaus, G. F. (Eds.). (1971). *Handbook on the formative and summative assessment*. New York: McGraw-Hill.

Boillot, H. (2004). *25 mots clés de la philosophie*. La Fleche: Broad & Taupin.

Borda-Carulla, S. (Ed.). (2012). *Tools for Enhancing Inquiry in Science Education*. Paris: Fibonacci.

Bursztejn, C. (2008). Dévelopment social et intersubjectif. In B. Golse (Ed.), *Le développpment affectif et intellectuel de l'enfant* (pp. 257-266). Issy-les-Moulineaux Elsevier Masson S.A.S.

Carulla, C. (2011). *Assessment for learning in inquiry based science education: From individualistic to socio-cultural perspectives* Aalborg University Aalborg.

Carulla, C., Duque, M., Molano, A., & Hernández, J. T. (2006). Trends in Pre-College Engineering and Technology Education and Pequeños Científicos Program. *Int. J. Engng Ed., 23*(1), 9-14.

Center-For-Science-Mathematics-and-Engeneering (1998). *Every Child a Scientist. Achieving Scientific Literacy for All*. Washington, DC: National Academy Press.

Center-For-Science-Mathematics-and-Engeneering (2000). *Inquiry and the National Science Education Standards*. Washington, DC: National Academy of Sciences.

Chronaki, A. (2004). Researching the school mathematics culture of 'others'. Creating a Self-Other Dialogue. In P. Valero & R. Zevenbergen (Eds.), *Researching the Socio-Political Dimensions of Mathematics Education* (pp. 145-165). Boston: Kluwer Academic Publishers.

Claparède (1926). *Psychologie de l'enfant et pédagogie experimental*. Genève: Kundig.

Cobern, W. W., & Aikenhead, G. S. (1998). Cultural Aspects of Learning Science. In B. J. Fraser & K. G. Tobin (Eds.), *International Handbook of Science Education*. Great Britain: Kluwer Publishers.

Compte-Sponville, A. (2001). *Dictionnaire philosophique*. Paris: Presses universitaires de France.

Cotton, T., & Hardy, T. (2004). Problematizing culture and discourse for mathematics education research. Deffining the issues; tools for research. In P. Valero & R. Zevenbergen (Eds.), *Researching the Socio-Political Dimensions of Mathematics Education* (pp. 85-103). Boston: Kluwer Academic Publishers.

Cowie, B. (2005). Student commentary on classroom assessment in science: a socio-cultural interpretation. *International Journal of Science Education, 27*(2), 199-214.

Cowie, B., Moreland, J., & Otrel-Cass, K. (2013). *Expanding Notions of Assessment for Learning. Inside Science and technology Primary Classrooms*. Rotterdam: Sense Publishers.

Cronin-Jones, L. L. (2006). Science teacher beliefs and their influence on curriculum implementation: Two case studies. *Journal of Research in Science Teaching, 28*(3), 235-250.

Daston, L., & Galison, P. (2010). *Objectivity*. New York: Zone Books.

Denzin, N. K., & Lincoln, Y. S. (2003). Preface. In N. K. Denzin & Y. S. Lincoln (Eds.), *The Landscape of Qualitative research. Theories and Issues*. London: SAGE Publications.

Descartes, R. (2008). *Discours de la méthode*. Paris: Flammarion.

Dezin, N. K., & Lincoln, Y. S. (Eds.). (2003). *The Landscape of Qualitative research. Theories and Issues*. London: SAGE Publications.

Donovan, S., & Bransford, J. D. (2005). Introduction. In S. Donovan & J. D. Bransford (Eds.), *How Students Learn: Mathematics in the classroom*. Washington, D.C.: The National Academies Press.

Douady, R. (1986). Jeux de cadres et dialectique outil-objet. *Recherches en Didactique des Mathématiques, 7*(2), 5-31.

Duit, R. (1996). The constructivism view in science education What it has to offer and what should not be expected from it. *Investigacaoes em Ensino de Ciencias, 1*(1), 40-75.

Duit, R., & Treagust, D. F. (2003). Conceptual change: A powerful framework for improving science teaching and learning. *International Journal of Science Education, 25*(6), 671 - 688.

Duschl, R. (2000). Making the nature of science explicit. In R. Milar, J. Leach & J. Osborne (Eds.), *Improving science education* (pp. 187-206). Buckingham: Open University Press.

Duschl, R. (2003). Assessment of Inquiry. In J. M. Atkin & J. Coffey (Eds.), *Everyday Assessment in Science Classrooms*. Washington DC: NSTA Press.

Duschl, R., & Gitomer, D. H. (1997). Strategies and Challenges to Changing the Focus of Assessment and Instruction in Science Classrooms. *Educational Assessment, 4*(1), 37-73.

Engeström, Y. (1987). *Learning by expanding: an activity-theoretical approach to developmental research*. Helsinki: Orienta-Konsultit Oy.

Engeström, Y. (1996). Developmental studies of work as a testbench of activity theory: The case of primary care medical practice. In S. Chaiklin & J. Lave (Eds.), *Understanding practice* (pp. 64-103). Cambridge: Cambridge University Press.

Engeström, Y., Miettinen, R., & Punamäki, R.-L. (Eds.). (1999). *Perspectives on Activity Theory*. Cambridge: Cambridge University Press.

Fairclogh, N. (2001). *Language and power*. Harlow: Longman- Pearson Eduaction.

Fairclough, N. (1992). *Discourse and Social Change*. Cambridge: Polity Press.

Fairclough, N. (2001). *Language and power*. Harlow: Longman- Pearson Eduaction.

Furtak, E. M., & Ruiz-Primo, M. A. (2007). *Studying the effectiveness of four types of formative assessment prompts in providing information about students' understanding in writing and in discussions*. Paper presented at the AERA annual Meeting.

Furtak, E. M., & Ruiz-Primo, M. A. (2007). *Studying the effectiveness of four types of formative assessment promts in providing information about students' understanding in writing and in discussions*. Paper presented at the AERA Annual Meeting.

Gee, J. P., & Green, J. L. (1998). Discourse analysis, learning, and social practice: A methodological study. *Review of Research in Education, 23*, 119-169.

Gipps, C. (1999). Socio-Cultural Aspects of Assessment. *Review of Research in Education, 24*, 355-392.

Godin, C. (2007). *La Philosophie pour les nuls*. Paris: First Editions.

Harlen, W. (2004). *Evaluating Inquiry-Based Science Developments. A Paper Commissioned by the National research Council in Preparation for a Meeting on Status of Evaluation of Inquiry-Based Science Education*: National Academies.

Harlen, W. (2006a). Assessing for Learning Facilitator's Guide. Workshop I: Introduction to Formative Assessment, from www.exploratorium.edu/ifi/workshops

Harlen, W. (2006b). Assessing for learning Facilitator's Guide. Workshop II: Assessing process skills Available from www.exploratorium.edu/ifi

Harlen, W. (2006c). Assessing for Learning Facilitator's Guide. Workshop III: Effective Questioning Available from www.exploratorium.edu/ifi/workshops

Harlen, W. (2006d). Assessing for Learning Facilitator's Guide. WorkshopIV: Assessing science ideas Available from www.exploratorium.edu/ifi

Harlen, W. (2006e). *Teaching, learning and assessing science 5-12* (Fourth ed.). London: SAGE Publications.

Harlen, W. (2007). *Implications of IBSE for curriculum content, student assessment and program evaluation*. Paper presented at the Colombian Science Academy.

Harlen, W., & Crick, R. D. (2002). A systematic review of the impact of summative assessment and tests on students' motivation for learning (EPPI-Centre Review, versio 1.1) *research Evidence in Education Library* (Vol. Issue 1). London: EPPI-Centre, Social Science Research Unit, Institute of Education.

Henriksen, L. B., Nørreklit, L., Jørgensen, K. M., & O'Donnell, D. (2004). *Dimensions of Change: Conceptualising Reality in Organisational Research*. Copenhagen: Copenhagen Business School Press.

IAP-working-Group (2006). *Report of the Working Group on International Collaboration in the Evaluation of Inquiry-Based Science Education (IBSE) programs*.

Inter-Academic-Panel (2011). IAP Science Education Program, from http://www.interacademies.net/Activities/Projects/12250.aspx

James, M. (2006). Assessment, Teaching and Theories for Learning. In J. Gardner (Ed.), *Assessment and Learning* (pp. 47-60). London: SAGE Publications.

James, W. (1907). *Pragmatism: A new name for some old ways of thinking*. New York: Longman Green and Co.

Jonnaert, P. (2002). *Compétences et socioconstructivisme. Un cadre théorique*. Bruxelles: Éditions De Boeck Université.

Kaartinen, S., & Kumpulainen, K. (2002). Collaborative inquiry and the construction of explanations in the learning of science. *Learning and Instruction, 12*(2), 189-212.

Kanselaar, G. (2002). *Constructivism and socio-constructivism*. Utrecht: Utrecht University.

Keitel, C., & Kilpatrick, J. (2005). Mathematics Education and Common Sense. In J. Kilpatric, C. Hoyles, O. Skovsmose & P. Valero (Eds.), *Meaning in Mathematics Education* (Vol. 37, pp. 105-126). New York: Springer.

Kincheloe, J. L., & McLaren, P. (2005). Rethinking critical theory and qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.), *The Sage Handbook of Qualitative research Third edition* (pp. 303-342). Thousand Oaks: Sage Publications.

Klein, É. (1994). *Conversations avec le sphinx. Les paradoxes en physique*. Paris: Albin Michel.

Krieger, S. (1991). *Social science & the selfe. Personal Essays on an Art Form*. New Brunswick: Rutgers University Press.

Lagemaat, R. V. d. (2006). *Theory of knowledge*. Cambridge: Cambridge University Press.

Lave, J. (1988). *Cognition in practice*. Cambridge: Cambridge University Press.

Lave, J. (1996). The practice of learning. In S. Chaiklin & J. Lave (Eds.), *Understanding practice. Perspectives on activity and context* (pp. 3-34). Cambridge: Cambridge University Press.

Lave, J., & Wenger, E. (1991). *Situated Learning. Legitimate Peripheral Participation*. Cambridge: Cambridge University Press.

Law, S. (2008). *La philosophie*. Paris: Grund.

Leach, J., & Scoth, P. (2003). Individual and Sociocultural Views of Learning in Science Education. *Science & Education, 12*, 91-113.

Lemke, J. L. (2001). Articulating communities: Sociocultural perspectives on science education. *Journal of research in science teaching, 38*(3), 296-316.

Leontyev, A. N. (2009). Activity and Consciousness. from Marxists Internet Archive:

Leung, F. K. S. (1998). The implications of Confucianism for Education Today. *Journal of Thought*(Summer 1998), 25-36.

Luft, J. A., & Roehrig, G. H. (2007). Capturing Science Teachers' Epistemological Beliefs: The Development of the Teacher Beliefs Interview. *Electronic Journal of Science Education, 11*(2), Retrieved from http://ejse.southwestern.edu.

Magnusson, S. J., Templin, M., & Boyle, R. A. (1997). Dynamic Science Assessment: A New Approach for Investigating Conceptual Change. *Journal of the Learning Sciences, 6*(1), 91-142.

Mäkitalo, A., Jacobsson, A., & Saljö, R. (2009). Learning to Reason in the context of Socioscientific Problems: Exploring the Demands on Students in New Classroom Activities. In K. Kumpulainen, C. E. Hmelo-Silver & M. César (Eds.), *Investigating Classroom Interaction* (pp. 7-26). Rotterdam: Sense Publishers.

Mäkitalo, A. s., Jakobsson, A., & Säljö, R. (2009). Learning to Reason in the Context of Socioscientific Problems: Exploring the Demands on Students in "New" Classroom Activities. In K. Kumpulainen, C. E. Hmelo-Silver & M. César (Eds.), *Investigating Classroom Interaction. Methodologies in Action* (pp. 7-26). Rotterdam: Sense Publishers.

Mansour, N. (2009). Science Teachers' Beliefs and Practices: Issues, Implications and Research Agenda. *International Journal of Environmental & Science Education 4*(1), 25-48.

Mercer, N., Dawes, L., & Wegerif, R. (2004). Reasoning as a scientist: ways of helping children to use language to learn science. *British Educational Research Journal, 30*(3), 359-377.

Merleau-Ponty (2002). *Phenomenology of Perception* (First ed.). New York: Routledge.

Ministerio-de-Educación-Nacional-MEN (Ed.). (2006). *Estándares Básicos de Competencias*. Bogotá: Imprenta Nacional de Colombia.

Monash-University (2007). Writing a research thesis. WEB: Monach University Education.

National-Academy-of-Sciences (1995). *National Science Education Standards* Washington, DC: National Academy Press.

National-Research-Council-NRC (1996). National Science Education Standards. In N. A. o. Sciences (Eds.) Available from http://books.nap.edu/html/nses/pdf/index.html (1 of 7) [27/12/2001 12:57:32 p.m.]

OECD (2009). *Education Today, The OECD Perspective*: OECD.

Padania, S. (2010). Adam Phillips by Sameer Padania. *Bomb 113*.

Pais, A., & Valero, P. (2012). Researching research: mathematics education in the Political. *Educational Studies in Mathematics, 80*(1), 9-24.

Pellegrino, J. W., Chudowsky, N., & Glaser, R. (2002). *Knowing What Students Know:*

The Science and Design of Educational Assessment. Washington: National Academies Press.

Perrenoud, P. (1998). From formative evaluation to a controlled regulation of learning processes. Towards a wider conceptual field. *Assessment in Education, 5*(1), 85-102.

Piaget, J. (2001). *The psychology of intelligence*. New York: Routledge.

Piaget, J. (2004). *The Language and Thought of the Child*. London: Routledge.

Piaget, J., & Inhelder, B. (1966). *La psychologie de l'enfant*. Paris: PressesUniversitaires de France.

Pomeroy, D. (1993). Implications of Teachers' Beliefs about the Nature of Science: Comparison of the Beliefs of Scientists, Secondary Science Teachers, and Elementary Teachers. *Science Education, 77*(3), 261-278.

Pons, P. (2011). Haruki Murakami, écrivain universel. *Le Monde Week-end, 12 février*.

Popkewitz, T. (2004). School subjects, politics of knowledge, and projects of intellectuals in change. In P. Valero & R. Zevenbergen (Eds.), *Researching the Socio-Political Dimensions of Mathematics Education* (pp. 251-267). Boston: Kluwer Academic Publishers.

Popkewitz, T. S., & Brennan, M. (1997). Restructuring of social and political theory in education: Foucault and a social epistemology of school practices. *Educational Theory, 47*(3), 287-313.

PRIMAS (2011). PRIMAS, from http://primas-event.ph-freiburg.de/

Pryor, J., & Crossouard, B. (2008). A socio-cultural theorisation of formative assessment. *Oxford Review of Education, 34*(1), 1-20.

Radford, L. (2002). Culture and cognition. Towards an anthropology of mathamatical thinking. In L. D. English, M. Giuseppina & B. Bussi (Eds.), *Handbook of international research in mathematics education* (pp. 439-462): Lawrence Erlbaum Associates.

Radford, L. (2008). The ethics of being and knowing: Towards a cultural theory of learning. In L. Radford, G. Schubring & F. Seeger (Eds.), *Semiotics in Mathematics Education: Epistemology, History, Classroom, and Culture* (pp. 215-234). Rotterdam: Sense Publishers.

Radford, L., & Empey, H. (2007). Culture, Knowledge and the Self: Mathematics and The Formation of New Social Sensibilities in the Renaissance and Medieval Islam. *Revista Brasileira de História de Matemática, Especial nº 1*, 231-254.

Radford, L., & Roth, W.-M. (2010). Intercorporeality and Ethical Commitment: An Activity Perspective on Classroom Interaction. *Educational Studies in Mathematics, Online First*.

Rogers, R. (2004). *Critical Discourse Analysis in Education*. Mahwah: Lawrence Erlbaum Associates.

Rogoff, B. (1999). Introduction: Thinking and Learning in Social Context. In B. Rogoff & J. Lave (Eds.), *Everyday Cognition. Development in Social Context* (pp. 1- 8). New York: President and Fellows of Harvard College.

Rogoff, B., & Toma, C. (1997). Shared Thinking: Community and Institutional Variations. *Discourse Processes, 23*, 471-497.

Rojas-Drummond, S., & Mercer, N. (2003). Scaffolding the development of effective collaboration and learning. *International Journal of Educational Research, 39*, 99-111.

Rojas-Urrego, A. (2002). L'adolescent et l'autre dans le mythe de narcisse. In M. Corcos (Ed.), *Babel. Psychanalyse et litérature* (pp. 117-146). Paris.

Rojas-Urrego, A. (2009a). *Introducción a la discusión del encuentro didáctico "Realidad Psíquica. Concepto y vivencia"*. Paper presented at the Encuentro diáctico de la Sociedad Colombiana de Psicoanálisis : Realidad Psíquica. Concepto y vivencia.

Rojas-Urrego, A. (2009b). *Introducción a la discusión del encuentro didáctico "realidad Psíquica. Concepto y vivencia"*. Paper presented at the Encuentro didáctico Sociedad Colombiana de psicoanálisis octubre 3 de 2009.

Rojas-Urrego, A. (2012). *Déceptions et conquêtes à l'adolecence. Devenir soi parmi les autres*. Paper presented at the Conférence. La différence... un défi de la vie ? Comment faire de ma différence une force ? Journée de formation continue des médiatrices et médiateurs scolaires.

Roth, W.-M. (2005a). Ethnomethodology and the R/Evolution of Science Education. *Canadian Journal of Science, Mathematics and Technology Education (CJSMTE), 5*(2), 17-30.

Roth, W.-M. (2006a). In search of understanding. In K. Tobin & W.-M. Roth (Eds.), *The culture of science education* (pp. 59-71). Rotterdam: Sense Publishers.

Roth, W.-M. (2006b). *In search of understanding. Or a career as an Emergent Phenomenon*: Sense Publishers.

Roth, W.-M. (2007). *In search of Meaning and Coherence*. Rotterdam: Sense Publishers.

Roth, W.-M. (2009). Specifying the ethnomethodological "what more?". *Cultural Studies of Science education, 4*, 12.

Roth, W.-M. (2012). *First-Person Methods*. Rotterdam: Sense Publishers.

Roth, W.-M. (Ed.). (2005b). *Auto/Biography and Auto/Ethnography*. Rotterdam: Sense Publishers.

Roth, W.-M., & Radford, L. (2010). Re/thinking the Zone of Proximal Development (Symmetrically). *Mind, Culture, and Activity, 17*, 300-307.

Roth, W.-M., & Radford, L. (2011). *A Cultural-Historical Perspective on Mathematics Teaching and Learning*. Rotterdam: Sense Publishers.

Rousillon, R. (2002). Réalité psychique. In A. D. Mijolla (Ed.), *Dictionnaire International de la Psychanalise*. Paris: Calmann - Lévy.

Ruiz-Primo, M. A. (2007). Assessment in Science and Mathematics: Lessons Learned. In M. Hoepfl & M. R. LIndstrom (Eds.), *Assessment of technology Education*. Chicago: Mc Graw Hill.

Ruiz-Primo, M. A., & Furtak, E. M. (2006). Exploring Teachers' Informal Formative Assessment Practices and Students' Understanding in the context of Scientific Inquiry. *Journal of research in science teaching, 44*(1), 57-84.

Ruiz-Primo, M. A., Li, M., Tsai, S.-P., & Schneider, J. (2007). *Exploring the effects of Constructing Scientific Explanations on Student Learning*. Paper presented at the AERA Annual Meeting.

Russ, J. (2004). *Dictionnaire de philosophie*. Paris: Bordas.

Säljö, R. (1997). Talk as Data and Practice-a critical look at phenomenographic inquiry and the appeal to experience. *Higher Education Research & Development, 16*(2), 173 - 190.

Saltiel, E. (2006). Methodological Guide. Inquiry Science Education Applying it in the Classroom, from http://www.pollen-europa.net/?page=%2Bag%2BXQhDnho%3D

Schawandt, T. A. (2003). Three Epistemological Stances for Qualitative Inquiry. Interpretivism, Hermeneutics, and Social Constructionism. In N. k. Dezin & Y. S. Lincoln (Eds.), *The Landscape of Qualitative Research. Theories and Issues*. London: SAGE Publications.

Schoultz, J., Säljö, R., & Wydhamn, J. (2001). Heavenly Talk: Discourse, Artifacts, and Children's Understanding of Elementary Astronomy. *Human Development, 44*, 103-118.

Schoultz, J., Säljö, R., & Wyndhamn, J. (2001). Conceptual knowledge in talk and text: What does it take to understand a science question? *Instructional Science 29*, 213-236.

Sfard, A. (2008). *Thinking as communicating. Human development, the growth of discourses, and mathematizing*. Cambridge: Cambridge University Press.

Shavelson, R. J., Young, D. B., Ayala, C., Brandon, P., Furtak, E. M., Ruiz-Primo, M. A., et al. (2008). On the Impact of Curriculum-Embedded Formative Assessment on Learning: A collaboration between Curriculum and Assessment Developers. *Applied Measurement in Education, 21*(4), 295-314.

Shepard, L. A. (2000). The Role of Assessment in a Learning Culture. *Educational Researcher, 29*(7), 4-14.

Sherman, W. (2004). Science studies, situatedness, and instructional design in science education: A summary and critique of the promise. *Canadian Journal of Science, Mathematics, and Technology Education, 5*, 443-465.

Skovsmose, O. (2005). Meaning in Mathematics Education. In J. Kilpatric, C. Hoyles, O. Skovsmose & P. Valero (Eds.), *Meaning in Mathematics Education* (Vol. 37, pp. 83-100). New York: Springer.

Skovsmose, O. (2009). *In Doubt –about Language, Mathematics, Knowledge and Life-Worlds*. Rotterdam: Sense Publishers.

Skovsmose, O., & Borba, M. (2004). Research methodology and critical mathematics. In P. Valero & R. Zevenbergen (Eds.), *Researching the Socio-Political Dimensions of Mathematics Education* (pp. 207-226). Boston: Kluwer Academic Publishers.

Stobart, G. (2006). The validity of Formative Assessment. In J. Gardner (Ed.), *Assessment and Learning*. London: SAGE Publications Ltda.

Suárez, S., Roa, M., Beltran, M., Pantoja, R. M., Carrillo, Y. E., Rubiano, C. I., et al. (2003). Percibir el mundo con los cinco sentidos. In A. Usón (Ed.), *Emociones y Razones para Innovar en la Enseñanza de las Ciencias*. Bogotá: IDEP - Instituto para la Investigación Educativa y Desarrollo Pedagógico.

Unidad-Curriculo-y-Evaluación-MEN (2006). *Evaluación para el aprendizaje. Enfoque y materiales prácticos para lograr que sus estudiantes aprendan más y mejor*. Santiago de Chile: Ministerio de Educación República de Chile.

Unidad-Curriculo-y-Evaluación-MEN (2009). *Evaluación Para el Aprendizaje: Eduación Básica Primer Ciclo. Enfoque y materiales prácticos para lograr que sus estudiantes aprendan más y mejor*: Ministerio de Educación, República de Chile.

Valero, P. (2004a). Postmodernism as an attitude of critique to dominant mathematics education research. In M. Walshaw (Ed.), *Mathematics education within the postmodern* (pp. 35-54). Greenwich (USA): Information Age.

Valero, P. (2004b). Socio-Political perspectives on mathematics education. In P. Valero & R. Zevenbergen (Eds.), *Researching the Socio-Political Dimensions of Mathematics Education* (pp. 5-24). Boston: Kluwer Academic Publishers.

Valero, P. (2007). Discourses of Power in Mathematics Education Research: Concepts and Possibilities for Action. *PNA, 2*(2), 43-60.

Valero, P. (2013). *Mathematics for all and the promise of a bright future*. Paper presented at the 8th Congress of European Research in Mathematics Education (CERME 8).

Valero, P., & Zevenbergen, R. (2004a). Setting the scene of this book. In P. Valero & R. Zevenbergen (Eds.), *Researching the Socio-Political Dimensions of Mathematics Education* (pp. 1-4). Boston: Kluwer Academic Publishers.

Valero, P., & Zevenbergen, R. (Eds.). (2004b). *Researching the Socio-Political Dimensions of Mathematics Education*. Boston: Kluwer Academic Publishers.

Vosniadou, S., & Brewer, W. F. (1992). Mental models of the earth: A study of conceptual change in childhood. *Cognitive Psychology, 24*(4), 535-585.

Vygotsky, L. (1978). Interaction between learning and development *Mind and Society*. Cambridge: Harvard University Press.

Vygotsky, L. (1986). *Thought and Language*. Cambridge: The MIT Press.

Vygotsky, L. (1997). Interaction between learning and development. In M. Gauvain & M. Cole (Eds.), *Readings on the Development of Children*. New York: W.H. Freeman and Company.

Vygotsky, L., Hanfmann, E., & Vakar, G. (1962). *Thought and language*: Cambridge, MA, US: MIT Press.

Wallon, H. (1947). *L'evolution psychologique de l'enfant*. Paris: Librairie Armand Colin.

Warfield, J. N., & Perino, G. H. (1999). The Problematique: Evolution of an Idea. *Systems Research and Behavioral Science*(16), 221-226.

Wenger, E. (1998). *Communities of Practice*. Cambridge: Cambridge University Press.

Wertsch, J. V., Minick, N., & Arns, F. J. (1999). The Creation of Context in Joint Problem-Solving. In B. Rogoff & J. Lave (Eds.), *Everyday Cognition. Development in Social Context* (2 ed., pp. 151-171). New York: President and Fellows of Harvard College.

Wiliam, D. (2011). What is assessment for learning? *Studies in Eductional Evaluation, 37*, 3-14.

Wiliam, D., Bartholomew, H., & Rey, D. (2004). Assessment Learning and Identity. In P. Valero & R. Zevenbergen (Eds.), *researching the Socio-Political Dimensions of Mathematics Education. Issues of power in theory and Methodology*. Boston: Kluwer Academic Publishers.

William, D., Bartholomew, H., & Rey, D. (2004). Assessment Learning and Identity. In P. Valero & R. Zevenbergen (Eds.), *researching the Socio-Political Dimensions of Mathematics Education. Issues of power in theory and Methodology*. Boston: Kluwer Academic Publishers.

Worth, K., Duque, M., & Saltiel, E. (2009). Designing and Implementing Inquiry-Based Science Units. In L. m. à. l. pâte (Eds.) Available from http://www.pollen-europa.net/?page=ietK5bjge5o%3D

Worth, K., & Grollman, S. (2003). *Worms, Shadows and Whirpools: Science in the Early Childhood Classroom*. Washington, DC: Educational Development Center.

Yin, Y., Shavelson, R. J., Ayala, C. C., Ruiz-Primo, M. A., Brandon, P. R., Furtak, E. M., et al. (2008). On the Impact of Formative Assessment on Student Motivation, Achievement, and Conceptual Change. *Applied Measurement in Education, 21*(4), 335-359.

SUMMARY

The study looks at assessment for learning and Inquiry Based Science Education —IBSE— as concepts established in a diversity of geographical areas, where the traditional summative assessment shapes what most individuals share as being experienced as assessment. Based on Leontiev and Radford's activity theory perspectives, this study looks critically at assessment for learning within IBSE activity research shaped by an individualistic approach to learning. The thesis proposed a movement towards an approach using a socio-cultural perspective. The researcher's process of learning structured the analytical process.

The main contribution was the analysis and the results of researcher movement from a view of assessment considering learning as a psychological process in the mind, independent of the everyday life of individuals, towards one considering the inseparability of collective and individual consciousness in everyday life. Learning was finally conceived as the collective process where the individual's subjectivity changes while he or she is interacting with others in a historical moment with shared meanings, artifacts, knowledge and relationships. The researcher's learning is described as identifying and differentiating forms of researching assessment, changing the researcher's perspective on research, and imagining a new theoretical approach to assessment for learning.

ISSN: 2246-1248
ISBN: 978-87-7112-197-1

AALBORG **UNIVERSITY PRESS**