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CENTRO DE INVESTIGACIÓN Y DE ESTUDIOS AVANZADOS
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BELIEFS, PRACTICES AND CONTEXTS OF TWO HIGH SCHOOL BIOLOGY TEACHERS IN MEXICO

Thesis to obtain the degree of Ph D in Sciences in the Speciality of Educational Investigations

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Dedicated with love:

to my husband Alberto,
my three children Cynthia, Sonia and Alberto,
and my grandson Tristán,
for all their loving support and encouragement
throughout my years as a teacher and student,

and to the memory of my parents:

Mildred A. Wright (1906-2000)
and
Lorne C. Paul (1904-2004)

role models of life-long learners and educators

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Resumen

Creencias, prácticas y contextos de dos maestros de biología del nivel medio superior en México

Esta investigación es un estudio longitudinal y etnográfico de dos maestros de biología que trabajan en preparatorias públicas en un estado del centro de México. Se aplicaron cuestionarios y llevaron a cabo entrevistas con los maestros al principio del proyecto en 2001 para identificar sus creencias iniciales como maestros de ciencias. Se hicieron observaciones naturales de sus prácticas docentes en el aula y el laboratorio durante cuatro años. Después de las observaciones se realizaron entrevistas para explorar las percepciones que los maestros tenían de sus propias clases. El análisis de discurso de las transcripciones fue diseñado para explorar evidencias de desarrollo de conocimiento compartido, aprendizaje colaborativo y comunidades de práctica, los modelos teóricos escogidos para el estudio. El propósito de la investigación fue buscar las congruencias y conflictos entre las creencias y prácticas de cada profesor, hacer una comparación entre los dos y notar los cambios. Como los dos profesores han participado durante este periodo en TACTICS, un proyecto extra-curricular a distancia de aprendizaje de ciencias con alumnos de preparatorias en México y Canadá, otro objetivo fue detectar posibles transferencias de estrategias del proyecto a sus prácticas y creencias normales. Los dos maestros demostraron crecimiento profesional durante el periodo, ambos acercandose, en diferentes grados, a estratégias más constructivistas, pero con poca evidencia de una transferencia de estrategias de TACTICS. Se le dio el nombre de *transmisión activa* al modelo de enseñanza seguido por cada maestro, un modelo esencialmente tradicional, centrado en el maestro pero con un énfasis en la participación más activa de los alumnos. Diferentes factores fueron identificados que parecen motivar o impedir cambios en sus creencias y prácticas, a nivel personal e institucional.

Abstract

Beliefs, Practices and Contexts of Two High School Biology Teachers in Mexico

This investigation is a longitudinal, ethnographic study of two biology teachers who work in public high schools in a central state of Mexico. Questionnaires and interviews were given to the teachers at the start of the project in 2001 in order to identify their initial beliefs as science teachers. Observations without intervention were made of their classroom and laboratory practices over a period of four years. Interviews were carried out after the observations in order to explore the teachers' perceptions of their class. The discourse analysis of the transcripts was designed to explore evidence of the development of common knowledge, collaborative learning and communities of practice, the theoretical models chosen for the study. The investigation focused on the congruencies and conflicts between their identified beliefs and practices as mediated by their contexts, as well as a comparison between the two teachers. As both were participating in TACTICS, an international, extracurricular project of science learning with high school students in Mexico and Canada, it was of particular interest to see if there was a transference of strategies from the project to their daily beliefs and practices. Both teachers demonstrated professional growth over the period, both reaching towards more constructivist strategies to varying degrees, but with little evidence of transference of strategies from TACTICS. The teaching model followed by both teachers was given the name *active transmission*, an essentially traditional, teacher-centred one but with an emphasis on more active student participation. Different factors were identified that appear to either motivate or constrain changes in their beliefs and practices, at both personal and institutional levels.

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I. Introduction: the Problem

Research in the past decade has focused on the need to study teachers' beliefs in order to understand their teaching practices and how they develop their professional knowledge (Calderhead, 1996; Good, 1996; Luft, Roehig & Patterson, 2003; Richardson, 1996; Ritchie & Rigano, 2002). Teachers' beliefs about teaching-learning processes are significant in determining the nature of their practices in the classroom and directly affect many aspects of their professional work, including interactions with the students, lesson planning, assessment and evaluation (Hewson & Hewson, 1988). Alternatively, practices and experiences in the classroom also have a decisive effect on beliefs, forming the basis of some, reconfirming others or provoking transformations in yet others (Richardson, 1996). In order to provide high-quality, diverse and varied opportunities to learn any subject, it is considered necessary to take into account the teacher's beliefs, attitudes, assumptions, and practices as well as the cultural contexts of teaching and learning (Bryan and Atwater, 2002).

Beliefs are defined as personal cognitive constructs accepted as true by the individual holding the belief (Richardson, 1996), with episodic roots based on personal experiences (Bryan & Atwater, 2002), while actions or practices are considered to be knowing-in-action (Schön, 1983), or observable pedagogical behaviour (Fishbein & Ajzen, 1975; Good, 1996). Beliefs are formed into belief systems or structured groups of beliefs with some more central and more difficult to change than others (Bryan & Atwater, 2002; Fishbein & Ajzen, 1975). Some may be explicit, but many are implicit ones that the teacher may be unable or unwilling to express; however, all are highly personal and context specific, serving to filter and interpret new phenomena (Pajares, 1992).

Beliefs and teaching practices are considered to have a highly interactive, bidimensional relationship, with attitudes and beliefs the driving force of a person's actions (Richardson, 1996; Bryan & Atwater, 2002), as well as practices affecting beliefs. Beliefs are also thought to be valid predictors of subsequent practice as well as being precursors to change (Haney, Lumpe, Czerniak, 2002; Jongmans, Biemans, Sleegers, & de Jong, 1998; Nespor, 1987). For science teaching, the teachers' views of the nature of science (NOS) are of particular interest but are difficult to identify, largely due to the fact that they have been found to be constantly changing and shifting and very dependent on the context (Nott & Wellington, 1996). In spite of the evidence that the relationship of these beliefs to a teacher's classroom teaching is neither direct

nor simple (Abd-El-Khalick, Bell & Lederman, 1997; Lederman, 1999), it would appear that certain epistemological positions tend to lead to specific teaching strategies: for example, a positivist view of scientific knowledge leads to a strong verbal domination of the classroom (Richardson, 1996: 107).

In order to have a more comprehensive vision of these personal and practical domains, it is essential to include the social and cultural milieu in which the teacher works, the particular historical, cultural and institutional context (Cole & Engestrom, 1993; Coll & Onrubia, 2001; Littleton, 2000). In other words, context is integral to situated activity and inseparable from practice (Lave,1996). A school context legitimises certain knowledge and behaviour, making the implementation of innovative strategies or different content in some cases a difficult task or even a professional risk for a teacher (Littleton, 2000). Each dimension of time, location, group, will also have its own defining characteristics that will affect and possibly constrain a teacher's choices of strategies, behaviours, attitudes, all of which may evolve over time. Studies done on the basis of observations and interviews at a particular instant are simply images of discrete practices and beliefs. By following teachers at different moments over a period of time while they are working with different groups of students, in the classroom and in the laboratory, it is possible to develop a comparatively holistic vision of their practices and underlying pedagogical concepts as mediated by their specific context.

Recent investigations on the beliefs and actions of teachers have principally concentrated on teachers who are in the process of formation or professional development, in both cases related to training programs or to the implementation of reforms (Yerrick et al, 1997; Bryan & Atwater, 2002; Haney et al, 2002; Luft et al, 2003). Other research has centred on the daily behaviour in the classroom and the underlying beliefs of the teachers (Tobin & McRobbie, 1997; Feldman, 2002; Rop, 2002). Although their goals and focuses vary considerably, all these studies coincide in the recognition of the complexity of the interaction of the teacher with the students and the context. They also emphasize the importance of considering the initial beliefs of the teachers with regards to their selection of teaching strategies in the classroom and the possibility of incorporating innovations or reforms. As well, they concur in pointing out the difficulty of modifying these beliefs.

By means of classroom observations, teachers' practices may be described and compared to their beliefs, to see if and where there is coherency between them, whether there is any

transformation over the period of observation. The goal is to explore how the context, an integral, mediating factor of the teachers' reality, influences their beliefs as well as their intentions and attempts to change their own teaching practices. The core of a study with this viewpoint is analysis of discourse in the classroom as an indicator of the types of interactions, the practices, the levels of teacher control, as well as a confirmation or negation of their beliefs as expressed in other moments. It also reveals features of the social institution of the school itself "as generated in and revealed by the language of the institution's participants as well as by their daily practices" (Mehan, 1996, p. 243).

In Mexico the investigation of science education is very recent so that there is relatively little information as to what actually occurs in science classes and even fewer details of science teachers' specific beliefs and practices (Flores, F. et al, 2000; Mendoza, 2003; Monroy, F., 1999). In 2003, a Mexican survey of national research in science education reviewed the decade from 1992 to 2002 (López y Mota, 2003). Within this period they found only 104 scientific publications, in both national and international journals and periodicals, covering all levels of science education from primary to university. These studies dealt with such diverse areas as students' preconceptions, conceptual change, curriculum as structure and process, evaluation, analysis of school textbooks, the history of science teaching and discourse analysis, amongst others, but none specifically focused on science learning environments, be it in schools or in classrooms.

In terms of discourse analysis in science education in Mexico, according to López y Mota (2003, pp. 431- 438) the most noteworthy program of research of the past decade was carried out by Candela between 1991 and 2001. She published numerous articles on science teaching in primary school (grades 1-6), on the dynamics of social interaction through the analysis of school science discourse. Her results have highlighted the characteristics of the social construction of school scientific knowledge and the socio-cultural factors that influence their construction.

Other recent investigations have shown the continued predominance of the teacher-centred transmission model of teaching in Mexican secondary school classes (grades 7-9) (Quiroz, 2000) and in agricultural technical high schools (grades 10-12) in one state of Mexico (Mendoza, 2003). Flores, Lopez, Gallegos, & Barojas (2000) have effectively initiated in Mexico the study of science teachers' scientific conceptions and beliefs with regards to the nature of science and learning. They described physics teaching in high school as generally

very traditional[1]. At the start of an in-service training program with a group of 12 high school physics teachers, these investigators identified the teachers' epistemological conceptions as *empiricist* and their learning conceptions as *behaviourist*. The post-course analysis indicated shifts towards *logical positivist* and *cognitivist* positions, considered by the authors to be intermediate stages towards constructivism. However, their study did not follow the teachers into their classrooms to observe their daily practices.

All of these authors accentuated the need to increase and improve the different areas of research in science teaching in Mexico, particularly with regards to classroom practices (López y Mota, 2003). It is thus very relevant to contribute to the construction of a richly detailed profile of Mexican high school science teachers through an exploratory study of the beliefs and practices of specific teachers. The results will also add to the development of a comprehensive description of different science learning environments in Mexican schools.

The two Mexican science teachers invited to participate in this study were chosen from two public, provincial high schools participating in an international project between four Mexican and two Canadian high schools. The project was designed in 2000 and carried out from 2001-2004. Groups of students worked in collaborative learning communities with the use of computers both as a source of information and the means of communication between groups.[2] The name given to this project was TACTICS[3], an anagram using words of French and Spanish, two of the three languages of the project, to refer to the teaching of science with the use of collaborative learning and information and communication technology (ICT). The main objective was to help students develop various competencies related to scientific reasoning and the social aspects of science, as well as procedural and collaborative skills related to the use of ICT in knowledge construction. Various research projects related to TACTICS, including the present one, have been carried out by investigators both in Montreal and Mexico.

The project involved six high schools: two in Montreal, Quebec, one a French-language private school and the other a French-immersion English-language public school; the four Mexican schools were in four different cities: one was a private school and the others public.

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[1] "Traditional" refers here to the pedagogical model centred on teacher transmission of knowledge with the student as a passive recipient.

[2] See Appendix G for the topics of investigation used in the project and the jigsaw model of the organization of the groups of students in TACTICS.

[3] Project sponsored by CONACYT, Mexico S33909-G. For more details on the TACTICS project, see Vázquez-Abad, Brousseau, Waldegg, Vezina, Martinez, Paul de Verjovsky, (2004)

The students were between 15 and 18 years old. The main instructional model for collaboration was the jigsaw model, modified for distributed work where five transdisciplinary science topics were each divided into three sub-topics[4].

The role of science teachers in the six different high schools taking part in TACTICS was to choose and supervise the students in their work of collecting and synthesizing information related to their topics of investigation and of communicating via internet with the other teams in their group in order to organize and synthesize a final report. A web page was specially designed to present the products of their work each year[5]. Neither of the teachers chosen for this study had any experience at the beginning of the project with either collaborative learning or with computers and Internet used for investigations. It thus provided an excellent opportunity to explore the possible effects of their participation in this project on their normal, daily teaching practices and beliefs, to see if there was any evidence of transfer of these new technologies to their daily practice. It is of particular interest to see if there is transference of any collaborative learning strategies or notable changes in the types of interaction with their students that might be related to their experiences in TACTICS. Whether or not any implementation of the innovations could actually improve the quality of the teaching and learning is beyond the scope of the present investigation.

This research presents the results of the longitudinal, in-depth case study of Maria and Hector, the two Mexican public high school biology teachers who participated in the TACTICS project. The data were obtained using qualitative multi-measurements to explore their beliefs and practices, a variation of contemporary ethnomethodology informed by discourse analysis (Adler & Adler, 1998). The purpose of this thesis is to investigate the temporal and evolutionary dimensions of practices and beliefs as situated activities by means of discourse analysis. This permits an evaluation of the coherency of the systems of beliefs with their practices, and the identification of possible transformations that may have occurred over the period of time in which both teachers were involved with new educational technology in TACTICS. An initial hypothesis was that there would be transference of some aspects of the new social and informatics' technology to their daily classroom beliefs and practices. The analysis involves not only describing the beliefs and practices as such, but also interpreting them

[4] Details of the organization of the work is given in the section on TACTICS, p. 77 and in the Appendix G.
5 www.cinvestav.mx/tactics

from specific theoretical perspectives, to develop scientific methods and concepts which may be used to study "societally significant practices" (Chaiklin, 1996: 386), as mediated by the specific science education context.

This study evolved from the project TACTICS which was founded on the models of collaborative learning and communities of practice. Thus the basic premise of this work was to investigate the three domains of beliefs, practices and context of each teacher in terms of the possible development of collaborative learning and a community of practice within the classroom. From an analytic perspective it was considered that collaborative work builds from a common knowledge base and that both are necessary but not sufficient aspects of a community of practice. The interpretive discourse analysis of the classroom interactions and of teacher interviews was consequently based on categories derived from the following theoretical references of these three models: common knowledge (Edwards & Mercer, 1987; Edwards, 1993; Crook, 2000), collaborative learning (Henri & Lundgren-Cayrol, 1998; Joiner, Thompson, Faulkner, Littleton, & Miell, 2000) and communities of practice (Wenger, 1998, 2001, 2002).

The objectives of this research are various:

- to describe both teachers' expressed beliefs concerning the teaching and learning of science;
- to observe and describe their daily classroom practices;
- to compare and contrast the data in order to identify the degrees of coherency or incoherency between the expressed beliefs and practices of each teacher, as well as to compare and contrast the data for both teachers;
- to detect any transformations that occur over the period of the study, with particular interest in possible transfers of strategies used in TACTICS, such as collaborative learning, a technique that neither teacher had used before; and finally
- to describe possible factors in the institutional setting that could promote or impede change in these teacher's beliefs and practices (Schön, 1991).

The presentation of the results of this study is divided into five sections. First a focused literature review provides a background of previous research related to the major concepts used in this work, principally beliefs, practices and innovations, plus school and specific Mexican contexts. The theoretical framework for the research is then identified briefly, including the

relevant foundations of traditionalism, socioconstructivism and the theory of practice, discourse analysis and context. Traditionalism was included due to its continued predominance in Mexican schools at all levels. The classroom is analysed as to how common knowledge is developed, to what extent there is collaborative learning, and whether a functional community of practice is formed. The specific school and the broader institution of the state university are much more inclusive communities of practice to which the teachers also belong, both of which create complex interrelationships of influences, conflicts, identities and, of particular interest in this study, possible constraining their members' professional development.

The research design and methodology set within this framework is presented along with a description of the categories of analysis used to describe the teachers' discourse both in interviews and in their classes. The methodological limitations of the study are also examined. The analytic description of the extensive empirical data collected over almost four years is then discussed at length, in light of the theory and supported by numerous specific references to the data. Throughout this process there was a constant search for patterns in the two teachers' beliefs and practices, for confirmations of the observations through triangulation of the data. The analysis is organised around basic noteworthy aspects of the teachers' beliefs and practices as mediated by their specific contexts, as well as facets related to identity formation.

Finally, the last section of discussion, implications and conclusions draws together the descriptions within the theoretical context. Fewer appropriations of new educational technology were identified in both teachers' beliefs and practices than had been originally anticipated. Thus, the implications of the transformations that were detected are discussed, along with considerations of the absence of change in other areas. Emphasis is placed on the various constraints, largely institutional, that were inferred to be amongst the principal limitations to these teachers' desire and efforts to change and improve the teaching-learning processes in their classrooms. Concluding reflections discuss the relevance of this investigation as well as the need for further studies that can broaden the profile presented here of two Mexican high school science teachers within their teaching context.

II. Review of Related Research

Beliefs

Research on teachers' beliefs or thinking has developed extensively over the past three decades, highlighting the impressive breadth of knowledge that teachers develop through their classroom experiences. This evidence has pointed to the need to understand how teachers interpret what happens in the classroom and how they respond to it (Calderhead, 1996). Pajares (1992) drew attention to the importance and necessity of teachers' beliefs becoming a focus of educational research, such as those beliefs related to self-efficacy, epistemology, specific subjects, the nature of intelligence, motivation. He emphasized that such research requires careful conceptualisation of all aspects of the construct "belief". In a review of research carried out from 1985 to 1992, Calderhead (1996) discussed the historical background of this area of research, of the change from the influence of the behaviourist position involving process-product studies to that of cognitive theory involving research on the interactions of knowledge, thought and behaviour. Calderhead outlined three stages of research in these areas: firstly, teachers' decision-making as a link between thought and action; secondly, teachers' perceptions, attributions, thinking, judgments, evaluations, actions; and lastly, knowledge and beliefs underlying teachers' thinking. He observed that "teachers clearly have a vast, somewhat idiosyncratic knowledge base that may be continuously changing and restructuring" (p. 710).

In an extensive analysis of the role of attitudes and beliefs in teaching, Richardson (1996) emphasized research that suggested that "both attitudes and beliefs drive classroom actions and influence the teacher's change process" (p. 102), coherent with cognitive theory that accentuates their influence on both what and how a person learns. She defined attitudes and beliefs as "a subset of a group of constructs that name, define and describe the structure and content of mental states that are thought to drive a person's actions" (p. 102). Richardson separated attitudes from beliefs, with the former as affective, learned predispositions that consistently affect actions, a manner to respond, including social attitudes to students, learning, education, teacher-student interactions. The latter she defined as cognitive mental constructs, as "psychologically held understandings, premises or propositions about the world that are felt to be true" by an individual (p. 103). Beliefs may be held in clusters that may be incompatible amongst each other, but it is very possible that these conflicts are never analysed by the person. The more centrally held beliefs are undoubtedly the most difficult to change. It is considered

unavoidable that beliefs must be inferred, taking into account the evidence given by the teacher or the assessments involved in the investigation (Pajares, 1992: 315).

Nespor (1987), Richardson (1996) and Bryan and Atwater (2002) all differentiated beliefs from knowledge, with beliefs having existential presumptions (beyond individual control or knowledge); alternativity (may differ from reality); affective aspects (feelings, moods); and evaluative bases (on personal preferences). Amongst researchers in this area, there has been a general consensus that "beliefs and knowledge are inextricably intertwined, but the potent affective, evaluative and episodic nature of beliefs makes them a filter through which new phenomena are interpreted" (Pajares, 1992: 325). Beliefs are far more influential than knowledge in understanding how individuals frame problems and organize tasks and are much better predictors of behaviour (Lumpe et al, 2000; Nespor, 1987). Beliefs influence a teacher's decision-making during classroom interactions, some explicitly, some implicitly as the teacher may not possess the language with which to express his/her beliefs or may be reluctant to express unpopular beliefs. Learning to teach is a very personal adventure in which beliefs about teaching are usually well-developed and firmly entrenched from previous educational experiences as a student (Pajares, 1992) and are either negotiated or reinforced in the field experiences. (Bryan & Atwater, 2002).

Richardson (1996) described beliefs and actions as constructs that act together in praxis within the complexity of contexts of teaching and of teachers' thinking processes and actions. Studies are thus very person and context specific. The perceived relationship is interactive and change occurs through reflection, personal exploration, experimentation. A teacher's experiences influence his/her personal practical knowledge which in turn influences different elements of the practice. Richardson suggested that the beliefs of a teacher are based on three categories of experience: personal experience in all its extent, experience with schooling and instruction (previous teachers, etc.) and experience with formal knowledge including both subject matter knowledge and pedagogical knowledge. "Professional growth is defined as changes over time in behaviour, knowledge, beliefs or perceptions..." (Richardson, 1996, p. 114 cited from Kagan, 1992). In order to study a teacher's beliefs, which are highly eclectic, Richardson stressed the importance of a qualitative methodology including interviews and observations with multiple measures, in order to give confidence that the inferred beliefs are reasonably accurate representations (Pajares, 1992).

Different classifications have been developed to categorize teachers' beliefs with regards to teaching, principally distinguishing between positions termed as teacher-centred/ content-oriented and student-centred/ learning-oriented with a possible transitional; intermediary phases (Kember, 1997; Salish, 1997; Samuelowicz & Bain, 2001). It is deemed essential to take into account the teacher's discourse and practices in order to make richer and more reasonable assessments of the beliefs (Pajares, 1992). Whatever beliefs are identified and however they are categorized, it must be recognized that they give only a small glimpse into much more extensive belief systems and that the context-specific effects of the beliefs must be taken into account.

Teaching practices

Teaching practices have been described to be "to a great extent, an uncertain and spontaneous craft situated and constructed in response to the particularities of everyday life in schools and classrooms" (Cochran-Smyth & Lytle, 1999, p. 262). This conception of practical knowledge or knowledge-in-action is assumed to be acquired through experience, with thought and action intimately linked (Schön, 1983). Teaching thus involves action and activities guided by past experiences and beliefs that have an essential role in defining and shaping what occurs in the classroom (Nespor, 1987). However, the view of "teaching practices" has been expanded to include not only a teacher's immediate actions in the classroom, but well beyond it, to take into account the wide range of decision-making and daily work that is part of teaching, as well as to the relationships with students, fellow teachers and the institutional community as a whole (Cochran-Smith & Lytle, 1999).

The theory of practice is a logical perspective from which to study teaching practices: teachers can be conceived of as practitioners within a societally significant institution, and their concrete, meaningful societal practices taken as the direct object of study. Such analyses should attempt to describe their practices in relation to the concepts of this theoretical tradition, as well as be directed toward developing further scientific methods with which to investigate these practices, many of which reflect the political and institutional constraints imposed on them. The analyses should thus include the societal role of the teachers in the practice (Chaiklin, 1996, pp. 384-385, 391). As stated by Chaiklin (1996):

> "The goal is to continue building our tools for understanding individuals engaged in meaningful practices in a way that acknowledges and builds the human values contained in

those practices, and with a view for these ideas to be potentially incorporated as a part of the practice." (p. 398).

In the introduction to a book on practice, Lave (1996) discussed two main theoretical positions regarding context as situated activity: activity theory based on historical-dialectic theory and social constructionism based on phenomenological social theory. The focus in the former is that "the central theoretical relation is historically constituted between persons engaged in socioculturally constructed activity and the world with which they are engaged" whereas the latter focuses on the "intersubjective relation among coparticipants in social interaction" (p. 17). As a result of efforts to find a new focus uniting the two perspectives, Lave suggested that the new research question becomes "What are the relationships between local practices that contextualise the ways people act together, both in and across contexts?" (p. 22). Chaiklin (1996: 384) considered this formulation to represent "an expanded focus on social, societal and historical factors as part of understanding individual practice".

Research on many different practices or activities has led to the conclusion that learning is ever-present, that a "situated activity always involves changes in knowledge and action...[which] are central to what we mean by 'learning'" (Lave, 1996: 5). Thus any study of teaching practices necessarily should analyse the individual's engagement in learning or his/her changing participation in a given context or the socially situated character of activity. The concept of learning becomes an aspect of culturally, historically situated activity (Lave, 1996) and the concept of practice as socially situated (Chaiklin, 1996). The integration of educational theory and practice occurs most productively when in real instructional situations with research and disciplined, practical inquiry, or as a *situated* activity, an all-inclusive perspective which considers the person, activity and situation all as one entity (Lave, 1996). It is considered that "knowledge and learning are distributed throughout the complex structure of persons-acting-in-setting" (Lave, 1996: p.9) which includes the tasks, tools and the institutional environment, the learning identities of the persons involved, an ever-changing, heterogeneous situation.

All practical activities are guided by a theory, some as simple as certain knowledge of the situation and a particular idea of what has to be done. Teachers develop personal practice theories of their own professional practice which "consist of sets of beliefs, images and constructs about such matters as what constitutes an educated person, the nature of knowledge, the society and psychology of student learning, motivation and discipline." (Sweeney et al,

2001, p. 408, cited from McCurcheon, 1992, p. 191). These practical theories, integrated from experiential and formal knowledge as well as personal beliefs (Schön, 1991; Van Driel et al, 2001) are highly complex, requiring research that is focused explicitly on the relationships to the actual teaching practices by means of multimethod designs (Nespor, 1987; Robinson, 2002).

Innovations in the classroom

In order for changes to occur in teachers' practices or for innovations to become established in any educational context, many factors are necessarily involved, not least of which include the teacher's beliefs in terms of their own self-efficacy, their levels of concern and professional orientation (Gallagher, 2000; Jongmans, 1998; Lumpe et al, 2000; Pajares, 1992). The values they relate to the specific innovation are also significant, as well as the institutional context or culture that may support or hinder the teacher's efforts to incorporate new strategies or technologies (Poulsen, 1998; Richardson, 2001; Robinson, 2002). It is suggested in the literature that most teachers change all the time and that this is voluntary and collaborative but that there is an undeniably complex intertwining of influential factors regarding these potential changes.

Educational innovations include different types of educational technology, amongst which are technical ones involving information and communication technology (ICT) with the use of computers, as well as social technologies such as collaborative learning. Since the 1970's both computers and collaborative learning techniques have been incorporated into normal educational practice in many countries (Cros, 1993; Navarro & Verdisco, 2000; Pelgrum, 1997; etc.) although their efficacy and cost-effectiveness are not clear nor the degree of incorporation into the beliefs and practices of teachers (Shaw et al, 1998).

Even though the use of ICT technology has been promoted widely at the international level to stimulate the development of critical thinking and higher level cognitive skills and processes (Haddad, 2003), as mentioned above, there are many factors that may influence whether or not these innovations are appropriated by the teachers and actually implemented in the classroom. The complex teaching culture, with the teacher as central actor, creates situations that can either promote or impede the recommended changes (Chomienne &

Vazquez-Abad, 1991; Gallagher, 2000; Poulsen, 1998). Teachers themselves have identified some of the obstacles as access to and training in the technologies, teacher personality, time and school curricula (Yerrick & Hoving, 1999). In Mexico, other recognized factors include institutional contexts of classes with large numbers of students, a lack of teacher training, traditional types of evaluation of students and teachers, amongst others (Quiroz, 2000). All of these issues plus the characteristics of the teachers themselves, their beliefs, past experiences, their knowledge, and their learning identities interacting with those of the students make it an extremely broad and complex area of analysis. This study is limited to only certain noteworthy aspects of the context within which these teachers work that could have implications in the transformation of their beliefs and practices as shown by the adoption of educational innovations.

School and institutional context

The classroom ecology or context is the result of the complex interactions of many distinctive factors and determines to a large degree what occurs in any given classroom. Knowledge is considered to be socially constructed through collaborative efforts, a relationship between human agents strongly embedded in the material and social contexts that define the momentary circumstances of the action (Pea, 1993; Crook, 1996; Rogoff, 1998). The political, social, physical and psychological aspects of learning environments, all part of the overall school sociocultural context, are considered very significant in determining human behaviour and what occurs in a school (Fraser, 1998). From the socioconstructivist or sociocultural constructivist viewpoint, teachers, students and activities are all one entity with the context, considered to be situated in it or mediated by it (Coll & Onrubia, 2001; Lave, 1996). From this analytic perspective, there are different levels of analysis: the specific classroom context and the factors immediately affecting the teacher-student interactions, up to the broader institutional context that has a much more indirect effect on the classroom (Fraser, 1998). Many diverse instruments have been focused on the associations between student outcomes and the environment as well as on criterion variables such as the evaluation of educational innovations and the differences between students' and teachers' perceptions of certain aspects (Fraser, 1998). Investigations have also been carried out on specific science learning environments, mainly referring to the teacher-students interactions in the classroom, using varied instruments from observational techniques to questionnaires and interviews to obtain data from both

students and teachers (e.g. Dass, 1998; Salish I, 1997; Tobin and Fraser, 1998). These last cited studies focused specifically on determining, through the use of different instruments, the degree of constructivist attitudes and activities in different aspects in the classroom.

Shapiro (1998) reviewed five case studies of learning environments from a semiotic interpretive perspective which assumes that one's culture provides signs, symbols and rule sets that significantly influence learning and teaching. Semiotics is concerned with how individuals make sense of practices within the larger context as well as how social groups construct meaningful practices of their own, part of social semiotics which connects discourse and practices of a community within broader social and political patterns (Coll & Onrubia, 2001; Lemke, 1990; Mehan, 1996). Semiotic activities include a wide range of repertoires of actions, of gestures and routines of talk and behaviour, socially learned and recognized by members of a certain culture. "These action repertoires can be considered as text forms in the sense that they mediate features of a multi-levelled discourse that successful students are expected to understand and use." (Shapiro, 1998: 61). The patterns of actions are determined even by the physical organization of a classroom or laboratory, by the positioning of the furniture. Height, for example, is traditionally associated with power and authority and can be seen reflected in the classroom by the teacher's desk on a platform, or by the teacher who is standing while speaking to seated students. The time and space designated within a lesson structure, as well as by the discourse or dialogue formations such as questioning patterns and interaction sequences all have specific significance to the participants. Students learn to "read the signs" in the classroom, as to what the teacher and the school itself convey that is necessary to be a successful learner. From the analysis of specific interactions, Coll and Onrubia (1996) suggested that there should be an integration of micro-levels of analysis which involve the semiotic representations as well as macro-levels which refer to the structure of a shared activity.

Wubbels and Brekelmans (1998) reviewed research on the interactions and communications of science teachers with their students, including verbal and non-verbal behaviours and instructional strategies, amongst others. These studies had principally process-product focuses, looking for a correlation between specific variables, such as teacher age and experience or teacher cognition, and the learning outcomes. Aside from the behaviourist framework, this would be an impossible task given the extreme complexity of identifying and

analysing context factors. Certainly it is evident that a teacher's behaviour is of great importance in creating a positive social climate in the classroom for science learning. Precisely due to the complexity of the context, it is considered crucial to use multi-level personal and observational information, combining both qualitative and quantitative data, in order to obtain a more comprehensive vision of the interacting factors (Fraser, 1998; McRobbie et al, 1998, Wubbels & Brekelmans, 1998).

The Mexican context

The following description is a brief outline of the specific Mexican context in which this particular study is placed, details of which will be enlarged upon throughout the work. The two high schools, referred to as the Prepa A and Prepa B, are affiliated with a particular higher education institute, in this case the state university, that determines the specific curriculum for each subject and the normative and political aspects of education such as the appointment of the director of each affiliated school every three years, teachers' contracts and class assignments each semester, the system of evaluations, to name a few. Most high school teachers only have a professional degree, normally in some field related to the subjects they teach, as they are not required to have teaching qualifications. In the case of the particular school system studied in this investigation, there are very few teachers with full-time contracts and the salaries are very low, forcing many to work in several schools, teaching many hours every week, in order to earn a living wage. As well as affecting the time a teacher may have to prepare classes, it also severely restricts the effects of any courses of professional formation that the school may offer as well as the possibility of contact among colleagues (interviews with the directors of the Prepa A, 2004, and of the Prepa B, 2003).

Studies on the teaching of science in Mexico have shown that the dominant cultural model in many schools is still very traditional, largely based on the transmission of information from an authoritative teacher source to passive pupil receptors (Flores, López, Gallegos, & Barojas, 2000; Mendoza, 2003; Quiroz, 2000). It is most likely that this has been maintained over time due to the context which frequently includes a lack of textbooks and didactic materials, an encyclopaedic science curriculum, the use of traditional means of evaluating learning, large numbers of students in each class, plus the lack of teacher training, all of which legitimise the use of dictation and memorizing strategies of teaching and learning (Arce Ferre & Estrella G.,

1998; García y Calixto, 1999; Mendoza, 2003; Quiroz, 2000; auto-evaluation by science teachers in a masters program of the state university, 1999).

In the great majority of public high schools in Mexico the use of "new" educational technologies is very limited, in this case the social technology of collaborative learning and technical one of computers, so that they may still be considered as innovations. Collaborative techniques are either unknown or used very little. Group work is used infrequently, except in the laboratories where it is inevitable due to limitations of materials and space, but then it is generally not organized around collaborative principles. Most frequently it is an exercise in following a recipe with a few working and the others copying, more a fulfilment of normative obligations than the learning of scientific techniques of investigation (observations and interviews with teachers, 2001). Computer laboratories exist in the schools in order to give basic computer skills to all the students, but they are not available for general classroom investigations.

III. Theoretical Framework

The following sections briefly outline various theoretical perspectives that were used to create the framework of this thesis. All of them are used at different moments with the purpose of exploring the beliefs, practices and context of the two teachers. The three major theoretical perspectives drawn on for the organization, analysis and presentation of the data are common knowledge, collaborative learning and communities of practice.

Traditionalism

In Mexico, as in many countries, teaching tends to be what is generally called "traditional", a rather ambiguous model at best (Bennett, 1979; Woods, 1984; Arce Ferrer & Estrella González, 1998; Pozo M. and Gomez C., 1998; Luft, 1999). The traditional role of a teacher is normally considered to be as an expert in disciplinary content with the goal of transmitting the content to the students. The content is defined by the official study plan and texts and the teaching strategies used are mainly lecture, demonstration and drill. The evaluation of the success of this knowledge transfer is through questions and exams, with occasional feedback and correction (Resta, et al, 1999). The traditional approach to building knowledge is by accumulation, efficient for learning lower level forms of knowledge as comprehension and even application, but much less so for the higher level uses of knowledge in analysis, synthesis and evaluation. The traditional cognitive theory views learning as a series of universal processes, a transmission of homogeneous, existing knowledge. This leads to the definition of failure to learn as an inability or refusal on the part of an individual to engage in the learning process (Lave,1996). There is also a traditionally static concept of context, as that of a container, having effects only at the borders of the phenomenon being analysed. This, in turn, justifies the analytic concept of the "decontextualization" of learning and knowledge, which can then be considered to be neutral and of a general nature that is independent of specific practices. In common educational practice, language is used as though it were a complete, unambiguous, explicit representation that is independent of local concerns or interests, creating what has been called the "myth of literal meaning" (Rommetveit, 1988, cited in Minick, 1996, p. 371). In the case of science, the use of formal, stylistic norms of scientific language helps to maintain the mystification of science as abstract, unchangeable and accessible only to experts (Lemke, 1997).

Bielaczyc and Collins (2000) described the traditional classrooms by means of various dimensions: students are to learn the same thing at the same time, a homogeneous treatment of learning; activities are often isolated, without active student participation in their development; the teacher is the authority who controls content, activities and the evaluation of student learning; students do not develop a community identity; resources are often limited or used as sources of expert knowledge, ignoring that of the members of the community; both teachers and text use a very formal scientific language that is to transmit a series of concepts that all students should learn, with breadth emphasized at the expense of depth; the products of student work are usually individual homework assignments with little collective work, usually done over a very short period of time; evaluation is based on exams answered individually (pp. 285-287, 301). All of these factors teach students that learning is the memorization of the "official" knowledge that exists on the school's study plan.

From an epistemological viewpoint, the traditional concept of science is positivist and portrays an ideal image of science, unquestionable truths, accumulated knowledge that is superior to other types of knowledge and a unique scientific method. The inductivist concept of the scientific method as the only formula to discover the truths of the reality of nature, a concept dating back to Francis Bacon in the 16th Century (Larroyo, 1949), is still clearly reflected in many standard textbooks used in high school science classes in Mexico, as well as in the teachers' conceptualisation of science (questionnaires applied by author, 2000). From this positivist vision of science, a corresponding pedagogical view has been developed with a formal, prescriptive character (Rueda, 1995), with the student as a "tabula rasa", a concept originally used by Locke in the 17th C (Larroyo, 1949), whereby receptive rote learning is "printed" in the student's memory; or in a more modern context, teaching occurs by the teacher sending a "fax" to the student's mind which is then returned the day of the exam and compared to the original as evidence of learning (Pozo and Gomez, 1998). The textbook is seen as the prime source of legitimised knowledge which is presented by the teacher in a fragmented, decontextualized form, with the focus on the theoretical content and inductive thought which is seen as an individual, internal process (León Trueba and Goñi Cedeño, 1995). These empiricist views have also influenced the development of programs for professional formation of teachers that are based on traditional suppositions of teaching and learning.

According to Glaser (1972), the social context of education since the 19th C and the importance of the selective definition of scholastic success based on only particular general abilities such as numerical and verbal skills, have led to an emphasis on the uniformity of teaching methods with minimal variations in conditions under which individuals are expected to learn. These concepts contrast sharply with the modern adaptive mode of education, as Glaser called it, where the educational environment should provide a wide range and variety of instructional methods that take into account individual differences.

The psychological learning theory of behaviourism postulated experience as the basis of empirical knowledge and focused on the interaction of organisms with objects and events with the emphasis on the object and behavioural modification (Rueda, 1995). Behaviourism, as exemplified by the work of Skinner, provided the theoretical framework for a very strong educational movement in the 1960's and 70's. This paradigm also reinforced many traditional methods including the teaching of small, concrete, isolated facts and of evaluating the observable results using objective exams (generally summative), completely ignoring the complex processes of teaching and learning as well as the importance of the specific context. Also the tradition of repetitive work to condition the reflexive response of the student, the use of material rewards such as grades, honour roles, as well as punishments for not following the rules can all be linked to the Skinner's operant conditioning theory of learning, concepts also reinforced by traditional folk culture such as that repetition will create wisdom (Larroyo, 1949). Scriven (1972) described Skinner's commitment to the "emptiness" of the human organism and the lack of a sense of autonomy on the part of the learner, as an untenable philosophical position but recognized it for the great stimulus it gave to educational investigations and the consequent important practical and social contributions to educational practices.

Porlan (1997) described different models of science teaching, including traditional or verbal transmission as compared to the inductivist-technological model which is largely based on the importance and use of the scientific method, a somewhat more sophisticated model but still closely linked to the former in its epistemological and didactic positions. He criticized the traditional model for its lack of democratic and participative principles, for its implicit, absolute empirical-positivist epistemological position, and the total absence of modern teaching and learning theories. The other alternative model offered in the 70's was that of

spontaneous discovery learning, where the student had a much more central role in the learning process; however, epistemologically it was still with a certain realism and naïve inductivism, still ignoring the personal knowledge of the student.

It is generally recognized that the traditional method of "transmitting" isolated, factual information in a lecture mode is not effective, that it is necessary to promote changes and variety in the teaching styles in order to improve science education (Hargreaves, 1986; West, 1998). In educational investigations the constructivist paradigm from cognitive psychology has largely superseded the previous ones, although this change is not necessarily reflected in the actual teaching practices in the science classroom.

There are many factors involved in the development and maintenance of the traditional model of teaching. One is the cultural context of Mexico, where authoritarianism has been part of life for centuries, a cultural view that supports and encourages the maintenance of an authoritarian educational system as the official socializer of its future citizens, comparable to what was seen in the extreme situation of Germany after WWII (Weber, 1970). Some of this tradition may be "inherited" by teachers who adopted teaching practices that are based on their own educational experiences (Rockwell & Mercado, 1987), usually from an autocratic, normative, narrative model of teaching (Barona, 2000).

Socioconstructivism

The psychological cultural theory, or the sociocultural theory that developed from the work of Vygotsky and the Russian cultural-historical school of psychology provides the underlying theoretical basis in this work for the analysis of teaching beliefs and practices. The theory presents learning as having a fundamentally *social* character that needs to be analysed in relation to the social structure and the cultural resources of the learning environment (Crook, 1996). In this sense, it is necessary to evaluate all educational resources in terms of their possibility for enriching the interpersonal contexts of learning. The cultural aspects include artefacts, institutions, rites, accumulated knowledge of prior generations, including material, symbolic and social resources (Cole and Engestrom, 1993). It is necessary to recognize the relationship between the mental processes and their cultural, historical and institutional context, that these cognitive activities and behaviour are to be seen within the external context (Säljö and Wyndhamm, 1996).

Vygotsky (1934) identified both *symbols* (signs, language) that act as psychological tools to regulate the conduct of others and our own cognitive processes, and *material artefacts* (physical tools) used to increase our control over the physical world, both culturally mediated human activities (Pea, 1993). He further identified *mediating elements*, such as the forms of speech and symbols used in a particular sociocultural milieu, as the cultural forms used to interpret experiences, to carry out interpersonal exchanges (Cole and Engestrom, 1993). Mediating elements are considered to be cultural resources, historically defined and socially organized. Intellectual development is characterized by access to the mediating elements as cultural resources used to interpret particular experiences. (Crook,1994)

The focus on mediation has three specific consequences: the definition of active cognition in terms of functional systems, the "situated" character of cognition and its profoundly social nature (Crook,1994; Lave, 1996). The unit of analysis becomes these functional systems (Cole and Engestrom,1993; Crook,1994) which include the individual plus the mediating elements, although some conceive of both "solo" and distributed cognitions which are distinguishable from each other but in an interdependent dynamic interaction (Perkins, 1993; Salomon, 1993). Cognitive change thus involves a restructuring of the means of carrying out certain cognitive activities, all in the "situated" context of the mediating elements, as a result of interactions.

From the Vygostkian view of the theory of activity, schools themselves may be considered to be "systems of activity" that have developed their own rules and tradition for communication and for the definitions of learning, competence, as well as the forms for their evaluation (Säljö and Wyndhamm, 1996, p. 328). From this perspective, the actions of the individuals are subordinated to what people assume to be relevant for the specific educational context. These investigators showed that, depending on the context or the system of activity, students see the task (in their case, calculating postage rates for a letter) in different manners and assign different meaning to it, showing the social nature of human cognition, that the context actually determines to a significant degree the cognitive actions. This position even puts in doubt the traditional assumption of the possibility of transfer of school-learned competencies to another system of activity.

Knowledge is considered to be socially constructed through collaborative efforts towards a shared objective (Pea, 1993), a relationship between human agents and the material and

social contexts that define the momentary circumstances of the action (Crook, 1996). Thus learning is the adaptation of a person to determined aspects of these circumstances and educational environments must provide the explicit environment to promote this active learning. In other words, there are cognitive, social, environmental and emotional dimensions to all learning (Lave, 1996). Considerations of learning must also take into consideration the differences amongst the actors, their interests, social positions, goals, motives and interpretations of activities, on the interpendencies, conflicts and power relationships involved. This "heterogeneous, multifocal character of situated activity", as Lave called it (1996, p. 15), implies that conflicts are an inevitable part in any social situation and requires investigations that explore these factors.

Situated learning

Situated learning has become a central interdisciplinary concept in socioconstructivist thought over the past decade, focusing on the relationship between learning, social situations, tools and representational media, or forms of social coparticipation. Situations may be considered to co-produce knowledge through activity, making it impossible to separate what is learned from how it is learned and used (Brown, Collins & Duguid, 1989). Lave (1996) described learning as "ubiquitous in ongoing activity", that it may be defined as "changes in knowledge and action" (p. 5). She went on to describe it as "participation in everyday life...a process of changing understanding in practice" (p. 6) where learning is "conceived of as the construction of present versions of past experience for several persons acting together" (p.8). Within this theory of situated activity it is impossible to "decontextualize" learning activities as it would be a contradiction in terms, as pointed out by Lave. "Action, thought, feeling and value" cannot be separated from "their collective, cultural-historical forms of located, interested, conflictual, meaningful activity" (p. 7). "Knowledgeability is routinely in a state of change rather than stasis, in the medium of socially, culturally and historically ongoing systems of activity"(p. 17), all of which are intrinsically heterogeneous.

The emphasis is on skills, not abstract, decontextualized knowledge, and on the perception that a learner acquires through *legitimate peripheral participation* (LPP), the process which Lave and Wenger (1991) called "the central defining characteristic" of "learning viewed as situated activity "(p. 29), "a descriptor of engagement in social practice" (p. 35).

This concept or analytic perspective of LPP thus represents the mode of engagement of a learner with an expert, initially in a limited fashion and with limited responsibilities until s/he acquires sufficient skills to become a full participant in the community, learning thus a process of participation, or a distributed one amongst the participants where "failure" or errors are considered a natural part of the activity. Participation is necessarily based on situated negotiation and renegotiation of meaning.

Although Lave and Wenger (1991) did not enter into the issues of schooling directly, they drew attention to the contradiction that the traditional organization of school learning is based on the assertions that knowledge can be decontextualized even though the school itself is a social institution that places learning in very specific, or situated contexts. Traditional schooling is organized around the individualistic cognitive focus on universal learning mechanisms of knowledge acquisition and assimilation within "reified 'knowledge domains'" (p. 52). This contrasts sharply with the social practice focus on participation within a sociocultural community, and on learning as LPP, which necessarily involves the construction of identities through evolving membership. In the traditional setting motivation is considered to be the responsibility of the teacher who organizes activities around specifically structured content, whereas in the social practice setting, increasing participation itself is the motivating factor. Lave and Wenger (pp. 96-97) differentiated between a *teaching curriculum* where there is directive teaching and prescriptive practices that control access to and limit the meaning of what is learned, and a *learning curriculum* which provides learning resources or situated opportunities for varied forms of participation for the learner. They then went on to make a distinction between the "exchange value" of what is learned in school for purposes of evaluative displays such as tests, as opposed to the "use value" or the "learning to know" in increasing participation (p. 112).

Distributed cognition

Traditional cognitive theories of learning consider learning to be an individual possession, constructed individually, whereas socioconstructivism regards it as constructed collaboratively and shared between different persons, or distributed (Cole and Engeström, 1993; Pea, 1993; McDermott, 1996; Rogoff, 1998; Tynjäla, 1999). Cognition is thus considered to be a distributed (shared or "stretched over") and mediated social activity, not the

individual property of storing private mental representations or tools (Salomon, 1993). The analysis of cognitive processes thus requires a shift in the unit of analysis from the individual to the sociocultural activities themselves (Rogoff, 1998). From this focus, it is necessary to study the cognitive agents during the interaction plus the diverse material and social contexts that mediate the action (Crook,1994). Knowledge and learning are considered to be distributed throughout the complex structure of persons acting in a setting, not in the head of an individual nor in assigned tasks nor external tools nor the environment, but in the relationship amongst them (Lave, 1996). However, Salomon (1993) also argued that cognition is situated but not necessarily distributed, that it may also be "solo" under certain circumstances, dependent on the context, that there is a reciprocal spiral-like interaction between individual and socially and technologically distributed cognition. This partnership of distributed cognitions leaves "cognitive residues" in the form of improved competencies which may be used later in subsequent activities. Intelligence is also considered by some to be distributed across minds, the product of symbolic and physical environments, and that it is accomplished, not possessed, individually (Pea, 1993).

The acquisition of new knowledge is due to social interactions and in order to explain the social transfer of cognition, Vygotsky's concept of the "zone of proximal development" (ZPD) is used by cultural psychology to explain the transfer of inter-mental (interpersonal) functions to intra-mental (individual) ones, or the process of "internalization" of socially distributed cultural processes (Pea, 1993), where the mediating element in both is language. The two fundamental theoretical concepts for learning or cognitive change to occur include the appropriation of mediating elements and social interaction in a supportive environment. It involves the amplification of a functional system of activity due to different forms of intervention organized on the social level, situated in the concrete contexts of the activity. (Crook,1994). The student learns through interactions with the teacher and the other students, remediating and perfecting his/her previously established functional cognitive system. Schools provide the sociocultural context for learning, through objectives, curriculum, priorities, values, rules, evaluation as well as the physical spaces which also impose a particular style of cognitive work. The motivation for these adjustments of already existing functional systems is explained by the concept of intersubjectivity, or the human capacity to project and interpret the mental state of others, and the desire to make adjustments between them, based on the joint,

organized activity of teacher and student in a given context. The affective aspect, the pleasure of shared knowledge and awareness of the interpersonal investment is considered to be one of the motivating factors. Rogoff (1998) defined intersubjectivity as "mutual understanding between people in communication...a process that occurs *between* people" (p. 681). Teaching is thus considered a social act, socially organized for effective instructional activities and discourse with intersubjectivity providing motivating elements for the student to learn, to adjust their existing functional cognitive systems (Crook, 1996).

With regards to the educational implications of the sociocultural theory of distributed cognition, Pea (1993) argued that learners should be empowered to carry out activities, that intelligence should be recognized as distributed and that education should elaborate designs in accordance with these ideas with the use of artefact-supported (tool-aided) cognitive activities with social "scaffolding", externally mediated. Education should be reoriented from individual, tool-free cognition towards novel uses of resources for creative and intelligent activities individually and collaboratively, to invent cognitive technology, to develop socially distributed strategies as participants in knowledge-using communities.

Perkins (1993) also supported the departure from the concept of individual thinking and intelligence and exhorted the educational process to be oriented to "person-plus", enabling the use of cognitive resources of the physical and social environment. Nickerson (1993) emphasized the importance of teaching the use of information resources effectively. Salomon (1993) summarized the educational implications in terms of goals in the distributed cognition domain as the means to improve competencies, both solo and distributed, and to design circumstances with situated cognition in order to promote or scaffold the cultivation of individual competencies.

The type of evaluation used should reflect the concept of learning. Traditionally this has been seen as a private process with the individual acquisition of information independent of the contexts, usually requiring a mastery of certain abilities, and that should be tested for individually. This contrasts sharply with the social constructivist concept of learning as a joint social activity, strongly imbedded in the contexts, thus a jointly accomplished performance (Pea, 1993). A transformation in the conceptualisation of teaching and learning should necessarily be accompanied by a transformation in the type of evaluation to be used (Bielaczyc & Collins, 2000). The very definitions of success and failure at learning in a school are

specialized social and institutional arrangements (Lave, 1996). What is actually learned is very problematic and differentiated, depending on subjective and intersubjective interpretations of the activities, of the how and why of them. Lave suggested that standardized exams could even be called "rituals of legitimisation or degradation and exclusion" (p. 10). Through these rituals and institutional arrangements, individuals learn their identities.

Common knowledge

In terms of education, teaching is viewed as a social act, with instruction socially organized for effective instructional activities. The key to the intersubjective character of the instructional discourse is the use of objects of common attention and shared resources clearly understood by all in order to build the base for later discourse. Effective instructional discourse is a socially distributed process and organized in order to integrate a variety of cultural psychological focuses. All of this requires very specific instructional techniques, such as summarizing to create a shared memory, stimulating, using structured intervention or "procedural facilitation" (Scardamalia and Bereiter, 1985) to negotiate meaning acceptable to all. Crook (1994) suggested that the social character of tutorial dialogue related to intersubjectivity included the concepts of:

- interiorisation (the joint active creation of cognitive systems through the promotion of conversation and action of the student/novice)
- semiotic mediation (a basic communication resource to stimulate the relation of an action to a previous experience to give greater relevance, to stimulate cognitive reflection)
- appropriation (activity in the ZPD through the joint effort of both the teacher and student to make sense of things in the learning context, providing the contextualisation).

Through socially organized teaching strategies, the teacher strives to create a common, stable base of understanding for all the students, which in turn acts as a positive force to seek different negotiable options. Through discourse, the teacher needs to motivate the students to adopt intersubjective attitudes through relating activities with spontaneous interests and priorities of the students, plus giving more equitable opportunities to allow them to participate in the social creation of the common knowledge base. This could include technology as part of the social context where a computer, for example, can act as a catalyser or a mediating

element, intervening in the forms of activities in the creation of a community of shared knowledge, as a general base for a series of collaborative encounters (Crook, 1996). As a computer can provide flexible representations of the action at hand and as such is part of the participative structure of learning, it can become the object of shared reference and a support for collaborative learning and must be taken into account when analysing the learning system.

The teacher is the actor responsible for socially organizing the development of the common knowledge base as the platform for further cognitive associations and development in the student. Once again the sociocultural theory provides a model for studying instructive interaction using the concepts (constructs) of common knowledge, socially shared knowledge and intersubjectivity (Crook,1994). The essential mediating role of the teacher is to explore the continuities and connections between separate activities. The mediating function of the conversation organized by the teacher includes the need for lateral continuity, the transfer of the learning to a more generalized knowledge that may be used in new situations, or the contextualisation of the new knowledge. The second aspect is longitudinal continuity to develop common knowledge, whereby the teacher uses interpretive discourse to give a determined meaning to the activity. Both the lateral and longitudinal continuity help the student create essential semantic relationships in order to appropriate the new concepts in a meaningful way (Lemke, 1997). The effectiveness of the instructional discourse depends on the establishment of the common knowledge base as well as the exploitation of the intersubjective knowledge during shared spaces and time, all mediated by the material content of the communication, the specific environment, the material resources used, to mention a few factors.

Edwards and Mercer (1987) considered education to be a public process of communication or discourse based on the development of common or shared knowledge and shared perspectives, all situated within a particular sociocultural context. They deemed a successful educational process one that transfered competence to the students, eventually giving the students autonomous control over their learning and knowledge. These authors described traditional teaching as focused on factual knowledge, precise memory, "correct answers", with transmission from teacher to student, without forming shared perspectives. They would arrive at a common knowledge that is neither discussed nor questioned by the students, with the final product the students' acceptance and understanding of what the teacher

knows. There is no discussion of common goals/ objectives of the curriculum nor incorporation of the students' experiences and interests. Thus, in the analysis of the formation of common knowledge, the processes or interactions that occur and their focuses are of interest, to see whether or not there is the development of a shared perspective. Crook (2000) exemplified how shared understanding or common knowledge between people can become a resource for a joint activity and thus, within the affective aspects, motivate collaboration, which, in turn, motivate learning (Rogoff, 1998).

Resta et al (1999) emphasized the importance of discourse in the classroom as a reflection of the levels of teacher control of dialogues, whether it be characterized or not by recitation and IRF interactions (teacher Initiation, student Response, teacher Feedback). These authors related these traditional, "common sense" practices to the difficulty of implementing educational reform and consequently on the need to focus on changing the structure of discourse within the classroom if students are to become truly active learners. They also pointed out, as a result of their own research with secondary (middle) school teachers, that if the questioning is all teacher-mediated and Socratic type, this does not give the students control over their own learning, nor does it open channels of communication that could lead to the production of a common knowledge base created through collaborative learning.

Collaborative learning

Collaborative learning, based on socioconstructivism, is defined in various ways, and often used synonymously with cooperative learning, but it generally refers to working together in groups with explicitly shared objectives and positive interdependence, mutual learning, negotiation, reflections and evaluation of processes and products. Rogoff (1998) defined it simply as when "an endeavour and its thought processes occur at least partially in common" within a group of persons (p.723). Mediating elements and the environment are essential factors to be taken into consideration when collaborative learning is being investigated.

Henri and Lundgren-Cayrol (1998) considered the essential components of collaboration to be two interacting systems: the psychosocial (the social and human character) and the cognitive, both systems mutually reinforcing each other through discussion and the use of mediating elements (pp. 96-97). The environment itself is critical for creating the spaces and activities of interaction in order to promote the transformation of information into knowledge,

which is then demonstrated through confrontations, explanations, and applications to problems to be solved. Henri and Lundgren-Cayrol (1998) focused on the cognitive dynamics of collaborative learning as involving three actors or poles of interaction: the learner, the group and the knowledge of the expert. In traditional situations the teacher is the source of expert knowledge, whereas in constructivist models the teacher is the facilitator and promoter of cognitive interactions. The interaction between these three poles is neither linear nor sequential, but all are iteratively involved in the three developmental phases of collaborative work: exploration (including both social and cognitive engagement), elaboration (negotiation, enrichment and validation, all requiring positive interdependence for collaboration) and evaluation (reflection and consolidation of knowledge). Each of these phases of collaboration involve communication, engagement and coordination. The cognitive abilities required in each of these phases are those of analysis, synthesis and evaluation, each involving particular cognitive roles for the actors.

Collaboration in a school setting is not considered to be a natural consequence of putting students to work in groups, but rather that careful preparation is required for them to learn to collaborate (Henri and Lundgren-Cayrol, 1998). At the beginning it is essential that they receive explicit and concrete descriptions of the functioning and requirements of the model of collaborative learning, the work to be realized, the schedules, the abilities to develop, possible resources, etc. This should be followed by a discussion with the learners of their perceptions, needs and contributions, in other words, a group diagnosis. The next step is that of collective negotiation of the rules to be followed, of the model to be used, the forms of collaboration and the different roles to be taken, all with increasing responsibility for acquiring necessary competences and knowledge, the evaluation of their work. According to the authors, all of this leads to a progressively increasing autonomy on the part of the learner with more control over their own learning during the three phases of collaboration described above, along with the development of their cognitive abilities. This necessarily requires a decreasing level of control on the part the teacher.

Rochelle (1995) focused on collaborative technology, basing his work on constructs from the educational philosophy of John Dewey and situated learning research. Dewey's view of technology included any tool serving the process of inquiry: symbols, languages, ideas, physical tools, any of which could be used to deal with problematic situations, thus related to

socially constructed experience, situated learning and community of practice. Rochelle described collaborative technology as any tool for the mutual production of shared knowledge, as one that allows for the clarifying of a shared problematic experience through the mutual production of new practices, the highly visible or public part of a shared experience, be it paper, chalk, talk or computer programs.

Joiner and his colleagues (2000), in their discussion on peer interaction and task presentation on the acquisition of scientific reasoning, defined psychological and technical tools in the Vygotskian manner, that they are both by their very nature social and that their introduction into an activity qualitatively changes the nature of the activity. Psychological tools include the universal, cultural tool of language as well as number systems and mnemonic strategies, while technical tools are physical ones such as rulers, watches, computers. Their study with 9-10 year old students presented evidence that the use of a computer simulation compared to the use of a physical apparatus for solving chemical combination tasks did change the types and quality of interactions, but did not necessarily improve the learning gains in terms of scientific reasoning.

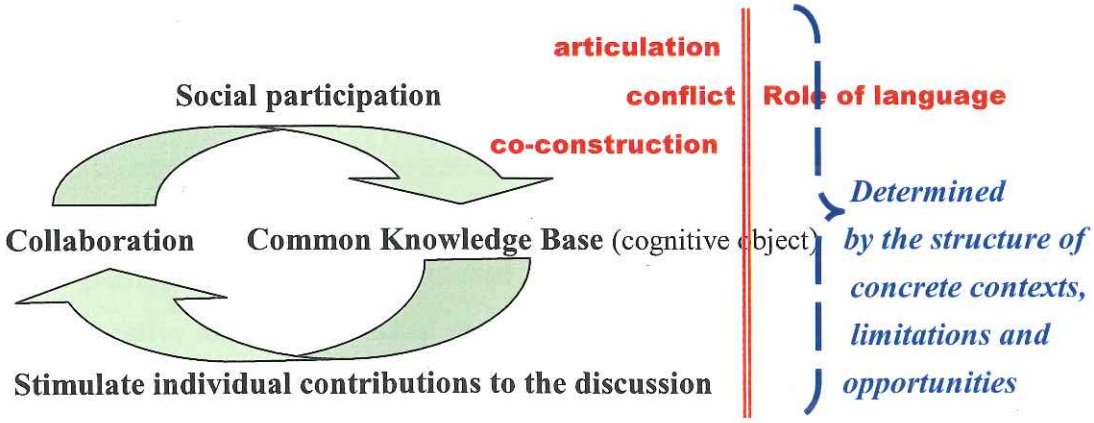
Charles Crook (2000) emphasized the essential ingredient of motivation, or human agency in collaborative learning but within the spaces or ecologies of collaborations. He defined collaboration as "certain forms of productive joint engagement" and ecology as "the immediate environments within which such activity is supported- the artefacts, the technologies, and the spaces for acting" (p. 162). By considering these factors, one can better understand the wide variation in the results obtained through collaboration, in affective and cognitive terms, as well as to design more effective collaborative experiences. Within the affective aspects, Crook exemplified how shared understanding between people, such as comprehending a software program, even if individually acquired, could become a resource for a joint activity and thus motivate the collaboration even further. A shared culture, such as that of an institutional context, could also help promote joint engagement based on this shared meaning or common knowledge, but always evoked within particular cultural contexts or ecologies. The ecological metaphor helps focus on the mediated character of social interaction through spaces, artefacts and technologies, the potentially systemic character of social exchanges, and the notion of cultural niches, understood to include the institutional or organizational settings.

Successful collaborative learning in a classroom depends then on the mutual appropriation of motives, intentions, ideas of the participants to create the shared cognitive context. The teacher needs skills in saying and doing things that precipitate and exploit possibilities, to establish resources of common knowledge in order to build on them. It is important to identify these sociocultural processes used in interactions between a teacher and the students, amongst students and between teachers. Crook (1994) described the psychological processes underlying collaborative work as including:

- *articulation* of intuitive ideas in a public manner, to justify in an interactive, social fashion in the ZPD which allows for the opportunity to create conditions to transfer from inter-mental to intra-mental
- *conflict* or disagreements to negotiate meanings, to stimulate discussion that allows for cognitive change or restructuring.
- *co-construction* where an activity is creatively worked on through useful reflection of previous and alternative ideas, with a sharing of responsibility to jointly construct the common knowledge.

The critical importance of language and interactive discourse is evident. I have represented Crook's (1994) description of collaborative interactions in the formation of common knowledge in the following diagram:

Figure 1: Collaborative interactions:



This could be thought of as a spiral process where each common knowledge base acts as a resource to provide the platform for further collaboration to formulate new cognitive objects, and so on. Effective collaboration, when dealing with the teacher, includes an active concern for the construction of the common base by coordinating the action and attention in relation to the centre of interest, requires shared perspectives as to the objective, and the anticipation of possible obstacles through careful design and description of the work and the clarification of the objectives. The teacher needs skills in how to direct the discussion towards shared references as a platform for new explorations, taking into account the material, affective and temporal dimensions. As learning is the centre of socially shared knowledge, collaborative relationships are those that construct the knowledge (Crook,1994).

Rogoff (1998) emphasized the importance of the school structure in determining the relative responsibilities of teacher-student collaborative relations. She pointed out that whatever the structure, however traditional it may be as teacher-centred, there is still collaboration with respect to the organization of time, resources and companionship. Collaborative activities may be formally planned or may occur informally within a learning community. Crook (2000) accentuated the need for creating "a setting which cultivates, records and exploits common knowledge" as well as developing appropriate mediating resources or collaborative tools (p. 174-175). The differences in levels of engagement and the types of shared experience may well be strongly influenced by these factors. Crook summarized by defining collaborations as "social events that are 'situated'; that is, they involve interpersonal co-ordinations around the artefacts and technologies of culture" (p. 177), thus invoking a broader focus in research on collaboration.

Littleton (2000) provided an overview of the rethinking of collaborative learning in the late 90's, emphasizing that careful discourse analysis is necessary, focusing on "the continual, subtle, evolutionary processes of negotiation and renegotiation of meaning" but without ignoring "the particular historical, institutional and cultural contexts" of the collaboration (p.248). Collaborative learning is situated practice with the unit of analysis becoming "people in action using tools of some kind" (Säljö, 1999, cited in Littleton, 2000, p. 250). Intersubjectivity, negotiation and co-construction are all involved in the joint creation of the meaning of educational tasks. Littleton also reviewed studies that raised the issue of individual reflection during collaborative work, of its importance at different moments, as well as the

difference between students who are apparently marginalized and disengaged as compared to those who are staying at a distance but still have input into the collaborative work (p. 253). She gave a word of warning concerning the difficulties of educational systems incorporating collaborative technology as part of their model, ending with the citation that

> established social institutions have a remarkable capacity for "neutralizing" the effects of new developments, technological or otherwise. The established culture of learning can impact significantly on the prospects for new....initiatives and existing practices will offer resistance to the "bolting on" of new forms of educational technology. (taken from Crook and Light, 1999, cited on p. 256).

Theory of practice

The conditions for the building of shared or common knowledge through social interactions are interdependent and interactive with the development of collaborative learning (Crook, 1996; Edwards and Mercer, 1987; Henri and Lundgren-Cayrol, 1998; Joiner, et al, 2000; Pea, 1993; Rochelle, 1995). Both aid in the growth of intersubjectivity with the subsequent empowering of the students to take an active role in their learning. In this sense, in a planned, institutionalized practice, collaborative learning could be considered a minimal requirement for the formation of a community of practice, one which is oriented to the distributed cognition domain (Salomon, 1993) where the goal is to improve both solo and distributed competencies in a situated practice (Lave and Wenger, 1991), with emphasis on negotiation, shared interests and knowledge, identity formation (Wenger, 1998, 2002). From a sociocultural view, learning, thinking and action are inseparable, permitting the integration of collaborative learning and community of practice concepts; additionally, the concept of thinking and identity construction may also be viewed as intrinsically linked (Littleton, 2000).

Learning communities

Although there are many definitions of learning communities, they may be considered to be groups of people learning through the process of transformation during participation in shared, socioculturally situated activities with evolving roles and understanding, a situated construction of collective knowledge along with the construction of collective and individual identities (Coll, 2001; Lave and Wenger, 1991; Rogoff, 1994). This alternative model to understand teaching-learning processes contrasts sharply with that of traditional learning of

knowledge transmission to passive recipients or of knowledge acquisition by novices (Coll, 2000). In a community of learners it is understood that not all participants will have the same knowledge, but that they will share their diverse knowledge and competences in order to solve a problem (Bielaczyc & Collins, 2000). This is a clear distinction from the traditional viewpoint that all students must acquire the same knowledge at the same time, that knowledge and performance are individual. In a community of learners there is collaboration between the participants, shared interest and mutuality with leadership provided by the teacher in the case of schools, but with increasing student responsibility and autonomy for their own decisions and learning. There is a collective effort to understand, an agreement and commitment to build and share knowledge and competences. The selection and planning of activities is collaborative and includes global, interdisciplinary focuses that are relevant to the lives of the participants (Coll, 2001). The participants should become critical thinkers capable of a profound understanding of the themes that they investigate, capable of analysing problems.

Bielaczyc and Collins (2004) developed a thematic map of a learning community[6] that included the following concepts: knowledge, discourse (articulation of goals, respect for others and negotiation), participation (central/ peripheral and identity, sharing, multiple modes to participate), teachers' roles and power relationships, resources (going "beyond the bounds" of the classroom), goals of community (emergent and community growth), learning activities (metacognition, depth over breadth, safe environment to fail, to take risks) and products (quality). In their instructional blueprint for learning communities in the classroom, they described the goals as fostering the culture of learning, where both individuals and the community as a whole are learning how to learn. They went on to specify that a learning-community's approach uses a variety of learning activities, including individual and group research, class discussion, tutoring, working together to create artefacts or public products to show both what is learned and ways of learning, and collaborative problem solving with students taking different roles toward a common end.

Learning community models, developed from the theories and focuses of situated and distributed cognition along with cultural and socio-cultural psychology, have been widely used as models for informal educational community organizations, but they could also be used to structure curricula for formal educational institutions so as to promote transformation and

[6] See map in Appendix E.

effective learning (Coll, 2001; ERIC Digests, 1999). From this perspective, all members of the institution would be committed to the construction and acquisition of new knowledge and competences and the bureaucratic structures would be replaced with collaborative work, shared leadership, participation and coordination. Through this structure a sense of group identity is built, of cohesiveness and distinctiveness that encourages continuity and the integration of different curricular experiences (ERIC Digests, 1999). Students would learn to face complex questions, reach their own conclusions, communicate and work with people of different knowledge and points of view, to share their knowledge with others (Bielaczyc & Collins, 2000). In a learning community, knowledge is a mode of participation, its value determined by its effectiveness, with the community of learners constantly changing as the participants' understanding evolves. Within a community of learners, an analysis to evaluate their learning would be focused on different factors, such as the changing roles and purposes of participants, of their flexibility and attitude toward change, the interrelation of their roles in a particular activity to those in another, their flexibility in evaluation of the processes (Rogoff, 1998).

Community of practice

The conceptual framework of communities of practice developed by Wenger (1998) is essentially a variation of learning communities that has evolved over the years (Lave & Wenger, 1991; Wenger, 2001, 2002). Wenger's concept of communities of practices was derived from the theoretical frameworks of social constructivism and distributed and situated learning (Crook, 1998; Lave, 1996; Lave and Wenger, 1991; Salomon, 1993; Vygotsky, 1988). As such it is a social theory of learning which provides a basis to understand learning as a social phenomenon, occurring through participation, embedded in the sociocultural context, providing a "design framework" through which to analyse educational situations. Wenger's model was chosen as the theoretical perspective for this research, initially because it had been taken as a theoretical basis for the project TACTICS, and also on account of the richness of its concepts that provide a privileged viewpoint from which to analyze a teacher's classroom practices.

Wenger (2001, 2002) identified a community of practice as a specific group of people characterized by the following three aspects:

- They share an interest in a topic in that they understand what the issues are and agree on common approaches. Wenger also called shared interest the sharing of a domain of

knowledge. In terms of a classroom, ideally the shared interest would be the issues and purpose of studying a particular topic plus the teaching agenda.

- They form a community by interacting and building relationships, helping each other solve problems and answer questions, networking across teams. In the classroom setting these would be the teacher and students, including their identities as members of the community.
- They have a practice where they share and develop knowledge, sharing information, insights, best practices, and build tools and a knowledge base. This would include the context of the class, the learning objectives, the mediating artefacts. They are not separate units but address the informal and tacit aspects of creating and sharing knowledge, as well as the more explicit aspects, allowing a much closer connection between learning and doing. At the same time, they provide structures where learning can accumulate plus creating connections among people, across institutional boundaries and potentially across the globe. (2001, p. 3).

In his book on communities of practice, Wenger (1998) regarded learning as individual but also distributed or collective amongst the community. He considered that a social theory of learning must take into account four components: meaning, identity, community and practice, each of which he described at length. Wenger defined meaning as the product of learning, our ability to take part in the world and to make sense of it, but also as a process of negotiation between members of the community, thus with both individual and distributed aspects. Negotiated meaning has a historical context and is dynamic, contextual and unique. Wenger referred to the duality of meaning arising from the interaction of participation and reification: participation as an interaction, a membership in a community, both personal and social, which shapes our experiences and those of the community and becomes part of our identity; and reification as "the process of giving form to our experience by producing objects that congeal this experience into 'thingness'" (p.58), giving status to aspects of our experiences in a specific context, focusing attention and enabling new understanding. Reification can include a study plan, texts, written notes, the teacher's knowledge. There should be a constant interaction or interplay between these dualities as they define people and things, which Wenger considered a profound principle for collaborative activities and instruction where a continuity of meaning is essential. Wenger pointed out that in traditional teaching there is a great dependence on

reification with very little opportunity for participation for shared experiences and interactive negotiations, an excess of formalism without participation.

One of the basic concepts continually referred to by Wenger is that of practice, a property of communities described as having three dimensions: mutual engagement, joint enterprise and a shared repertoire, three interdependent and interlocked elements that lead to the continuity and adaptability of the community. Mutual engagement establishes relationships within a social complexity and is also the mutuality of learning, while joint enterprise is that of mutual accountability. The shared repertoire involves artefacts, history, concepts, words, style, discourse, gestures. The community of practice is thus seen as the locus of engagement in action, interpersonal relationships, shared knowledge, joint learning, formation of identity and the negotiation of enterprises, or as the key to transformation of both the individual and the community. There is constant emphasis on this dynamic, flexible, continuously changing character of communities of practice.

Communities of practice are not seen as isolated phenomena but with evident links to the external world, with everyone belonging to different communities (multimembership) that are interconnected through participation or brokers, and through reification or boundary objects. Legitimate peripheral participation is an important factor to consider here, characterized as a "process by which newcomers become included in a community of practice" (Wenger, 1998, p.100). Lave and Wenger (1991) developed this concept based on the idea that for learning to occur, a modification of forms of participation takes place, which required both legitimacy and peripherality. This allows for gradual entry of potential members into the practices of the community but with more supervision, with less risk, a form of apprenticeship. It also involves processes of negotiation between the community and the newcomers with their different perspectives, thus stimulating a continual evolution of the community. In this fashion, the peripheries are considered to be fertile areas for transformation.

Competence is defined as experience that is demonstrated by members of the community through their practice. Knowing is seen as competent participation in practice whereas learning is the transformation of knowing, the combination of the experience of meaning and competence, both individually and collectively. Knowledge is thus knowing, or the experience of meaning and the regime of competence plus the orientation of the practice in broader constellations or related communities. Change occurs in a community's regime of competence

through negotiation, reification, redefining the enterprise, adding new elements to the repertoire. If the member has enough legitimacy, they may be able to change the regime of competence, thus having an enormous potential for learning, both individually and collectively, and for creating new knowledge.

Identity is one of the main concepts developed by Wenger with the unit of analysis being the process of negotiation of the duality between individual and collective identity. Identity is how we define ourselves in terms of experience, participation, reification, and membership in terms of competence, a constantly evolving social experience. Wenger emphasized learning in practice as precisely the negotiation of an identity influenced by multimembership of each person in other communities, defined by what we are (participation) and what we are not (non-participation). The question of non-participation is of great significance as it can lead to marginality or peripherality; it may be caused by institutional conditions, or may actually be a strategy or a cover for the person to separate different parts of their life or as a shield against broader conflicts.

Modes of belonging thus have a significant potential for learning and identity and, according to Wenger (1998), they define our actions and meaning. He described three modes of belonging or processes of identity formation (2001):

- Engagement: how to create meaningful activities related to the life of significant communities. It is the active involvement in mutual processes of negotiation of meaning, of the production and adoption of proposals for meaning, creating a shared reality in which to act, an essential source for the construction of an identity, for the formation of communities of practice with the definition of a common enterprise. It is the production of a local regime of competence, the accumulation of the history of shared experiences, the development of interpersonal relationships, the management of boundaries and the opening of peripheries. "It is this dual access to participation and reification that makes engagement a special context for learning and identity" (p. 185). Through engagement we contribute to the community enterprise and thus define ourselves and our identity of competence and accountability. The lack of the ability to contribute to the collective production of meaning leads to marginality and to a poor development of our identity.
- Imagination: how to build productive images of who we are, of the world, of the possible; creating an image of the world in which you make sense of who you are and the

activity in which you are engaged. It may include the creation of new images, sometimes through the use of stories, parables, social events, generating new relationships through social interactions, extrapolating from our own experiences, processes all requiring risk-taking and time, resulting in transforming part of our identity, creating a sense of affinity or participation. However, this requires the balancing of participation and non-participation, of the actual and possible, so if the imagination is disconnected and ineffective, it may cause the loss of the sense of social competence, again leading to marginality.

- Alignment: how to enable effective participation, how to act. It involves the coordination of personal and communal energies and activities towards a common purpose, the ability to affect the negotiation of meaning and to share the ownership of meaning, to fit into and contribute to broader enterprises outside of the community of practice. It may increase our sense of power and sense of possibilities but it can also be just be a matter of compliance to expectations of an institution, a literal and procedural action disconnecting the person from the community.

Wenger defined identity formation as a dual process of identification and negotiation, always emphasizing the subjective and collective aspects, and its dynamic character. He considered identification to be the core of the social nature of identity by means of providing experience and materials with which to build identity, essential to develop forms of membership (one aspect of social status) and thus communities which emphasize social configuration that allow for identity formation in relation to belonging or not (one aspect of social structure). Negotiation, with its dual processes of participation and non-participation, determines the degree to which we can use, control and modify local meanings, defined within a social configuration and our positions within it, hence termed "ownership of meaning".

Wenger further defined learning as an interaction between experience and competence within a community of practice, an experience of identity, transforming who we are and what we can do, thus a social reconfiguration, a defining of an identity of participation. A community of practice is also influenced by modes of belonging, where different combinations of the three modes may produce different effects: if imagination and engagement are involved, this may lead to a reflective practice; if imagination and alignment are used, they produce the ability to act, to understand the relationship to the broader levels; if engagement and alignment

come into play, this leads to the coordination of different perspectives and the possibility of exploring boundaries.

Wenger (1998) emphatically claimed that learning cannot be designed, only the social infrastructure that fosters learning, the social processes and artefacts, involving practice and identity but not form. He defined a learning design as a proposal of identity that creates a focus for identity, a bid for ownership of meaning. It must generate social energy and set up a negotiable framework. He applied the three modes of belonging to a learning design as the three infrastructures of learning: a) imagination: which included orientation, reflection, exploration; b) engagement: mutuality, competence, continuity; and c) alignment: convergence, coordination, arbitration.

Wenger (1998) placed the discussion of education within the framework of communities of practice. He was insistent that education must above all address identity and modes of belonging, and only then skills and information or the delivery of the curriculum, that it must open spaces for the negotiation and transformation of identity for students who are to go out into the world. Education should be primarily concerned with identity formation, a mutual developmental process between individuals and the community. He formulated the corollary to this, that it is more important to create transformative experiences of identity than to cover the entire curriculum (2002). He described a classroom based on the community of practice model as a curricular model with the domain inquiry as a learning journey, a discovery of joint topics within a community circle (2002). Practice would be based on laboratory work, projects, cases, group investigations, keeping records and developing documents and resources. Roles would be shared by taking charge of common building tasks. Connections would be made across boundaries by means of guests, visits, fieldtrips, all with private space in the centre and public space outside along with technical support.

Wenger described knowledge as codified in texts and curricula or as reified subject matter. Knowing and its evaluation as such in a traditional system is thus reduced to reified items, apparently ignoring the need for participation and negotiation, and, as a result, does not develop ownership of meaning. It is essential that there be negotiation of meaning, not just mechanisms of instruction for the transmission and acquisition of information and skills. He emphasized that ownership of meaning is the source of energy necessary for learning, and thus the source of motivation to become a learner. Questions related to this refer to how much

reification is necessary, what forms of participation are the most useful in the transformation of identities. Teachers and teaching do not cause learning, but only provide a context, act as learning resources, provide spaces for negotiation. Teachers must be "opportunistic" (p. 267) to take advantage of the uncontrollable effects of their teaching, with the issue being the interaction between the planned and the emergent. Teaching and learning should be resources to each other.

A classroom has its own local regimes of competence, but it should use local learning within experiences in a broader context. The traditional approach of trying to solve this problem through the use of abstract formulations with a wide application is mistaken, according to Wenger (1998), as the applications are questions of identity that require a negotiation of meaning to be able to carry our experiences from one context to the other, not by means of abstractions. Thus schools must allow students to engage in experiments of identity that are not limited to the content of teaching. Questions here are complex: how to create links to other practices, how to enable experiences to transform students' identities, how to balance broader scopes with local engagement.

Wenger claimed that education should include meaningful engagement of the students, participation in negotiation that leads to ownership of meaning. Without this, many students are marginalized, not for lack of interest or abilities, but for lack of the opportunities provided by communities of practice. Questions related to schools should be focused on the following: what are the sources of identity, how to design opportunities to build an identity of participation, whether there is negotiation of the definition of success and failure.

In summary, in terms of education and identity, Wenger (1998) again referred to the three modes of belonging. The engagement of the student must be meaningfully connected to the world with the community of practice providing experiences with processes that include social relations and interests that will lead to genuine learning. These activities must provide challenges and responsibilities, continuity and long-term commitment. As a consequence, the curriculum would be converted from a list of subject matter to an itinerary of transformative experiences of participation. The community of practice thus would provide resources for organizing learning and the contexts for the identity of participation. Imagination is what gives the students a sense of possibilities, or orientation, reflection and exploration. Alignment helps students take charge of their destiny, of how to coordinate local actions to global ones, of how

to use power, to have opportunities to explore and interact beyond the boundaries of the community, to coordinate multiple perspectives. From this point of view, education is not a matter of information and skill nor multiple practices, but of identity. Educational resources must be connected to the outside, using the surrounding world as learning resources. Generational interaction is necessary to maximize identification and negotiation, mutual engagement and accountability. Wenger believed that the most powerful teaching asset of teachers was to manifest their identity as authentic participants of a community of practice, not just their identity in an institutional role.

Wenger (2001) represented the dimensions of community-based knowledge in a figure composed of four crossing axes[7], each one representing one dimension of the social life of knowledge. In each case the first pole of the axis described below is composed of various processes for creating and cementing knowledge-oriented social groups, whereas the other pole is considered as processes for exchanging knowledge with or without the existence of a community. According to Wenger, the inherent tensions between the two ends or requirements of each axis need to be integrated in a functional community of practice (pp. 43-44). . The four axes are:

Axis 1: Social structuring of knowledge: one pole represents the need to form specific social structures or communities to allow ongoing participation in knowledge-creating and -sharing processes, versus the other pole that is the need to provide access to expertise, generalized mechanisms for accessing and exchanging knowledge across boundaries.

Axis 2: Processes of sharing knowledge: one pole is composed of interactions, the need to interact and negotiate meaning, to create and share knowledge in the context of conversations among people, while the other refers to documents, the need to create a repository of knowledge captured in documents, which really have significance only through the interactions they reflect.

Axis 3: Contexts of learning: one pole is the need to have a joint project, a context for working together, while the other is instruction, the need to conduct specific activities oriented to learning specific skills.

[7] See Appendix D for Wenger's diagram of the axes of social knowledge.

Axis 4: Management of attention: one pole is the long-term need to support the ongoing integration of work and knowledge or the knowledge workers, while the other is the need to support interactions which call for the full but fleeting attention of participants.

Communities of practice are at the intersection of all these dimensions of the social life of knowledge, making it necessary that they all be integrated in order to produce a full knowledge system. Learning depends on how well they work in concert and how well the two poles of each axis are integrated.

Discourse analysis

In the social sciences, it has been a constant challenge to develop the most productive and comprehensive research methods possible in order to attempt to understand how and why people behave and interact as they do and to understand human and educational experiences. Clandinin and Connelly (2000) credited Schön's work (1983) on professional practice and reflection-in-action (cited on p. 35) for helping to break with the technical rationalism that was predominant during the 20th century. One of the responses has been the development of narrative inquiry, a relatively new, interdisciplinary field developed since the 1980's based on qualitative, collaborative inquiry between researchers and participants into the narratives or stories of their experiences, all embedded in a temporal, cultural and spatial context. As described by Clandinin and Connelly (2000) "narrative inquiry is stories lived and told" (p. 20), or experiences involving continuity and interactions (Dewey, 1916, cited in Clandinin and Connelly, 2000, pp. 2, 32). Narrative inquiries take into account the interconnected features of a situation: temporality, the people as embodiments of lived stories, actions involved, the specific context, and the degree of certainty of any interpretation, always tentative as to an event's meaning. Through this narrative process, a person's experiences are reconstructed in three dimensions, in relation to the temporal, personal and social, and physical context (p. 50).

The narrative research approach is based largely on phenomenological-existential psychology (Giorgi, 1985) in the development of methodology and interpretations without a specific theoretical framework, which Clandinin and Connelly (2000) considered restrictive and formalistic (pp. 40-43). Another discourse analysis research approach, dialogic inquiry (Wells, 1999), is also concerned with experiences and memories as expressed in teacher and student discourse, temporal, social and spatial factors, but within the Vygostkian sociocultural

framework. Much of the discourse analysis research is highly linguistic in methodology and analysis, but other more generalized approaches have developed methods for understanding discourse as contributing to processes of common knowledge construction, such as that of Coll & Onrubia (1996), or Edwards and Mercer's "intuitive observation of verbal interaction"(1987, p. 40).

Coll and Onrubia (1996) regarded school education as a social process with the dual functions of developing persons socially and individually, an active, social construction of both knowledge and identity of teacher and students (p. 54). Within the theoretical basis of sociocultural constructivism, Coll and Onrubia (2001) described language as having a position of priority in terms of the interactive processes of collectively and individually constructing shared meaning, presumably the primary goal of educational instruction. From this Vygostkian viewpoint, language is a most powerful psychological and cultural tool as well as being the principal medium of communication, the privileged instrument of mediation in interpersonal, social construction of common knowledge (Vygotsky, 1934; Edwards and Mercer, 1987; Coll and Onrubia, 1996, 2001; Coll and Rocha, 2000). Language thus has a double function, of both communication as well as symbolic representation, a mediating instrument "*por excelencia*" as described by Coll and Onrubia (2001, p.22), both to intentionally construct and communicate meaning between teacher and students in the progressive construction of common knowledge, as well as in the process of constructing the activity itself, a shared discursive activity.

The study of the use of language-in-action can then give a better understanding of how and when teachers have a positive educational influence of their students' learning, but dealing with the mediating discourse and the mediated activity as a unit, all situated within the particular context. Coll and Onrubia (1996) described discourse as an essential instrument in the process of constructing common knowledge due to its semiotic nature and capacity to define, refine and share discursive activities (p. 53). Littleton (2000) emphasized that discourse and cognition both serve to establish a social role or identity of a person with respect to others. The study of classroom discourse is an excellent indicator of the role of the teacher: in a traditional situation the teacher is typically in the centre of the dialogue, controlling nearly all verbal exchange, characteristically with extensive use of triadic dialogue interactions[8] (Lemke, 1997; Resta et al, 1999; Wells, 1999).

[8] This refers to IRF strategies: teacher **I**nitiation, student **R**esponse, teacher **F**eedback

Through the processes of presentation, elaboration, modification, negotiation of content, a final representation is reached. Coll and Onrubia (2001) distinguished two different phases in these processes of constructing meanings between teachers and students: the first one was approaching new content, each person with their own representation, a phase that required the development of the first levels of intersubjectivity of shared knowledge that could serve as an initial base; the second phase involved evolution and enrichment of the shared representations, processes requiring higher levels of intersubjectivity in order to construct a much richer, more complex representation, each time closer to the intentional or expert meaning. Both phases required authentic negotiations of meaning involving the double functions of language to construct common knowledge and the activity itself.

Brown, Collins and Duguid (1989) considered conceptual knowledge as similar to a set of tools, but one that can only be fully understood through use, in this case through language, in order to develop a robust, useful knowledge (p. 2). Coll and Onrubia (2001) identified different discursive strategies and semiotic mechanisms used in the construction of systems of common knowledge or shared meaning between students and teachers. The discursive strategies are intentional ones employed by the teacher to guide the students' knowledge construction towards a particular goal, ones that reflect the context of the interactions which includes the rules and obligations of the institution itself. Their concept of semiotic mechanisms, based on Wertsch (1998, cited in Coll & Onrubia, 2001, p. 24) referred to the particular forms of language use that permit the creation and transformation of shared knowledge in a communicative situation between two speakers each of whom has a different representation or understanding of what is under discussion. The semiotic mechanisms are thus manners of using language that permit the speakers to establish and modify their degree of intersubjectivity, such as "we are talking *of this*". This also permits them to develop the necessary semantic relationships between the concepts they already have and the new ones (Lemke, 1997).

The importance of discourse analysis is evident if the interactions of the teacher and students are to be interpreted in light of the mechanisms and semiotic resources of discourse that are used, in order to elucidate the different forms of organisation and their evolution during the activity. According to Coll and Onrubia (1996) there are three essential dimensions of participation that need to be studied in order to understand discourse as contributing to the

processes of constructing common knowledge: a) the structure of the social and communicative participation that sets the obligations and the common rights of the participants or rules that structure and organise the activity; b) the cognitive and learning participation, or the structure of the academic work around which the shared activity occurs, which depends on the logical disciplinary structure of content; and c) the instructional participation or the intentional instruction of the shared activity. Successful participation in class depends of the possibility of giving sense to the activity, which largely depends on the students' comprehension of what they need to do, the how's and why's of the work, showing the fundamental interrelation of discourse and activity. Resta and collaborators (1999) suggested that there is a need to study this structure if there is to be a change in education from the didactic model to a more constructivist one, while Lemke (1997) emphasized its significance specifically in science teaching and learning processes.

Context

Context is a critical facet of any sociocultural research in education and refers to material aspects as well as social interrelations, cultural and institutional ones. The material aspect was central in the ecological position of Crook (2000) when he referred to a learning situation, in which he included artefacts, signs, tools and technology, as a starting point to explore the mediated character of the social interaction of a classroom. Learning is thus the adaptation of a person to determined aspects of the material, social and educational contexts (Crook, 1996).

Context also refers to more than the classroom space itself, the structures such as artefacts and technology present, but also the development of activities to transform information into knowledge (Crook, 2000; Littleton, 2000). This aspect has only recently been widely recognized as an essential aspect of studying collaborative learning. Crook (2000) was emphatic with regards to the role of the institutional context and shared cultures in promoting (or constraining) joint engagement that he considered essential for collaboration. He judged common knowledge or shared understanding as a resource for joint engagement and also for motivating collaboration. Littleton (2000) also discussed the importance of the social climate in the classroom, and the manner in which success- failure, competition-collaboration are dealt with, the style of discourse that is developed, the cultural and institutional context, all determinant in establishing social roles and the negotiation of identity.

Teaching culture

Cultural models are used unconsciously to identity oneself, to organize knowledge, to interpret relationships within a given social framework. The culture of teaching, developed from an anthropological viewpoint as described by Feiman-Menser and Floden (1986), is embedded in the beliefs and knowledge that teachers share. Within a particular institutional context, there are certain common beliefs and purposes, or models about teaching and learning, mainly implicit, "common-sense" ones, and generally a certain culture of teaching is prevalent, such as teacher collaboration and collegiality as compared to teacher individualism and isolation (Hargreaves, 1993). Those who differ actively from the common views or culture may even be labelled as heretics if they are seen as challenging the educational system (Hargreaves, 1993).

Different aspects of shared teaching culture include the culturally appropriate ways to behave, the possible professional rewards (What's in it for the teacher? What are their expectations? their status?) and the knowledge necessary to carry out their job. This necessary practical knowledge has been classified into three categories by Feiman-Menser and Floden (1986): a) content: of self and the milieu, subject matter, activities or surface content, and learning priorities or organizing content; b) uses: to make sense of teaching, to structure social realities, conditioned by teacher conceptions of theory, practice and relationships; and c) organization: belief as to how to react in particular situations, the rationale and images.

These authors also emphasized the importance of identifying the teachers' norms as a part of the description of the teaching culture, such as the norms of non-interference as a cultural standard where professional autonomy is considered correct and necessary, that each teacher works out his/her own solutions to problems in isolation, as well as the norms governing interactions of teacher-student, teacher-teacher, teacher-administrator, teacher-parent. In order to do so it is necessary to investigate the teachers' ideals or images with respect to these interactions, with images seen as the mediator between thought and actions, showing where knowledge and values come together. Conflicting norms, such as between the teacher and administrator, or teacher and student, create a dilemma and tension for the teacher that may lead to the formation of survival or coping strategies instead of effective teaching strategies, and in extreme cases, may lead to teacher burnout. From this ecological perspective it is necessary to include the context of teaching, the constraints and opportunities of the

institution, the managerial and instructional responsibilities in the classroom and societal factors including economic, political and social components. Teachers are seen as active agents, constructing their own perspectives and choosing actions where their commitment is seen as an essential factor for their success within the system.

The teaching culture is intimately related to the school culture that frames the activities within the institutional context. This culture gives meaning and purpose to the activities that are socially constructed through negotiations among present and past members. School science activities tend to be hybrid, as described by Brown, Collins and Duguid (1989, p. 4), implicitly framed by the school culture, but explicitly attributed to a scientific one. If we take their definition of learning as a process of enculturation, these hybrid activities make it even more difficult for students to relate to "real" science as the activities, the systems of learning and evaluation which are all part of the school culture. These authors characterized traditional school cultures as ones that "assume that knowledge is individual and self-structured, that schools are neutral with respect to what is learned, that concepts are abstract, relatively fixed, and unaffected by the activity through which they are acquired and used" (p.8). They themselves conceived of knowledge and learning as both situated and distributed through the minds and environment, both social and physical, and that learning methods must be embedded in authentic situations in order to be meaningful. School activities are usually simulated and require one approved manner of action, and thus fail to provide the necessary context to make them authentic. They advocated the need for a change in the epistemology that has guided educational practice for centuries, one that has assumed conceptual representation as prior to all else, to an epistemology that begins with activity and perception as suggested by the theory of situated cognition.

IV Research Design

Type of investigation

This thesis presents the data from a longitudinal case study carried out over nearly four years using qualitative, naturalistic multi-measurements with constant comparison of social phenomena across temporal, situational and instrumental categories (Cohen, Manion and Morrison, 2000). The intention is to identify which aspects of the teachers' practices and beliefs change and which are relatively constant, to discover any incongruence between the personal and practical domains, as well as to attempt to classify aspects that appear to promote or constrain change, all within their particular contexts. As explained in the introduction to this thesis, the beliefs and practices were analysed through the study of the degrees of development of common knowledge and of collaborative learning in the classrooms, as well as to identify to what degree the classrooms could be considered as functional communities of practice. The discourse analysis of the classroom interactions and of teacher interviews was consequently oriented by the theoretical framework of these three models using codes developed from specific categories of common knowledge (Edwards & Mercer, 1987; Edwards, 1993; Crook, 2000), collaborative learning (Henri & Lundgren-Cayrol, 1998; Joiner et al., 2000) and communities of practice (Wenger, 1998, 2002)[9]. In some cases, in order to classify other aspects of teaching-learning processes identified during the analysis, other codes were also developed and applied.

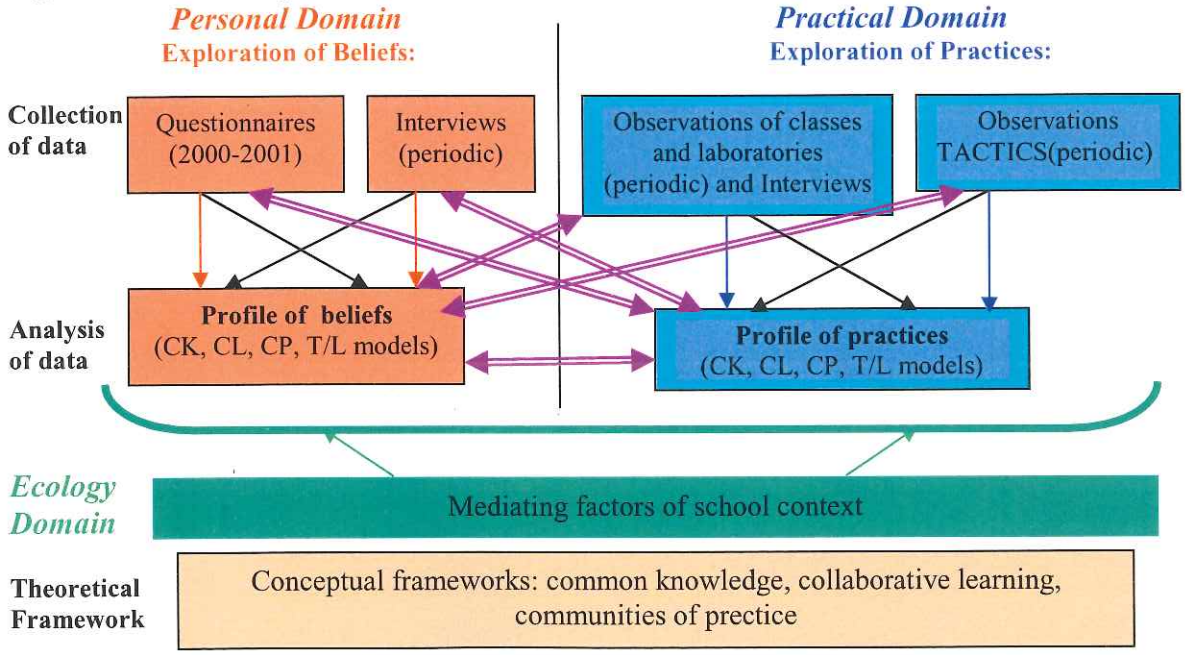
Due to the complexity of the interactions between beliefs, practices and context, multiple instruments have been used, including non-participant observations of classes, semi-structured, in-depth interviews and questionnaires, a variation of contemporary ethnomethodology directed towards discourse analysis (Adler & Adler, 1998). This could also be likened to what Bleicher (1998, p. 93) calls an "alloy" of classroom ethnography and sociolinguistic discourse analysis for the study of classroom interaction. The ethnographic, case study orientation was directed towards discovering common challenges and predicaments of the two teachers and their strategies, beliefs, feelings that affect their responses, on how they try to make sense of their educational world (Schön, 1991). The methodology was designed to probe the teachers' practical knowledge, their beliefs as to teaching and student learning, their activities as shown through their discourse and actions, identifying key issues and recurrent events related to each

[9] See Appendix C for the description of the categories of analysis.

teacher's expressed beliefs and observed practices. It was considered of the utmost importance to discuss the teachers' intentions as a very dynamic, reciprocal relationship between beliefs and classroom practices as has been identified in other studies (Richardson, 1996; Lederman, 1999). By means of the interviews after observations, the teachers were encouraged to engage in a reflection of their practices by making explicit their procedures, actions, reasons (Vermesch, 1994), thus becoming legitimate, peripheral collaborative inquirers in the process. This form of ethnomethodology gives voice to the teachers to express their beliefs, their manner of organizing and understanding their world as school science teachers (Taylor & Bodgan, 1990).

The diagram below illustrates the multiple sources of data and the triangulation among them all in order to develop a profile of the teachers' beliefs and practices as situated in their particular contexts. The analysis is descriptive, interpretive, focused on the degree to which each teacher developed common knowledge, collaborative learning and/ or formed a functional community of practice. From the analysis, it is possible to develop a broad-based view of each teacher's common practices and underlying pedagogical beliefs, his/her specific classroom and school contexts and their common institutional context, all relevant for the construction of a richly detailed profile of high school science teachers in Mexico as well as for the development of a comprehensive description of different science learning environments in Mexican schools.

Fig. 2: Research design of thesis:



Key: CK: common knowledge; CL: collaborative learning; CP: community of practice; T/L: teaching-learning

Data Collection and Analysis

Methodology

Due to the extreme complexity of identifying a teacher's beliefs and whether or not they are coherent with their practice, it is necessary to use a wide variety of empirical methods to collect data in order to begin to describe the many interlinked facets of a teacher's explicit and implicit professional practice. The table of field work activities presented on the following page indicates the organisation and timing of all the data collection; this is followed by a description of the specific procedures of data collection. The overall methodology designed to uncover the beliefs and practices is presented, followed by a more detailed description of each instrument at the end of this section, along with the description of the analytic categories developed from common knowledge, collaborative learning and communities of practice.

Fig. 3: Table of field activities (from Dec., 2000 to Nov., 2004)

Teacher:	**Observations of classes and laboratories:** date and (# of classes on same day)	**Interviews:** Date and reference (# of cassettes + hours) *(All formats of interviews are in Appendix B)*	**Questionnaires:** Date and reference *(All formats of questionnaires are in Appendix B)*
Maria (Preparatory A)	**Pilot classes:** 07.12.00 (2) **P1**# **Classes:** **1.** 09.01.01 (2)* **2.** 15.01.01 (2)* **3.** 04.03.01(2) **P3** **4.** 03.12.01(1) **P14** **5.** 11.03.02 (1) **P3a** **6.** 30.10.02 (1) **P8** **7.** 12.02.04 (1) **P16** **Laboratories:** **1.** 12.03.01 (2) **P13** **2.** 11.03.02 (1) **P6** **TACTICS:** 1. 30.10.02 (1) **P10** # identification of transcripts and documents in Atlas.ti * field notes only	**Interviews§:** 1. 22.02.01: App. X (diagnosis, TACTICS) (1 cassette, 30 min.) **P2** **2.** 28.11.01: App. VII: philosophy of teaching (2 cassettes, 1 ½ hours) **P4** **3.** 03.12 .01: after class observation (1 cassette, 1 hour) **P5** **4.** 11.03.02: after laboratory observation (1 cassette, 1 hour) **P7** 5. 30.10.02 after class observation (1 cassette, 1 hour) **P9** **6.** 30.10.02: after TACTICS (1 cassette, 45 min.) **P11** **7.** 20.12.02: family and professional background (1 cassette, 1 hour) **P15** **8.** 12.02.04: after class observation (1 cassette, 45 min.) **9.** 12.02.04: Director of Prepa A. (1 cassette, 1 hour) **P18** **10.** 20.10.04: final interview (1 cassette, 1 hour) **P17** § guide for interviews after observations : App. XV	**Questionnaires:** **1.** 01.01: App. V: science and technology **2.** 01.01: App. IV: constructivist environment **3.** 02.01: App. X: quest. Professors of TACTICS **4.** 05.01: App. VII: demographic information **5.** 05.01: App. I: TEAI for science teachers **6.** 10.01: App. VI: Nature of science 7. 10.01: App. II: Stages of concern **8.** 10.01: App. XII: professional orientation **9.** 10.01: App. XIII: collaborative learning **10.** 11.01: App. VIII: philosophy of teaching **P4** **11.** 29.05.02: App. XIV: evaluation of TACTICS **P12** **12.** App. XV: After class observations **13.** App. XVI: Interview with director
Hector (Preparatory B)	**Pilot classes**: 06.12.00 (2) **P26** (bio.) and **P27** (chem.) **Classes:** **1.** 16.01.01 (2)* **2.** 14.03.01 (1) **P43** **3.** 19.11.01 (1) **P44** **4.** 13.03.02 (1) **P45** **5.** 11.11.02 (1) **P28** **6.** 15.10.03 (1) **P42** **Laboratories:** **1.** 14.03.01 (2) **P37** **TACTICS:** **1.** 19.04.02 (1) **P46** * field notes only	**Interviews§:** **1.** 12.01.01: App. X (diagnosis and TACTICS) and VIII (partial) (1 cassette, 1 ½ hours) **P36** **2.** 19.11.01: after class observation (1 cassette, 1 hour) **3.** 28.11.01: App. VIII (last part) (1 cassette, 1 hour) **P38** **4.** 13.03.02 after class observation (1 cassette, 1 hour) **P31** **5.** 10-05-02: family and professional background and TACTICS (1 cassette, 1 hour) **P32** **6.** 11.11.02: after class observation (1 cassette, 45 min.) **P29** **7.** 11.10.02: TACTICS (1 cassette, 45 min.) **P34** **8.** 08.04.03: Director of Prepa B (1 cassette, 45 min.) **P48** **9.** 15.10.03: after class observation (1 cassette, 45 min.) **P40** **10.** 05.11.04: final interview (1 cassette, 1 hour) **P47**	**Questionnaires:** 1. 01.01: App. V: science and technology **2.** 01.01: App. IV: constructivist environment **3.** 02.01:App. X: quest. Professors of TACTICS **4.** 05.01: App. VII: demographic information **5.** 05.01: App. I: TEAI for science teachers **6.** 10.01: App. VI: Nature of science **7.** 10.01: App. II: Stages of concern **8.** 10.01: App. XII professional orientation **9.** 10.01: App. XIII: collaborative learning **10.** 01.11.01: App. VIII: philosophy of teaching **P38** **11.** 29.05.02: App. XIV: evaluation of TACTICS **P39** **12.** App. XV: After class observations: **13.** App. XVI: Interview with director

Beliefs.

The teachers' initial beliefs have been partially inferred from the first nine questionnaires that are on the table of activities above[10] that were applied in the first year, during 2001, all developed for high school science teachers[11], which included ones on constructivism, on the nature of science (NOS) to identify their epistemological beliefs as a science teacher, on professional concerns. Another questionnaire (#11), was applied in 2002 as an evaluation of TACTICS. In addition, semi-structured, in-depth interviews were carried out, one on their philosophies of learning (questionnaire #10) and one on their family and professional backgrounds, as well as four interviews after classroom and laboratory observations. The latter semi-structured interviews encouraged each teacher to make his/her objectives explicit, to give reasons for using certain strategies, to evaluate the class and to suggest changes if s/he were to repeat the same class, thus improving the validity of the data collection and later interpretations (Taylor & Bogdan, 1990). An interview was also carried out with the director of each school to gather additional information on the context in which each teacher works. Each interview generally lasted between 45 minutes and one-and-a-half hours. All the data were audiotaped and transcribed by a research assistant, and were later checked for accuracy through comparison to the original tapes. The teachers' beliefs were inferred by triangulating data from these questionnaires and interviews as well as from classroom discourse. One portion of the analysis was focused on their initial positions to compare with any changes at a later period. Any identified changes were then examined for the possibility of transference of collaborative learning strategies and/or beliefs from their experience with TACTICS to their own personal pedagogical practices.

Teaching practices.

Teaching practices were observed by means of non-intrusive, naturalistic observations of biology classes and laboratory sessions, each one 50 minutes in length, all videotaped and transcribed (Adler & Adler, 1998). The observations of the teachers carried out from late 2001 onwards were followed by interviews, which were an encouragement for the teacher to review

[10] All questionnaires were analysed in a qualitative fashion in order to identify beliefs, even though some had been originally designed for large-scale quantitative analysis.
[11] See Appendix B for all questionnaires.

and explain their class[12], and thus a form of stimulated recall (Vermesch, 1994), but without the intention of deliberately promoting change. Two of each teacher's classes were observed in December of 2000 as pilot runs, to aid in the formulation of a methodology of observations appropriate for the contexts. Field notes were taken of the pilot observations but the classes were not videotaped. In Maria's case, ten hours of class were observed and recorded over the nearly four-year period and three laboratory practicals plus one TACTICS session. In Hector's case, seven hours of class and two of laboratory work were observed plus one of TACTICS. Over the years of the study, numerous other appointments had been made in order to carry out other observations but for a variety of bureaucratic reasons in the schools, such as unprogrammed holidays, they were not realized. Field notes were taken of observations that would not have been recorded on the tapes, such as movements or activities in areas of the classroom or beyond it that would not have been within the range of the recorders. Notes were also made of materials used by the teacher and the students (Cohen et al, 2000). The classroom observations carried out at the start of the project served as a record of each teacher's teaching practices at that time, to be used as a point for comparison with data collected later. The data collected through these multiple measurements also served to characterize the class and school context.

The collection of data was designed to probe both teachers' beliefs about science teaching and student learning, their conceptions of the nature of science and their practices as shown through their discourse and actions. The questionnaires were analysed with the coding information provided in each case[13]. The data of the transcripts were analysed with the codes described in Appendix C, developed from the categories of the theoretical frameworks of the three previously described models. The software *Atlas.ti* (Scientific Software Development, Berlin, 1996-2000) was used to flexibly codify the data according to these pre-determined categories and codes. The transcripts were read and relevant phrases marked with corresponding codes[14]. During the procedure, some emergent codes were added as deemed necessary in order to identify certain teaching-learning aspects more precisely, ones that had not been included in the theoretically developed codes. The software enables one to group all quotations for any one code, thus greatly facilitating the analysis of discourse, permitting the

[12] See the Appendix B App. XV for the interview guide.
[13] See the Appendix B for each questionnaire's coding categories.
[14] See the Appendix A for two examples of the coding of transcripts.

identification of relative frequencies of expressions of beliefs or practices, as well as any changes over time for either teacher or both. Where there was no evidence for any one code, it remained empty. As mentioned previously, the discourse analysis used here followed Edwards' model (1993) of pragmatic observation of verbal interactions, starting with the identification of the basic rules of the educational discourse in building common knowledge, to the specific aspects of collaborative learning, through to the categories of communities of practice. The data were triangulated among the observations, interviews and the questionnaires applied over almost four years, a constant comparison that permitted the key issues and recurrent events to be identified as related to each teacher's expressed beliefs and observed practices. The comparison and contrast over time was made for each teacher as well as between the two teachers.

Description of the Instruments

Questionnaires

An initial questionnaire was given to each teacher in order to obtain a general inventory of the schools and the teachers (App. VII[15]: Salish I, 1997). Another general questionnaire was given to all the teachers participating in TACTICS as an evaluation of the project as of May, 2002 (App. XIV).

As the research being carried out had the purpose of identifying possible changes in the teaching practices and beliefs of the teachers during their experiences with TACTICS, it was considered relevant to explore their concerns and professional orientation at the start of the project as both of these aspects are considered by researchers to influence the implementation of educational innovations (Jongmans et al, 1998; Gallagher, 2000). This was done through the application of two questionnaires: the first one on Stages of Concern (App. II: SoCQ, 2000), was designed to identify the concerns that people have about implementing innovative educational technologies by means of 35 questions answered on a Likert scale. The analysis was done on a concerns-based adoption model (CBAM; Dass, 2000) which identified seven levels of concern: awareness, informational, personal, management, consequence, collaboration and refocusing. The first level was considered the most basic, one that could seriously interfere

[15] All questionnaires are referred to by an appendix number, as App. VI, all of which are found in the Appendix B of the Questionnaires.

in the implementation of the innovation, sequentially building up from there to the last level where the new technology would be most likely put into practice. The second questionnaire on professional orientation (App. XII: Jongmans, 2000) explored the teacher's opinions on professional development and levels of collaboration within the school community by means of 13 questions also answered on a Likert scale.

Constructivism, the dominant educational paradigm today in all its variations, was the theoretical basis of various courses of the Master's program in teaching science (MEC)[16] in which both teachers were enrolled at the start of this investigation; it was thus deemed important to analyse their beliefs in this regard to compare with their actual classroom practices. Two questionnaires were applied in order to obtain a more detailed view of their beliefs as science teachers (App. I: TEAI, Dass, 1998, and App. IV: Salish I, 1997), both consisting of a list of questions concerning the teachers' attitudes and their beliefs about the students' attitudes towards science classes, the classroom practices, amongst others, each to be answered with a frequency scale. Both questionnaires contained integrated guides for evaluating the answers, to aid in analysing the teachers' positions with matters related to constructivist viewpoints within science classes.

Results of educational research suggest the importance of the congruency between innovation and the philosophy of learning, the sense of self-efficacy, the levels of training and practical constraints in the teaching environment (Poulsen, 1998). According to Poulsen, there are three factors that could influence the use of a new educational technology, collaborative learning in this particular case: the value placed on the strategy by the teacher, their expectancy of success (including both internal and external factors) and the cost of the implementation (in terms of time, effort, etc.). The second factor, that of expectancy of success - whether the teacher feels that he/she has sufficient skills in an adequate context - is considered to be exceptionally relevant. As TACTICS was based on collaborative learning (CL), this was an area where changes could reasonably be expected to occur in both the teachers' beliefs and practices. Thus a questionnaire on attitudes towards collaborative learning (App. XIII) was given to the teachers at the start of the project to identify their initial perspectives. This questionnaire (based on CLIQ; 1998) was designed to identify what reasons may affect whether a teacher implements

[16] MEC is the anagram for: Maestría en la Enseñanza de las Ciencias

collaborative learning strategies or not. It consisted of 48 questions on professional opinions concerning collaborative learning, all answered with a Likert scale.

In the teaching of science, one of the main international, educational objectives is the formation of a scientifically literate person. A functional understanding of the nature of science (NOS) is considered necessary in order to reach this goal. Numerous studies have been carried out concerning the relation of a teacher's conceptions of NOS to his/her classroom teaching (Abd-El Khalick et al, 1997; Lederman, 1999). The results of these investigations indicated that the relation is neither direct nor simple, with many factors compromising, be it by impeding or by facilitating, the ability of the teachers to transfer their own conceptions to their students. Nonetheless, there is evidence that certain positions tend to lead to certain teaching strategies, such as a positivist view of scientific knowledge leads to a strong verbal domination of the classroom (Richarson, 1996: 107). Two questionnaires were applied to identify the teachers' positions regarding NOS. The first one (App. V: Salish I, 1997) was a series of 19 questions referring to NOS as well as opinions related to the role of science and technology in society (STS), all answered on a Likert scale, plus a guide for evaluating the answers. The second questionnaire (App. VI, Monk and Dillon, 1995) consisted of a series of 24 questions, also with a Likert scale and a guide for classifying the answers within five specific epistemological axes: relativism / positivism, inductivism / deductivism, contextualism / decontextualism, instrumentalism / realism and process-driven / content-driven.

Interviews

The interviews included one on pedagogical philosophy (App. VIII: Salish I, 1997), particularly designed to detect constructivist aspects of the teachers' answers, analyzed with the STAM matrix and the coding index provided by Salish II (App. IX, Salish, 1997; Salish II, 1998). The transcript of this interview was also analysed with the codes based on the theoretical frameworks. Additionally, there was a diagnostic interview (App. X), a general one for science teachers (App. XI) as well as one on their expectations of TACTICS (App. X). A single interview was also carried out with each of the directors of the two high schools (App. XVI) to obtain the administrative vision of the school, the teacher and TACTICS. The remaining interviews with the teachers took place after class, laboratory or TACTICS observations (App. XV), a form of stimulated recall with the intention of having the teacher

describe their views of what had occurred, their planning, the context and the students, the development of the class, their evaluation and suggestions for improvements. Each teacher was given a final, concluding interview in the fall of 2004 in order to verify or not previously stated beliefs as well as to incorporate their intentional practices for that school year[17]. All interviews were semi-structured in the sense that the guides were generally followed, but when interesting comments pointed in another direction, they were also pursued.

Observation in the classroom

Observations were carried out from the very outset of the project to identify teaching practices, the first ones as pilot runs to obtain an initial vision and record of regular classes with each teacher. During these first observations field notes were taken but the classes were not videotaped. In 2001, the observations were video taped and transcribed for later detailed analysis. There were observations made in both classes and in laboratory sessions, to cover both contexts of science classes. In the fall of 2002, observations were also made of the two teachers while working with the students who were participating in the project TACTICS, followed by an interview of their observations and interpretations of the session. These parallel observations of the teachers working in these two very different contexts were analysed and compared. Numerous informal observations were also made, particularly in TACTICS in the first two years, but only brief field notes were made as these were mainly moments of technical assistance to the groups. Even so, they served to broaden the view of the teachers' roles with their students on these occasions.

[17] The state university administrative staff went on strike in early October, 2004, closing all the affiliated educational institutions; at the time of these interviews, it was still not resolved so that the teachers had only taught their classes for one month at the start of the school year.

Research questions

The analysis of the transcripts of the interviews and the teachers' dialogues during classes was based on the following research questions, each with their corresponding subset of questions based on the categories of analysis[18]:

I. What evidence is there of the building of common knowledge?

What is the use and style of the questioning; is there use of IRF strategies; is there active participation and, if so, to what degree; what are the basic rules of discourse and the manner of teaching content?

II. What evidence is there of collaborative work?

What are the specific characteristics of social and cognitive engagement of the students? Is there an exploration of knowledge, elaboration, negotiation and validation of knowledge; what are the types of evaluation used in the classroom? What are the varieties and use of collaborative technology? What are the aspects of the context or ecology of the classrooms?

III. What evidence is there that the teacher and students are forming a community of practice and to what degree?

i. What evidence is there that the teacher and students share an interest in a topic/ a common enterprise/ project? Are there mutually understood issues; do they agree on common approaches?

ii. To what degree is there interaction and the building of relationships? Do they help each other solve problems and answer questions; do they network across teams; to what extent is there evidence of participation and of what type? Is there evidence of mutual engagement, mutual accountability, shared repertoire, sharing of teaching and learning? Are the learning practices global or local? Are the teaching strategies designed or emergent? Is there evidence of competence?

iii. Is there a sharing and development of knowledge and to what extent? Do they share information and insight, do they share best practices, do they negotiate meanings? Do they build a shared repertoire and, if so, of what type? Do they build tools and a knowledge base?

iv. Is there evidence of identity formation? What are their identities as members of the community of practice of TACTICS, of the MEC, of the school communities? What are the modes of belonging involving engagement, imagination, alignment?

[18] The detailed description of these analytic categories is found in Appendix C.

By means of the qualitative and interpretative analyses of the data, I have attempted to answer these questions from the corresponding theoretical framework. The information obtained was also used to identify coherencies and/or contradictions of their stated and inferred beliefs contrasted with their observed or described practices over time for each teacher and in comparison to each other, as well as to highlight any transformations.

Methodological Limitations

The fact that this is a case study of only two teachers is an obvious constraint to the conclusions that may be reached as well as to their applicability, principally due to the limited amount of data. Although the method used was the least intrusive (Adler & Adler, 1998), there are still the inevitable effects of having an observer in a classroom, and there is an unavoidable researcher bias (Luft et al., 2003). These effects could be considered as part of what Clandinin and Connelly (1998) described as the interactive and temporal conditions of personal experience methods while representing the field experiences as field texts and then converting them to research texts. However, both teachers had taken three courses from me during their study program of the MEC during which time a good rapport developed among us, thus increasing their level of comfort at having an observer in their classes, a completely new experience for both. This is of considerable importance to the present investigation as it is deemed to have increased the authenticity of the data collected during these observations and interviews (Taylor & Bodgan, 1990).

However, the validity of the conclusions has been strengthened by triangulation of the data collected with the numerous instruments. The interviews after the observations also reinforced the conclusions as they are considered to be the only reliable way to identify the underlying causes or reasons for actions, goals, preconceptions of a teacher (Vermesch, 1994). Whenever any questions arose during the analysis, the teachers were asked to clarify my interpretations. Reliability as to the significance of the observations was also increased by means of the longitudinal study over almost four years, observing the teachers with different groups of students working on different scientific content, sometimes in the class and sometimes in the laboratory (Adler & Adler, 1998).

Description of the two collaborating teachers and their contexts

Maria

Maria is a biology teacher in a rural, agricultural town in the southeast corner of a central state in Mexico. She grew up in the town, living in the family home of several generations, leaving only to study her bachelors degree in biology at the State University in the capital of the state. She was 45 years old at the start of the project, married with no children, and had been teaching for 18 years in the same public high school, which I shall call Prepa A, that is affiliated with the state university. The students are mainly from the town, but some also come from surrounding villages and, according to the director and Maria, most are from families with lower middle-class socioeconomic profiles. Maria said that the majority of the students go on to further studies, either in the state university, in a technological university in a nearby town, in the Normal school, or in other institutions[19].

At the start of TACTICS Maria was in her second year of a Master's program in Teaching of Science (MEC) at the university for in-service high school science teachers. The biology section of the program was under my coordination and through this we became acquainted, leading to the invitation to first join TACTICS and then this research project. She had previously taken various diploma courses offered by the university, mainly for updating in biology themes but also some on teaching, but had had no continuous, formal teacher training until taking the Masters program. In spite of these courses, she considers her own experiences in the classroom to the most relevant factor in her professional formation as a teacher.

Maria teaches biology, some semesters in the morning shifts and others in the afternoon as well as in the "open" high school system for persons returning to complete their studies. She is also an academic technician in the school's laboratories. Her normal teaching load is 20 hours a week although she was granted a reprieve by the university in 2001-2002, teaching only 12 hours to allow her time to work on her Master's thesis. Her contract with the university is "horas definitivas", which means she is assured of a certain number of teaching hours and is paid by the hour, but even if she teaches full-time she is paid much less than a teacher with a full-time contract. Most of her classes have between 30 and 40 students. She is not required to remain in the school the entire day, just to cover her hours of classes or specific work. During

[19] It was impossible to verify this information as the school does not keep statistics on the graduates.

2001 she was also the assistant treasurer of the school's teachers' union. She has also been active in the biology teachers' academy of the university where decisions are made on curricular details and the standard departmental exams are formulated. She was invited to join the TACTICS project in 2000 and accepted enthusiastically. She has worked with the TACTICS students, checking on their progress by mainly supervising their attendance at a considerable distance. She had essentially no experience with either computers or Internet so this has been a concern of hers from the outset.

The Prepa A is on the main road going into the town, on the side of a river. The school is set back from the road behind a parking lot for the teachers' cars with guards at the gate where the cars and students enter. There are two shifts, the morning one from 7 a.m. to 1 p.m. and the afternoon one from 2 p.m. until 8 p.m., with 1,200 students in the morning and about 800 in the afternoon shift. The students wear a uniform most of the time, a white shirt, the boys with navy blue pants and the girls with a plaid, pleated skirt. The school itself is divided into different two-storey buildings that are separated by attractive, open patios with trees, flowering plants, and places for students to sit. There is an outdoor lunch-bar in the centre of the school area for both students and teachers where they sell complete meals, tacos, tortas, drinks, and so on all day long. There are also basketball courts and a soccer field on the school grounds.

Photo 1:The patio of the Prepa A as seen from Maria's classroom.

As the area has a very hot climate most of the year, the upper half of the classrooms walls have an open brickwork ventilation grill (*celosia*) with no windows, to allow for circulation of air aided by ceiling fans[20]. There is thus a full view of the patios from inside the classrooms and all the noise that arises from them is very clearly heard. The rooms have cement floors and walls with a raised platform for the teacher's desk and a whiteboard of variable quality. The students have individual chairs with a wooden arm on one side on which to write, some of which are in a very poor state of repair. There is little sign of student work or didactic material throughout the classrooms but noticeable graffiti both on walls and desks. There are two old science laboratories but also two new ones as of 2000, with very good light, space, with eight laboratory benches, all equipped with gas, water and electricity, sinks on the side, and a whiteboard. However, there is shortage of equipment, such as only 6 good microscopes for large groups of up to 40 or 50 students. There is a lab assistant to hand out and receive materials. In contrast to the classrooms, the walls are decorated with student work: collections of organisms, posters, models of reproduction, taxonomy, etc. There is a small school library, with some reference books and sufficient table space for a group of students to work.

There is a fairly large computer laboratory, made completely of glass walls, originally with Venetian-type windows providing ventilation, but as of April, 2002, all the windows were changed and air conditioning was installed. There are computer instructors who impart classes for all the students, although not all of the 50-some computers work all the time, and they are sometimes without Internet connections through the university line. It should be noted, however, that the connections have improved greatly during these years of observation. This laboratory is used full-time to teach all students basic computer skills.

The six computers of the TACTICS project were delivered in December, 2001 and were installed in February, 2002 in a corner of this laboratory, a rather reduced but adequate space for 6 computers, with Internet finally connected in April, 2002, first through a telephone line that the administration provided, and then through the university line. A glass separation was eventually set up to close off the area of the TACTICS computers, still leaving it under the close supervision of the computer teachers. Several of these teachers have been assisting with the technical aspects of TACTICS.

[20] In 2003-2004 the director was in the process of changing these "celosias" for regular windows and air-conditioning in some of the classrooms, with the intention of doing it eventually throughout the entire school.

Informal observations made during numerous visits to the school indicate that there is little or no supervision, neither of the classes themselves nor of the patio. Students often arrive up to 10-15 minutes late to class, on occasions even more. There are almost always students in the patios and, at times, classes without teachers. This allows for considerable noise that is clearly heard in all the classrooms, given their open structure, but particularly in one that Maria frequently uses which is directly outside of the school lunch-bar.

Hector

Hector is a science teacher in the capital of the state. He teaches biology, chemistry and sometimes physics in the morning shift in the high school which I shall call the Prepa B, also affiliated to the university. At the start of this investigation he was 44 years old and had 15 years of teaching experience. He grew up in the same city, but went to Mexico City to study dentistry. He started to teach in order to have a more secure income than that from his initial work as a dentist (22 years at the start of the project) and has since continued with both jobs. In his own words, he has continued teaching partly because of the regular salary but also because he enjoys teaching. He has his own dentist's consulting room where he works every afternoon during the week when he has patients, putting in about 20 hours a week. He also took specialization courses in orthodontics during 2001-2003, to learn how to put on braces, and now works certain afternoons with a specialist. He is married with two children.

Hector was also in his second year of the Master's in Teaching of Science (MEC) at the start of TACTICS. He continued teaching throughout the MEC, as did the other teachers in the program. He had had no formal teacher training until the MEC, and considers it to be the most relevant factor in his professional formation as a teacher.

He normally teaches 35-40 hours a week, but in 2001-2002 was released from his normal load and given only 20 hours a week in order to finish his Master's thesis. His contract with the university is "horas definitivas" as is Maria's. He prefers to teach biology, but due to the university's system of distributing classes, has no choice and is sometimes forced to teach chemistry and physics as well even though he does not feel as well prepared. Most of his classes have approximately 40 students. The invitation in 2000 to take part in the TACTICS project was willingly accepted. He has worked with the TACTICS students, choosing them and encouraging them in their investigations but without close supervision or direction. He has

been learning about computers and Internet along with the students, having had relatively little experience at the start.

The Prepa B is on the industrial side of the city on a major road. The school has 1450 students in the morning shift from 7a.m. to 1:30 p.m., primarily from the city, but also some from surrounding towns, most of them from families with a middle-class socio-economic profile. According to administrators of the school, only 20-30% of the graduates go on to the university, with possibly another 20% going to private universities or centres[21]. The school is set back behind a parking lot for the teachers' cars, with guards at an inner gate leading from the parking lot to the school area. The school itself is very spacious with many patios with trees, grassy areas and playing fields amongst the separate two-story buildings of classrooms, library, administration, labs, etc. There are also soccer and basketball courts on the school grounds.

Photograph 2: View of the administration building of the Prepa B from the main patio:

[21] Again, it is impossible to verify these statistics.

The classrooms are similar to those of the Prepa A, with the floors and walls made of painted concrete with a raised platform at the front for the teacher's desk and a whiteboard, also of variable quality. There is basically no didactic material or student work displayed on the walls; I was told the reason for this was that the students of the two shifts had no respect for each others' work. There is graffiti in the rooms themselves, on the walls and the desks. The rooms have very high windows on one side, slightly lower on the other but with no view from the outside. There are ventilation grills ("celosia") about 1/3 of the way down the wall that also let in noise from the outside. The student chairs are old, with a wooden arm on one side on which to write. There is very little room to move amongst the students in the larger groups.

There is a complete computer laboratory with instructors for all the students, with Internet connections through the university line, with similar problems to those of the Prepa A. The library has few books, but there are tables at which the students may work. There are fairly spacious science laboratories with six large concrete worktables, each with gas, water and electricity, but there are very limited materials considering the large groups of students and frequently the students are asked to provide the reagents/ materials necessary for the labs. The laboratories are rather poorly maintained in terms of paint, with nothing on walls other than a small periodic table.

As in the Prepa A, students often arrive 10-15 minutes late to class, or even more in some cases during my observations of Hector's classes. There are always numerous students outside the classrooms, sometimes playing basketball or soccer, playing music or simply carrying on noisy conversations. On occasions, classes were seen that had no teachers, also contributing to the high levels of noise in the school, particularly noticeable while observing Hector's classes. The teacher and students appear to be accustomed to this and seem to be able to ignore the distractions outside their classroom.

The computers of the TACTICS project were delivered to the school in December, 2001 and were installed in February, 2002 in what had been a laboratory preparation room, on the side of an old laboratory that was converted some years ago into a little-used biology museum. The room was painted, electrical installations put in and a connection made to the main computer laboratory to link with the university Internet line. There is a fan to make it more tolerable in the hot weather as there is only one small window for ventilation. The space is somewhat reduced, but adequate as rarely do all the students work at the same time. The

computer technicians in the school were very helpful in the installation and maintenance of the equipment. As the room is set off from the rest of the school, the control of its use is fairly secure as only Hector, the director and the cleaning staff have the key, a point of considerable concern to Hector as the equipment is intended for the exclusive use of TACTICS while the project lasts, and only at the end will they become school property.

The Master's program in Teaching of sScience (MEC) and the university context

The Master's program, offered by the state university from 1999-2001, was limited to in-service high school science teachers in public, university-affiliated schools; fourteen teachers began in 1999 but only eleven were left by the end of the two years, five in the area of biology which I coordinated. The purpose of the program was to attempt to improve the areas of science teaching and learning that had been identified as being very weak and problematic in all the affiliated high schools. The teachers were all granted fewer hours of teaching in their respective schools during this period in order to facilitate their studies. The program was organized into eight trimesters with classes held Friday afternoons and Saturday mornings for four hours each session and in a more intense manner during periods of school vacations. There were common subjects given to all the teachers together and other subject-specific ones for those in chemistry, physics or biology. The common courses, largely based on socioconstructivism, included two courses on psychological theories of learning and development, general didactics, evaluation, development of projects on teaching science, science and society in the 20th Century; the subject-specific courses included two on disciplinary content, as well as one on subject-specific didactics, amongst others. The classes varied in style and content according to each professor, some given in a very traditional lecture mode but others with more open, collaborative discussions. Final evaluation of each course also varied, but included papers or specific products, according to each professor's choice; 80% attendance was a university requirement as well as grade averages of 8 or above. Most of the eleven teachers completed the courses in 2001 and, although all had chosen topics and had begun work on their theses, due to administrative problems the program was never officially registered in the university. The teachers protested through the university teachers' union, and eventually in 2004 a one-year, special period was granted for them to complete their theses and

to receive their degree. As of early 2005, none of them had yet completed their work, although Maria, Hector and several others were carrying out their research.

The university, during the same period from 1997 onwards, also began to apply standardized semestral exams as a means to measure the levels of learning of each specific subject within the affiliated high schools. Academies of teachers for each subject were set up to make these exams. The hidden agenda of these two institutional innovations was to make the individual teachers visibly responsible for their students' academic levels. As it was common knowledge that many teachers didn't even complete the study plans and that their manner of evaluating student learning was very open to criticism, a first attempt had been made to evaluate the teachers themselves through student evaluation forms. However, this created an uproar and the teachers' union blocked the initiative. Thus the application of standardized, semestral exams, written by the same teachers in the academies was begun with the same purpose but in a more indirect manner. The academies were also assigned the role of reviewing and revising study plans, laboratory manuals in the case of the sciences, developing teaching materials, and so on.

Description of the TACTICS project in each school

In the pilot phase of the TACTICS project in the spring semester of 2001, Maria and Hector each chose a group of 20-25 of their own students from different classes to participate voluntarily. Each teacher formed five *expert groups* of four or five students[22], each group working via Internet with two other expert groups from two other schools, one Canadian and one other Mexican, the three expert groups forming a *base team*. Each base team was given one of the five transdisciplinary science topics previously selected by the TACTICS group of investigators, with each expert group given a predetermined subtopic from it. Each expert group was to investigate the scientific, ethical, historical, social and legal issues of their subtopic and write a paper of 10-15 pages. During this process they were supposedly in touch with the other expert groups in their team, who were working on the related subtopics. At the end of this period, they formulated questions on their own work that the other expert groups were to answer, along with identifying similarities and differences in their work. At the end of this period, the three expert groups were to collaboratively develop a synthesis of their joint

[22] See Appendix G for topics of investigation and the organization of the groups.

work. During the four years, there were very variable results, with some base teams communicating well throughout their work, producing a good synthesis of their results. However, others worked essentially in isolation within their school, having virtually no communication with the other two school groups, thus ending with only their own expert group investigation but no synthesis of the entire team. There were also problems of dropout of students during each session of the project, in some cases leaving only one student in charge of finishing the work for their expert group.

During the pilot phase, both Maria and Hector worked by themselves with their students, without inviting other colleagues to participate although it had been suggested to them as a possibility, as was done in the two other Mexican schools. They largely supervised attendance and the final product of each expert group, although they occasionally assisted in the students' Internet search for information, or suggested local sources of information. As there were many problems with the schools' computer centres, as well as a one-month strike of the university in February, 2001 which closed down all the schools, the students generally had to use Internet centres outside of the school, and thus outside of school timetables. There was constant assistance from different investigators in TACTICS to help them get started with the use of the Internet and Yahoo egroups, which were used as the platform for their work. Nevertheless, this situation created considerable pressure on the students and the two teachers in terms of time and money.

In the second phase of the project, from September 2001 to May 2002, Hector again invited 20 students from different classes he was teaching to join the project, but in the case of Maria, the new director of the school suggested she use all of one particular class, a group of 35 students. The organization of the work was the same as in the pilot run, but with different combinations of schools. In spite of initial enthusiasm, many did not carry through on the project, leaving a reduced number of students doing the work, only 2 or 3 in some groups. Again, in both schools there were many technical problems, starting with the late arrival and installation of the computers donated to the schools for project use plus constant problems with the Internet lines, once again requiring the use of Internet centres outside of the school in the first semester.

A one day workshop on collaborative learning was set up in October, 2001 for all the teachers supervising TACTICS groups in the four Mexican schools. This was organized as a

result of the identification of the variable approaches of the different teachers' with regards to their role, with the intention of giving a common basis of understanding of collaborative learning. The characteristics of collaborative learning (CL) were discussed along with different strategies and various CL exercises were carried out. Hector attempted to use some of these exercises in his classes in the spring school session of 2002 but Maria did not. In May, 2002, at the end of the second run of TACTICS, a day-long evaluation workshop was held with all investigators and teachers from the four Mexican schools.

For the 2002-2003 session, Maria invited two computer-laboratory colleagues to take part in the project and Hector invited a chemistry teacher in his school to take the responsibility of different groups of students. In Maria's case, there was little help from her colleagues with the groups, and she believed that one actively obstructed the project on occasion by not always giving the students access to the computers. In any case, they did help resolve technical problems. Hector's colleague did carry on with her group throughout the year. At the end of the session, there was a forum held in Colegio Madrid in Mexico City for all the Mexican students to present their work, but unfortunately neither teacher took their students to participate.

For the 2003-2004 session, another investigator in TACTICS and I prepared a mini-course for Maria and Hector, along with the teachers they had invited to participate. Maria again had invited the two computer colleagues and Hector the same chemistry teacher and another biology teacher. The course consisted of articles on collaborative learning to read and discuss, as well as direct discussions and specific organization of the work to be carried out by both supervising teachers and the students during the project. Regrettably, due to lack of participation on the part of the teachers, the course had to be dropped. In Maria's school, the two colleagues again had a distant relationship with the students, mainly helping with some immediate technical problems. Hector's biology colleague dropped out in the first semester, leaving the other two. At the end of the year, a forum was again organized for all the students from Pachuca, Colegio Madrid and Maria's and Hector's schools, this time held at the Prepa B. By this date many of Maria's and Hector's students had dropped out, leaving few to finish the work. Nonetheless, those who made poster presentations did it well.

In the summer of 2004, the group of Mexican researchers in TACTICS decided to carry on the project for one more year, but just between the 4 Mexican schools. As the problem of

teacher formation and participation was very evident, a teacher-training forum was set up for the fall of 2004. As most had not actually used virtual academic groups and chat, the forum was set up through Yahoo egroups (Tactics_Mexico) as the platform for communication and MSN Messenger for chat sessions once every two weeks. Articles were provided on the egroup platform to give them a better understanding of the theoretical background of collaborative learning (CL), as well as very specific strategies and tips for the use of CL in classrooms. These articles were to be the basis for the chat sessions, discussing possible applications in their classes, previous experiences, and so on. Most of the investigators of TACTICS also participated in the discussions, the intention being to set up a truly collaborative community among the teachers and researchers. A face-to-face meeting was carried out early in January of 2005 to evaluate the forum and to choose topics of investigation for the following phase of student investigation and interaction in the spring; it is to be essentially the same as TACTICS, but over a shorter period of time and with only the four Mexican schools. One of the objectives is to revise and improve the student manual for possible use by other teachers and/ or schools, as well as to promote greater appropriation of the project by the teachers. Both Maria and Hector agreed to collaborate in this final year of the TACTICS project.

V. Analytic Description of Beliefs, Practices and Contexts

The following section has been structured on the two teachers' beliefs, practices and contexts through the description of several basic facets of their professional work. The analysis is based on a narrative, interpretive approach to discourse analysis of the transcripts of the interviews and classroom observations, complemented by summaries of some particular aspects of their discourse and practices. Their beliefs include their conceptualisation of learning, their perception of their roles as teachers and their description of the characteristics and responsibilities of the students. Their practices include their planning and organization of work, teacher-student interactions and the different forms of evaluation of learning. The context includes the class, school and institutional contexts as described by the teachers, the directors and as inferred from the observations. The teachers' diverse professional identities within their different communities of practice have been analysed in a separate section, including their identities within communities of practice of the school and institution, in the classroom, and finally in relation to the MEC and TACTICS.

Beliefs

The beliefs of each teacher influence every aspect of their teaching practices and vice versa, the relationship being an interactive, dynamic one. The beliefs were identified by inference through the triangulation of many different sources of data, concentrating on those that were represented most clearly through the questionnaires, interviews and observations. The initial beliefs of each teacher were partially inferred from the ten questionnaires that were applied in the first year, the majority developed for high school science teachers. The analysis of discourse from the interviews and after-class observations also extended the portrayal of their enacted beliefs, to be contrasted with the initial ones expressed in the questionnaires. This section begins with a description of the data from the questionnaires, all applied in 2001, followed by an analysis of three specific, essential systems of beliefs: their conceptualisation of learning, their own roles as teachers and their characterization of the students and their responsibilities.

Analysis of the questionnaires

From the analysis of "Levels of Concern" (App. II) [23] Maria demonstrated extremely high degrees of apprehension with regards to educational technology, in this case the use of computers and Internet[24]. Her greatest concerns were not having enough time to organize well, the potential of conflicts between interests and responsibilities, the effects on her professional status, her possible inability to use the technology, amongst others. When examined with regards to the Stages of Concern levels (SoC, Dass, 2000), her answers corresponded to the most basic, lowest levels, or what Jongmans et al (1998) identified as the least developed level: self-concern and task-concern oriented to her own class practice[25]. According to Jongmans et al (1998) and Gallagher (2000), this position would not readily facilitate the implementation of educational innovations. Her position of high degrees of concern with regards to technology was reiterated in various interviews (App. X and XIV).

Hector's answers were similar to Maria's, although to a slightly lesser extent of immediate concern, but he also indicated high degrees of concern with regards to educational technology. This corresponded mainly to the same basic level as Maria, of self-concern and task-concern regarding his own class practice. He had no clearly identified concerns regarding the consequences for pupils and the possible restraints. This position was comparable to Maria's although to a lesser degree, but presumably would not easily facilitate implementation of educational innovations either. However, in other interviews and questionnaires (App. X and XIV), Hector indicated much more confidence than Maria in his own ability to use the technology.

With respect to Maria's professional orientation (App. XII), it was evident that she was strongly in favour of professional development and participation of the school community in school-related decisions. She definitely recognized the need for professional development for teachers to improve their teaching strategies as well as the need for collaborative work between professors. According to Jongmans et al (1998), Maria demonstrated a strongly extended professional orientation that would tend to lead to a better implementation of educational innovations, possibly compensating for her lack of confidence in the technology

[23] See the Appendix B for questionnaire formats and keys for analysis.
[24] Of her 35 answers, 33 were in the range of the "I am very concerned now" end of the Likert scale.
[25] Higher levels would be: concern over the consequences of the innovations on student learning, over collaboration and improvement of the processes.

itself. Her position has also been reflected in her active participation in the university academy of biology teachers and in her continuous involvement over the years in courses offered by the university for professional development.

The analysis of Hector's position indicated that he was not fully in agreement with regards to the need for professional development and participation of the school community in decisions, taking a neutral position as to who should make decisions with regards to teaching content and methods. He definitely recognized the need for professional development for teachers to improve their teaching strategies, but was less emphatic about the collaborative work between professors than Maria. This was later reconfirmed in various interviews when he expressed a clear lack of confidence in the administration and teachers of his school, as well as with his minimal participation in the biology academy. According to Jongmans et al (1998), Hector's attitudes regarding professional development could be a constraint on successful implementation of educational innovations.

Maria's position on constructivism (App. IV) indicated a positive attitude to its basic tenets, at least in theory. This was not fully supported by the analysis of her philosophy of learning (App. VIII) with the STAM matrix[26] which showed a preponderance of teacher-centred beliefs, mainly in the didactic category but with some extending to early constructivist, student-centred categories. In terms of a constructivist learning environment (App. IV) Maria was fully aware of the importance of the global aspect of learning, of linking learning to the world outside of the school, sometimes starting with an actual problem, but she also believed that this is not always possible with scientific learning in school. She considered that science learned in school involves little awareness of social and cultural influences. She thought that students should be allowed to have a critical voice in their science learning, to question and to have some sharing of responsibilities by occasionally helping to plan activities but within certain limits of teacher control. With regards to student negotiations, she supported their discussion of ideas, but recognized that she provided no specific context nor structure for this to occur. She assumed her students' attitudes towards science learning to be very variable, depending on the particular activity being carried out.

Maria's initial descriptions of her teaching (App. I; App VII; App. XII) uniformly exemplified her interest in using different strategies, working with the students individually

[26] See Appendix B, App. IX for the STAM matrix and Appendix F for the STAM analysis of Maria.

and in group, in class and laboratory, with discussions and notes on the whiteboard. Her main goals were very student-centred: a) to motivate the students to learn biology, b) to relate it to other sciences, and c) to learn to be "educated" and respectful. Maria was concerned with being up-to-date in her knowledge and creative in presenting it with appropriate strategies, trying to relate topics within biology as well as in an interdisciplinary fashion. She rated different experiences in her own professional formation in terms of relevant importance: her own classroom experiences first, followed by professional university courses, with the experiences in the Biology Academy with other teachers as last out of six. When asked about the advantages of computers for teachers and students, she left it blank, another confirmation of her uncertain, somewhat fearful attitude towards technology.

The analysis of Hector's position on constructivism showed his beliefs to be spread across the whole range, from didactic to constructivist positions, as in Maria's case. He demonstrated less concern than Maria that science taught in school should have a personal relevance for the students, marking that *sometimes* it was important (App. I) and considered that students do not learn much about social and cultural influences on science. He stated that he encouraged his students to feel free to ask questions about his teaching or to express their opinions, to participate, to have a critical voice in the class as well as occasionally sharing the planning of work, having the opportunity to negotiate ideas. However, in another questionnaire (App. IV) he contradicted some of this by stating that his students rarely have the opportunity to really design their activities. He said that he learned along with them, that he tried to apply scientific concepts, but that in spite of his efforts, the students' attitudes towards their science classes varied mainly according to the activities. His confidence as a teacher had grown markedly over the years and he felt successful.

When asked for his three principal goals for student learning (App. VII), Hector simply wrote that they should understand as much as possible. He consistently described his teaching strategies as varied, from almost always dictating or writing notes on the blackboard, to class discussions and problem solving, to the use of student expositions and laboratory practicals. He considered the most relevant influences in his own professional formation as a teacher to be the outstanding teachers that he had had in his own schooling, secondly the courses and workshops he has taken, and thirdly, his own experiences. He put the school academies as the least influential, not surprisingly so as he considered them to be essentially political

instruments of the university. He believed the use of computers to be advantageous both for teachers and students, mainly in question of time and resources for the teacher, but more broadly in terms of improved learning for the students. Hector stated that he tried to keep up-to-date in his science knowledge by reading professional magazines and by participating in workshops.

Maria's definition of collaborative learning, a year into the project, was that of students working in groups under her control and assessment ("que los alumnos trabajen en equipo pero dirigidos y asesorados por mí", App. XIV). In this same questionnaire she demonstrated a much more constructivist, student-centred attitude with regards to its value that "many times there was a feedback of different ideas, good and bad ones, that enrich learning" ("muchas veces existe una retroalimentación de ideas diversas buenas y malas que enriquecen el aprendizaje"). On the questionnaire on collaborative learning (App. XIII) Maria showed a high level of expectancy of success both for the students and herself as a teacher, although it should be noted that this must be taken within the context of her concept of collaborative learning. However, she also doubted her own and the students' actual skills and saw many obstacles or practical constraints to its implementation, with time constraints and problems of discipline being major barriers. She recognized the value of the interchange of diverse ideas to enrich learning, to improve social skills, but at the same time felt that competitive learning was better preparation for the real world. Yet, her overall positive position would presumably favour the implementation of some approximation of collaborative learning.

Hector defined collaborative learning as a group of persons working together for mutual benefit ("es hacer algo con un grupo de personas para beneficiarse mutuamente," P36:7), a slightly more specific definition than the one given by Maria, although still not distinguishing it clearly from traditional group work. He considered it to be a valuable teaching strategy, one that students appreciate, and expressed a fairly high level of expectancy of success with regard to its effect on student learning, that it could improve learning of both the low and high achievers. He said that collaborative learning supported his own personal philosophy of teaching and his personal compromise with teaching, although he also stated that in the case of students and teachers, the teacher knows more concepts and can give more, or answer their questions, thus implying a definite asymmetry of legitimate knowledge at the outset. With regards to himself as a teacher, his expectations were lower, having doubts about his own and

his students' skills, and saw some obstacles or practical constraints to its implementations. He identified the main obstacle to its implementation to be the large number of students in his classes rather than questions of time or administrative questions such as organization. As his expectancy of success and his assessment of collaborative learning were high, these would possibly overcome his doubts, thus favouring its implementation. This was strongly supported by the fact that Hector had planned to use collaborative learning as the basis for his Master's thesis research, even though he never carried out the work.

With regards to Maria's epistemological stance (App. V and VI), she principally expressed traditional positivist-inductivist-realist beliefs, but at the same time was aware of the importance of the context, of social and, to a lesser degree, cultural influences, as well as the importance of scientific processes as opposed to content alone. These beliefs all indicated an intermingling of a positivist position with more relativistic, contextualised beliefs. She expressed a fairly instrumentalist view of science and technology, that both should help solve social and daily problems, and that at the same time should be held responsible for any negative effects. Maria acknowledged the constant changes in scientific theory and opinions, but generally within the positivist-realist standpoint.

Hector's answers in both questionnaires were very tentative, with some contradictions and a general lack of consistency, indicating that his conception of the nature of science (NOS) was not well formed. Overall, his general position was very eclectic, including aspects of positivism, inductivism, realism and contextualism, with a very empirical stance with regards to the NOS and the production of scientific knowledge. With regards to the nature of technology and the social implications of science and technology, he had a much broader conception, including social, political, economic aspects.

On the basis of these questionnaires on the nature of science, one might expect both teachers to present scientific knowledge in a traditional fashion in their classes, but with a fairly complex view of social and cultural aspects of technology and its social implications. However, as teachers' views of the NOS have been found to be changeable and very eclectic (Abd-El-Khalick, Bell, & Lederman, 1999; Lederman, 1999), questionnaires are recognized as unreliable in identifying their stance (Mellado, 1998). Taking this into account, the data still provided an interesting point of comparison with their practices and certainly their positions reflected that of many other science teachers (Flores et al., 2000; Mellado, 1998).

The analysis of Maria's philosophy of learning (App. VIII) [27] situated a considerable number of her answers in the conceptual and early constructivist categories, a progression towards a more student-centred style, in contradiction to the results of the questionnaire on constructivism. There was no one aspect where her answers were not spread across these categories, even though she herself stated that she rarely gave the students liberty to plan their own work. Her model of interactions was very teacher-centred, or didactic: she answered doubts, she motivated the students, she told them what to do and they listened to her. Maria was also very content driven, concerned about where to find information, that it be up-to-date. She also believed learning occurred with the use of teaching materials such as models, and that a lack of these materials could be a restraint to learning.

The analysis of Hector's answers to the philosophy of learning interview with the STAM matrix was also very similar to Maria's but with less extension into early constructivism, with his organization of work and content very teacher-centred and didactic, and fully directed by the official subject curriculum. His model of interaction was also very teacher-centred, with the initiatives and decisions coming from him: selecting, providing the material and explaining it. He recognized that teacher talk did not promote learning, although his conceptualisation of learning was that students listen and "capture" information (discussed below), indicative of another conflict in his stated beliefs.

Conceptualisation of learning

The essential goal in each classroom is "learning", largely dependent on what each teacher considers learning to be. Previous experiences and the institutional contexts are very influential in the development of the conceptualisation of learning in each person. The students and teachers reach a shared understanding of learning within their particular context, negotiating its significance and the processes considered necessary to reach this common goal.

Maria and Hector both articulated very similar beliefs in terms of their conceptualisation of learning: that a person learns individually by reading, followed by explanations and discussion with the teacher-expert. Maria's own personal learning was individualistic, expressed as one of internal processing through reading and repeating, with intrapersonal testing of understanding, if

[27] See Appendix F: Maria STAM analysis.

she could relate ideas or apply them (P4: 9)[28]. Hector's additional description of learning in his profession as a dentist was a clear example of legitimate peripheral participation (Lave and Wenger, 1991): he observed experts, then imitated them and knew he had learned well if he could apply what he had seen (P38: 11, 21).

As regards student learning, Maria expressed her belief as follows: "... [the students] learn best when they read, understand and one explains their doubts." ("...aprenden mejor cuando ellos leen, entienden y uno les explica sus dudas". P4: 24). Hector's was essentially the same, both based on their own experiential roots of learning, although Hector also emphasized the importance of learning to read, to identify key words and to write syntheses (P31:36). Both teachers also accentuated the importance of linking concepts, to relate new words with what one already understood in order to form a new concept (P4: 9; P29:7; P31:4). Both also said that you have "learned" something when you can apply it and relate it to other themes or phenomena (P4:45, P38:21). Their planning and actual teaching practices were largely coherent with this learning model, based for the most part on reading texts and teacher explanations that attempted to link different concepts, at the same time endeavouring to promote student involvement. By means of these strategies, they developed semantic relationships between the concepts (Lemke, 1997), stressing the importance of active student participation in their own learning (P4:27). In spite of this position, their overall model of learning essentially legitimised the identity and the value of the teacher within the community as the indispensable centre for all teaching-learning processes, from choosing material to read, providing the copies, designating activities to be carried out, and, above all, determining a significant portion of the final grades.

Maria and Hector both expressed the belief that students are responsible for their own learning, the role of the teacher being to present the information and, to a certain degree, to try to motivate them (P4:35; P9:3; P36:21). They also stated that all students are equally able to learn and that it is a matter of motivation rather than abilities (P4:35; P36:21). Maria, for example, said that she tried to be more patient with students who have problems and told them to put more interest in their studies and to pay more attention (" Pues, trato de ser más paciente con él y decirle que le ponga más interés a su estudio, que ponga más atención. P:4:35). This is

[28] The reference to the citations, for example P4:9, refers to the identification of the primary document or transcript (ex. P4) as classified on Atlas.ti, followed by the number of the quotation (ex. 9). This nomenclature is used throughout the thesis when referring to the different transcripts. See Table 1: Summary of field activities, p. 61 where each transcript is identified by date and subject.

essentially one facet of the argument described by Mendoza (2003) that the collective treatment of students as a homogeneous unit was an implicit rationalization of the belief that all students are equally capable of learning what is being presented. It also reflects the traditional school context that supports the tacit justification for the uniform treatment of all students without concern for their inherent differences (Bielaczyc & Collins, 2000).

Maria's and Hector's learning model as expressed in interviews, was essentially a teacher-centred, traditional one, one that pointed to the legitimisation of the reified, formalized, knowledge of teachers and texts in the teaching-learning processes, a conception apparently accepted by the students and the institution. The coincidence between the two teachers in terms of their learning models may possibly be explained by a similar number of years of teaching experience spent within the same institution, high schools of the state university (15 and 18 years respectively at the start of this project), as well as having had joint membership in both the MEC and TACTICS. Additionally, both teachers, according to their own descriptions, started their teaching careers with similar traditional teaching practices.

As described previously, the analysis of their answers to the questionnaires applied at the beginning of the project indicated a wide spread of student-centred/constructivist beliefs intermixed with a preponderance of teacher-centred/traditional ones. Maria, in particular, expressed the importance of promoting a "constructivist" classroom environment and stated that she encouraged student negotiation and control. In interviews, both teachers articulated occasional constructivist concepts of learning, such as stating the intention of having the students construct their own knowledge and of facilitating the transfer of knowledge to their daily lives, but these concepts were interspersed amongst traditional ones, such as the teacher "doing", "explaining", "choosing", with the latter concepts prevailing in their practices.

Both teachers appear to have tried to resolve the evident conflicts between the different aspects of their concepts of learning by incorporating elements brought from their other communities, most likely those of the MEC and TACTICS, by promoting more active participation of the students, even if principally through the extensive use of questioning. They expressed the conviction that the students did construct their knowledge when they answered questions and wrote summaries. As this appeared to represent a firmly held view, one repeated over the years, I have called this conceptualisation the *active transmission model*.

Teacher's role

Both teachers have demonstrated a mixed perspective regarding their teaching roles in the classroom. In line with their conceptualisation of learning, their roles included traditional ones of presenting content and explaining doubts, of controlling all aspects of planning and organization (P4:6 and 23; P5:4 and 27; P7:19; P9:13; P29:2 and 7). Hector said he had to get information out of the students and that he used and related the ideas in order to make notes on the board ("Voy sacando las ideas, relacionándolas y manejándolas...P29:7). Maria expressed a similar role through the traditional metaphor of students as vessels to be filled:

I'm going to try to get information out of them and, at the same time, I'm going fill them with new information to enrich them, right? (P7: 9)	Voy a tratar de sacar información de ellos y a la vez, pues, voy a irles metiendo la nueva información para que ellos vayan enriqueciendo, ¿verdad?

Both displayed a somewhat more constructivist position as teacher-experts, suggesting that they had to lead the students to see the relationship between concepts (P4: 9; P29:2; P31: 22; P36: 3 and 26; P37: 1), but with the students as active participants (P4: 45; P31: 34; P41). Maria expressed her role as facilitator on numerous occasions, encouraging the students to find the answers (P5: 33, P7: 56), stating that she had "to ask questions that will lead them to understand" ("plantearles preguntas para encaminarlos hacia el entendimiento" P5: 2). However, even when accepting students' interventions, the teachers were still the ones to validate student knowledge and participation (P27:4). Both were convinced of their role as motivators of student learning, by calling their attention (P7: 22- 23) and by organizing interesting activities (P9: 5; P36: 21; P11:2). Maria demonstrated her particular conceptualisation of constructivism when she said the students would be constructing their knowledge while filling in a chart with nutritional information that they had to look up in photocopies that she gave them (P9:9). Within TACTICS both teachers displayed a more definitive role as a guide, both recognizing that fact that the students knew considerably more about computers than they did (P11; P25:7), thus placing them in a completely different relationship than in the classroom.

Both were convinced that they had evolved from the traditional methods of teaching that they had used earlier in their professional careers. In Maria's words:

Before I was a traditional teacher: it was only important for me to look for information in just one book, to dictate it to them or tell them about things myself (P4: 09-18).

Lo de antes fue que era yo una maestra tradicional; solamente me importaba buscar información en un solo libro, dictárselos o contárselos yo misma.

In the same interview Maria said that a teacher must not only know their subject but also how to present it to the students in order for them to be able to make use of the knowledge ("aprovechar los conocimientos", P4: 44). She expressed confidence that she had improved and said she was satisfied with her professional identity as a good teacher who knew her subject, although she still measured her success to a large degree by students' grades, a direct reflection of the institutional context. Over the past few years she said her fear of losing control over the class had diminished:

Now I feel a bit more sure of myself when I set the students to work in groups, wanting them to learn by themselves, because before I was more afraid, I felt that I couldn't control them, but now I can...(P4: 34)

Ahora me siento como un poquito más segura cuando pongo a trabajar a los alumnos en equipos y el querer que ellos aprendan por ellos mismos, y antes me daba más miedo, sentía como que no podía, que no los podía controlar y ahora sí...

However, concern over control has been a consistent theme throughout her interviews (P4: 6; P5: 16).

Hector also expressed the conviction that he had changed greatly as a teacher over the years, that he had even denied being a real teacher at the start as a means of hiding his deficiencies and errors ("Yo antes decía, bueno, es que yo no soy maestro, a la mejor ocultaba mis deficiencias o mis errores diciendo eso..." P25: 17). He said that he was not the best of teachers even now, but that at the time of the interview in 2002, he felt that he was at least recognized as a teacher (P25:18). He was convinced that he was much better, that he no longer did all the talking and that the students were real participants in his classes (P31: 13). Control over the teaching-learning activities was never an explicit concern for him as for Maria, but it was evident in both his practices and in his discourse.

Students: characteristics and responsibilities

The educational traditions of the students may greatly enhance or obstruct efforts to implement innovations on the part of the teacher. It has been reported in studies of secondary schools in Mexico (Quiroz, 2000) and in agricultural technical high schools (CBTAs) (Mendoza, 2003) that the students are very well trained in the passive role of taking notes, accepting the traditional strategies of teacher expositions to transmit knowledge. These

content- and teacher-centred strategies are very focused on the evaluative aspects of schools, with the inevitable effect of reinforcing student habits that would undoubtedly be carried on to later educational experiences. Another essential factor in a classroom is the teacher's attitudes towards the students, how s/he "sees" the students and what s/he attempts to develop in them. Consequently, this section has been devoted to the descriptions given by the teachers of their students, in order to analyse them in relation to their practices in the classroom.

Maria and Hector both described the ideal students as those who were easily motivated (P7:65), listened to the teacher and understood easily (P4:11; P36:25), who finished their work quickly (P5:9). At the same time both said that they should be able to interrelate concepts and apply what they learn, that they should be capable of teaching themselves, of investigating further (P38:14). This was an interesting combination of the *active-passive student* and quite coherent with their *active transmission model of learning.* Once again, these concepts exemplified an intermediary position, between the traditional, passive view, which was presumably developed from their own experiences as well as from the institutional context itself, and the more participative, constructivist views presented in the MEC and in TACTICS, from which they most likely appropriated the more active components.

Maria and Hector worried about getting students to participate in class, but their beliefs as to the causes of their passivity differed considerably. Maria felt students were disinterested due to personal characteristics, such as being shy or insecure, or to the lack of attention from teachers in previous classes (P5:11), an experience she herself lived and has vowed not to repeat with her own students, showing the experiential roots of her beliefs and practice (Schön, 1983). Hector considered it to be an inevitable, essentially unchangeable situation due to the general tradition in the schools of maintaining passive students who just took notes (P31: 34; interview with the director of the Prepa B, 2003), plus the custom of working individually instead of cooperatively in class (P31: 1). Several times he also expressed the belief that it was due to the characteristics of the students themselves, their family background as well as the school environment (P29: 9; P38:6):

I feel that in our school the majority of the students in any subject have little initiative. It is something that may be due to a lack of motivation on the part of us, the teachers, but, um, it is, um, a school, eh, somewhat special in the sense of the type of persons here, that aren't of a high social level, um, I think it is sometimes difficult to motivate them.

Este, siento que en nuestra escuela la mayoría de los alumnos en cualquier material tienen poca iniciativa. Es una cosa, a lo mejor, tal vez, por falta de motivación por parte de nosotros los maestros, pero, este, como es, eh, una escuela, eh, poquito especial en el sentido del tipo de personas que hay, que no son de un nivel social alto, este, considero que es difícil a veces motivarlos. (P35:1)

Hector also said the students in his school didn't know how to read with comprehension (P31:18), that they had little initiative and were uninterested in learning, with sometimes only two or three in each group who paid attention and learned something (P29:9; P35:1). Maria had a similar vision of the majority of her students as well, although for different reasons as mentioned above (P5:11). Each teacher had individually developed their own strategies to bring their students closer to their "ideal" student, coherent with the causes that they attribute to the lack of participation. Hector, for example, did so by emphasizing the writing of summaries from the texts, while Maria continually tried to incorporate the marginalized students. This will be discussed in more detail in the section on practices.

Hector appeared to consider the aforementioned obstacles to be essentially beyond his power to overcome, and said that he only worked with those who wanted to participate, leaving the others aside (P36:24); in spite of that, he did try out new practices to attempt to improve participation. Both Hector and Maria distributed the accountability between the teacher and the students for preparing conditions for learning, with the teacher's initial role to be that of the provider of knowledge and motivator, but with the students ultimately responsible for their own learning (P4:35; P9:3; P36:21), a very traditional stance (Bielaczyz and Collins, 2000).

Maria tried some innovative strategies in her classes and had sufficient confidence in her beliefs and more active practices to continue using them with each new group of students, even though she had to train them each time, convinced that it worked (P7: 13) and that it would help them in future studies (P9:20). She said there was always some protest from the students who attempted to negotiate a return to their preferred traditional method of passive note-taking, but she was firmly convinced that it was the wrong route to learning, so persisted with her own strategies, eventually winning over many of the students (P7: 64). In these cases of protest, she refused to negotiate her position with the students, imposing her control over activities, albeit for their own benefit. She said some students had definitely learned to prefer her more active way of teaching and that they had told her that in the other traditional classes of dictation they were only

waiting for the bell to ring. She considered this to be a great verification of her teaching strategies (P7:64), but it could also be considered to develop shared interests in terms of classroom activities. It is also indicative of the students' attitudes, of a readiness to become more directly involved in the teaching-learning processes when given the opportunity.

Hector also felt that he had made good progress, particularly with a new strategy of using his brother's biology notes[29] as a basis to synthesize the information together with his students. He emphasised that the students' training in taking dictations made it a struggle to change their habits, but that they eventually accepted his new way of working (P40:29, 33). He was confident that he was breaking the students out of their passive habits, teaching them more active, questioning skills of reading and synthesizing information that would help them in their future studies, although he neglected to recognize that the verbal questioning skills were essentially his. This belief was expressed in the passage on the following page:

[29] This strategy is described in more detail in the following section on practices.

But I think that I am creating a different habit, that in their way of going to school, definitely, of not being passive, but on the contrary that they question. (P31:34, 366-370)	Pero siento que sí, les estoy creando un hábito diferente, que en su manera de ir a la prepa, definitivamente, ya no de ser pasivo, sino que al contrario que cuestionen.

Hector said that he did not check student comprehension of what they had just seen the previous class, assuming that they realized they should learn it (P29:20); nor did he check if they were taking proper notes, even though he recognized that some did not (P40:11). He took for granted that each member of the community should fulfil their own responsibilities, the teacher supplying the knowledge and the students learning it. This reinforced a "typical" classroom situation where the general problem-solving relationship was a tacit one between each student and the teacher, implicitly understood that the students had to memorize all the information and algorithms exactly as presented by the teacher, reified on the board or in photocopies, and only for exam purposes.

Both teachers believed that the students themselves valued their exam grades above all else, or, in Maria's words:

I sometimes think that they don't value learning, but just their grade and their attendance, and in third place, learning. (P4: 28)	A veces siento que lo que ellos valoran más es su calificación y su asistencia y ya en tercer lugar, el aprendizaje.

Hector expressed it in very similar terms, that they only studied for their exams, not for learning itself (P31:40). It could be inferred that this was a common attitude in most of the communities to which they belonged, including the school, the university, the academy, as well as in the classroom itself, as exam results were the most relevant definition of student achievement at all levels, a situation not open to negotiation.

In terms of the institutional norms, the students were required to pass their exams and to have at least 80% attendance, although if they obtained 8.5 on their semestral exams, poor attendance was pardoned. Otherwise they failed the subject and had to take extraordinary exams[30] the following semester. If they failed more than two subjects, they were expelled from the entire university public high school system (interview with the director of the Prepa B, 2003). Aside from attendance and exam results, the students had no officially specified responsibilities in the school, although the director of the Prepa A (interview, 2004) did mention additional student responsibilities, such as to be respectful of the teachers, staff and peers. The Prepa A also offered tuition scholarships at the end of each year to those students who did well, with a reduction in fees ($1500 pesos per year) in proportion to their grades, providing an economically fostered motivation for good marks. The influence of the

[30] These are exams given just before the following semester where students have a chance to present their exams again, a second opportunity to pass to the following grade.

institutional norms was evident in all facets of school life, from the accepted levels of attendance and behaviour, to the formation of identity of both students and teachers based on exam grades[31].

Students also wielded a degree of political power within these high schools through their student association. They had a voice in choosing the director of their school every three years and at any time could bring complaints to the administration about the work of a teacher (interview with the director of the Prepa A, 2004). This placed them in an interesting balance of power and control within the school community, giving them a power of negotiation at least within the social-political spheres of the classroom and the school, even if only indirectly in the academic one. In the latter case, they were observed at different moments to negotiate dates of exams, homework requirements, attendance, and, to a certain degree, even grades on homework and on partial exams.

An initial summary of Maria's and Hector's overall articulated beliefs indicated an eclectic position between their teacher-centred models and constructivist ones as well as in their conceptualisation of the nature of science. There were few changes in these expressed beliefs over the period of observation, with the most noteworthy ones being more student-centred strategies developed by both teachers in 2003-2004. Their stance could represent a partial appropriation of certain terms only at the level of discourse, most likely concepts assimilated from their joint membership in the MEC and in TACTICS, but not fully integrated into their system of beliefs on teaching and learning of science, with the possibility that they may never become so. Their positions, however, were deemed to be coherent with constructivism itself as the model entails an active construction of new concepts over time that inevitably involves contrast and interaction of the old and new ideas during the development of a new one, a transitional stage. As pointed out by Lemke (2001) a conceptual change is not simply a rational choice but a social process that affects one's identity in a community, making change a very complex process.

[31] The importance of the semestral exam may diminish in the coming years due to the fact that since 2003 it was being given less weight: from being the preponderant grade, it is now only one quarter of the final grade and the remaining part is taken from the teachers' three partial exam results (interviews with directors of the high schools, 2003 and 2004).

Practices:

Teaching practices were analysed from the classroom observations, from the teachers' discourse and interactions with the students throughout the classes, as well as from their own descriptions of practices as given in interviews. Practices were considered to include everything that occurred in the classroom as well as the planning, organization and evaluation of student learning. The previously described categories based on common knowledge, collaborative learning and communities of practice were again used to analyse the data. The common threads found amongst these three theoretical frameworks have been chosen as the clearest approach with which to present the data: planning and organization of work, interactions and evaluation. Discourse analysis was used concurrently to identify Maria's and Hector's manners of speaking in class, to what degree and in which style they "talked" science with their students.

Planning and organization of work

As the teacher is the official transmitter of information in a classroom, the one with the institutionalised role of organization, responsible for what occurs or not in the classes, his/her planning and organization are critical in the creation of relationships with the students. The manner in which they are implemented determines the degrees of joint enterprise, mutual engagement, the types of interactions that occur as well as the shared resources that are developed. This section describes the planning and organization that both teachers carried out for their class and laboratory work and the implications on their classroom practices.

In different interviews, Maria and Hector expressed the common goal of teaching their students the curriculum content of the official study plan for biology (P4:12; P38:18), principally to pass the standardized semestral exams; this was a joint enterprise or shared goal with their students (P4:28; P5:10 and 15; P29:11). Their practices were completely coherent with this goal as the great majority of their questions were focused on biological vocabulary, its terminology, definitions and classification, as may be seen from the passages cited in this study. The notes they wrote on the boards also reinforced this goal. These practices reflected the reification of the official study plan as it was essentially a list of terminology and classifications to be memorized by the students. On a few occasions both teachers expressed implicit goals beyond the traditional teaching-memorizing of terms, those of teaching the students to use these biological terms, to "speak" as a biologist, such as expressed by Hugo:

I try to get them to underline [the important words] and that they articulate the important points of the topic. (P40:5)	yo trato de que ellos subrayen [las palabras importantes] y que ellos vayan diciendo las cosas importantes del tema

In addition to the goal of teaching basic biological terms and concepts, in interviews they also pronounced other goals considerably broader than this, such as teaching their students to become sincerely interested in science, to read and synthesize information, to develop skills to become lifelong learners (P9:20; P40:2, 12 and 43). As discussed earlier, at the beginning of the project Maria and Hector were asked in a questionnaire to write down their three principal goals for student learning. Maria's three goals were very student-centred, reflecting broad, explicitly formulated concerns for her students' learning, whereas Hector wrote only one goal: that they understand as much as possible. Nevertheless, these goals were never explicitly stated in class so it was not clear up to what point they were shared with their students.

Both teachers also stated that they tried to simplify the information presented to their students (P29:1; P31:4) which they explained as requiring knowledge of the content and the manner to teach it (P4:44; P38:8), exemplifying their practical knowledge as teachers. Both teachers also affirmed that they tried to update their knowledge of biology through reading scientific articles, taking mini-courses offered by the university for high school teachers (Maria more than Hector) and by watching science programs on TV (P4:3; P36:26). Maria was particularly concerned with finding up-to-date, simplified information for her students, buying her own books when necessary.

Both teachers reiterated on numerous occasions the aspiration to instil in their students the desire to learn for learning's sake, not just to pass exams; yet at the same time they considered the definitive measure of learning to be the grades the students received on exams, specifically the semestral ones. They both recognized that these exams, which were essentially the reification of the study plan, were very limited as to the cognitive levels of evaluation, yet their influence was seen to be omnipresent in every aspect of teaching and learning. The importance of the semestral exams was very evident in both their teaching agendas and could even be considered to be the motor of much of the class dynamics. As the exams essentially covered definitions and classification, they also reinforced the traditional teaching of biology. The results of the standardized multiple-choice exams given each semester were so important that, according to Maria, some teachers even gave their students the answer keys to learn ahead of time, although she didn't.

Well, I'd say that with all of them, my challenge is .... that they learn, right?, that they learn, not so much for the semestral exam, although it is a challenge in the exam, that, though I don't give them the key to study from, but that they learn and in any exam that they are given, that they could answer it. (P7: 22).

Pues, yo digo que con todos, mi reto es.....que aprendan, ¿verdad?, de que aprendan, ya no tanto por el colegiado, pero sí es un reto en el colegiado que a pesar de que yo no les dé claves para que estudien, si no que ellos aprendan y que cualquier examen que a ellos les pusieran, ellos lo supieran contestar.

Maria and Hector both admitted that they never wrote out their teaching plans for their classes, but that each basically followed the official study plan for biology, teaching to cover the necessary content for the semestral exam (P4:12; P38:18). As of 2003 even the partial exams throughout the semester were being prescribed in both content and dates by the teachers' academies of the university, and although formulated by each teacher, this new institutional norm put even more pressure on each teacher to stick very closely to the study plan.

Maria used photocopies extensively, taken from various sources that she considered appropriate for her students, no longer just dictating from one book as she did at the start of her career (P4:2). Hector was observed dictating notes from texts twice, in March and in November of 2001 (P26, P43 and P44), but his use of photocopies increased over the period of observation with no further observations of dictation. In spite of not writing out their teaching plans, this strategy required previous organization to choose the material and to provide the students with a master copy with sufficient time for the students to make copies (P31:1). As the students brought some of the materials used in the laboratory practicals, they also had to tell them in advance. Maria acknowledged that by not recording her strategies, she could forget to repeat activities in subsequent years that she had found to be successful (P9:18). She generally had a pre-designed, mental teaching plan (P5:25), often including specific materials, but repeatedly she had to recur to emergent plans, usually when students did not prepare their work ahead of time, a frequent situation that required certain flexibility in her practices, one that she said also promoted her creativity.

In Maria's classes, a large number of students regularly did not do homework assignments that involved reading and were not punished for it, but, in turn, agreed to work during class time, an implicit negotiation of responsibilities. Hector also had similar responses from his students, even leading to negotiation with the students that they would get an extra point if they did their homework (P43). Both teachers accepted the situation and gave reading time in class. Maria, in particular, would adapt her strategies to the conditions of the group, something that she did without difficulty, quickly formulating questions for the students to answer while

reading in class. This tacit negotiation appeared to be part of the unwritten rules of the classroom, or the shared repertoire as both teachers and students knew they could do this without much disruption of the class dynamics, in spite of the teachers going through the normative ritual of giving homework assignments.

In various interviews, Hector admitted to not planning his classes, just following the official study plan but without preparing teaching strategies:

> Normally I don't choose a teaching strategy in a specific way, but at the moment that I am in class, something occurs to me in a specific way and I try to apply it. (P36:1, 9-11)
>
> Normalmente no escojo una estrategia didáctica en forma específica sino en el momento en que estoy en la clase, este, se me ocurre algo en forma específica y trato de aplicarlo.

Twice he invited me to observe classes where he was going to use the jigsaw method for collaborative learning[32], the basic collaborative learning strategy used in TACTICS[33], but on both occasions he had not prepared anything so resorted to his normal strategies. In class he frequently referred directly to a text, at times even copying from it to make notes on the board, an indication of a lesser content mastery and organization than that of Maria. On several occasions, there were observed errors in the content knowledge that he presented to the students, such as in cell organelles and functions (P26) or in photosynthesis (P44). He also admitted to sometimes not even knowing what he was going to teach to the following class "Sometimes I don't check what I'm going to see with the following group". ("A veces no checo qué es lo que voy a ver con el siguiente grupo." P29:25, 528-538). He himself acknowledged that this lack of planning hampered his good intentions, such as when asked what he could do in order to improve collaborative work in groups: "Well, to have everything really well planned." ("Pues, realmente tener bien planificado las cosas ¿no?" P31:37, 396-407). His lack of planning also left interactions very open to spontaneous development, something that all teachers use opportunistically at times, but Hector did it consistently, relying on his experience of teaching essentially the same content throughout his career.

Both teachers also stressed intentional learning, at least at an implicit level, in other words that the students should understand the importance of the knowledge that they were to learn, by occasionally connecting concepts to their daily lives. They also linked different scientific topics within the class, such as diffusion with excretion or with molecular energy, or nutrient

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[32] See Appendix G for the model.

[33] For further details, see Vázquez-Abad, J et al (2004). Fostering distributed science learning through collaborative technologies. *Journal of Science Education and Technology* 13 (2): 227-232

content of foods with properly balanced diets according to energy requirements (P1:76 and 80; P7:6; P28:6). Hector also attempted to bring in related topics through the periodic use of analogies of situations that the students were familiar with; for example. when teaching metabolic processes and the need for energy in a cell, he said to the students that if:

> You stop putting gas in a car, it stops working... putting gas in a car is the transformation of chemical energy into mechanical energy. (P28:7)
>
> Ustedes dejan de echarle gasolina a un coche, deja de funcionar.... eso de ponerle gasolina a un coche es la transformación de energía química en energía mecánica.

He said he used these analogies spontaneously, without planning them ahead of time (P31:30), as well as with the use of the occasional conceptual maps that he drew on the whiteboard (P40:14). The more intentional use of conceptual maps was a clear example of deliberately helping the students to develop semantic relationships amongst different concepts.

Maria had explicit intentions of facilitating the transfer of knowledge from the classroom to the daily lives of her students, such as learning to improve their nutrition from a simple exercise in the laboratory (P6) by using a food pyramid. She demonstrated her intention to build from the students' previous knowledge, as expressed in the interview after the laboratory.

> [My objectives in this class] were, in the first place to know if the students know what is in food, and the other objectives that, well, that they learn...by practice or theory...well, the objective is that they improve their daily meals, right? (P7: 6).
>
> [Mis objetivos en esta clase fueron] en primer lugar, saber si los alumnos saben qué contienen los alimentos, y los otros objetivos son que, pues, que ellos aprendan, ...ya sea práctica o teórica,... pues el objetivo es que mejoren su comida diaria ¿verdad?

Her objectives here were very clear and specific, although possibly not well matched with the simplicity of the exercise. She showed concern for the students improving their nutritional intake, a desired transfer of "theoretical" biological knowledge to their own lives, although it may have been a naïve intention as the anticipated transfer was a major "leap" with no directives nor assistance from her. These beliefs were undoubtedly the driving force in her choice of a new book she had just bought and from which she had taken this particular laboratory exercise through which she believed she would be able to accomplish her overall goal.

In another class Maria tried to bring in some of the cultural customs of the Day of the Dead by having the students individually glue together the bones of a paper skeleton and then write a traditional, humerous verse (*calavera*), in this case related to nutritive content of bones (P8:4; P9:2). The intention was to relate the activity to the syllabus topic being covered at that time, the biochemical components in nutrition. This second objective was not reached as the

students spent the entire class assembling the skeletons, a very mechanical activity, with only one boy writing a *calavera*, but it was still an innovative attempt at border crossing, joining local cultural traditions within the biology community of practice. Maria had written her own *calavera* which she read out to the class, causing laughter when she referred to specific students. These efforts promoted the engagement of the students' attention and developed shared interests and repertoires while attempting to build a common knowledge base.

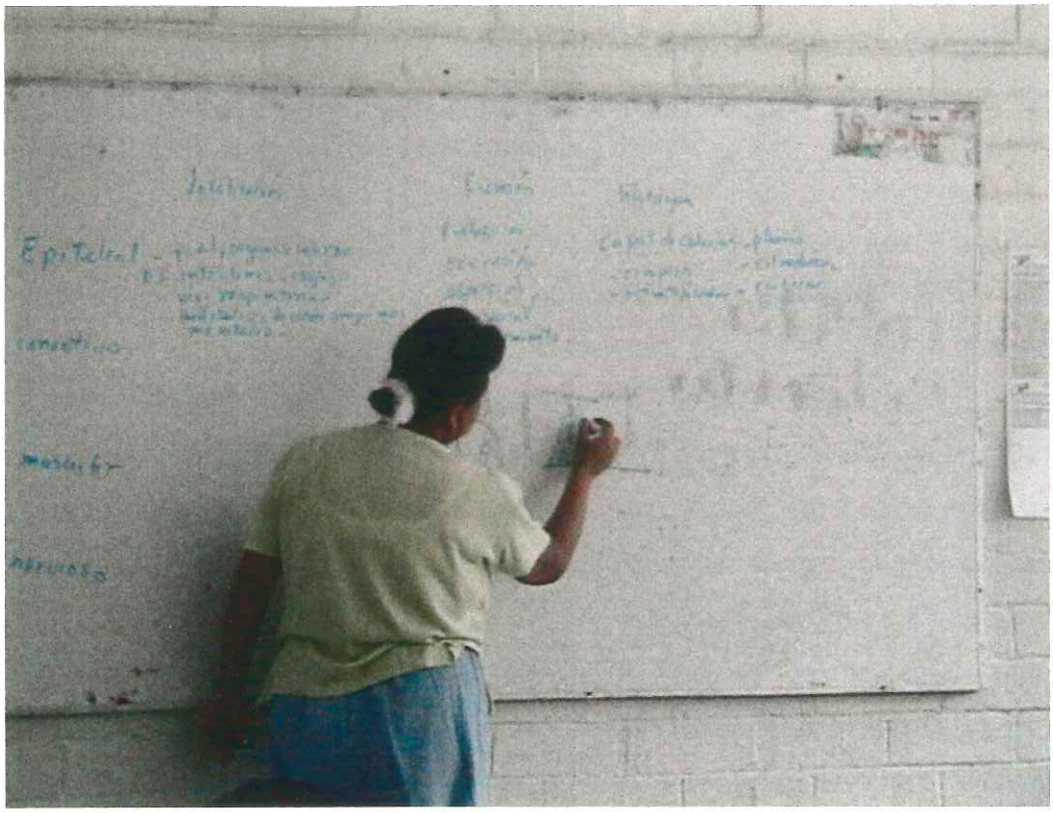
She normally spent a considerable portion of the class time building the basic scientific vocabulary necessary to understand the topic under study, such as in her first class on nutrition that she described in the interview after the laboratory:

> We talked about defining the concept of nutrition, that it's a process of using nutrients, and from that follows digestion, absorption, defecation, these are the steps, the processes of the nutrients. (P7: 12)
>
> Ya hablamos sobre definir el concepto de qué es nutrición, que es un proceso del uso de nutrientes y que ahí va lo que es lo de la digestión, la absorción y la defecación, son los pasos, los procesos de los nutrientes.

Although she said "we talked about," it is unlikely that the students gave more than one or two word answers, as seen in the examples presented here, scarcely a chance to practice using the scientific language they were to learn. However, in this description Maria showed that she went beyond the immediate definitions and tried to develop a more global view of nutrition, to show the students the different processes that are involved. She attempted to contextualise the topic within processes of digestion, something with which the students are familiar. The strategies that Maria used that were more ritualistic, in the sense of focusing on biological definitions and basic vocabulary, were undoubtedly strongly influenced by the institutional context of the official study plan and semestral exams.

However, at many moments during the observed classes it was evident that Maria also attempted to promote a more comprehensive grasp of the interrelationships between important concepts in order to develop semantic relationships (Lemke, 1997). She would frequently do this by summarizing concepts on the board in tables (as in the Photo 2, below) or diagrams, by repeating phrases, by rephrasing explanations, by asking for definitions, by using multiple examples, all reflecting her emphasis on the importance of learning the biological *language*. One of her stated teaching objectives was that they *learn*, and not just memorize to pass an exam, although, as mentioned repeatedly, the importance of the standardized multiple-choice exams given each semester was also very evident in her teaching agenda.

Photograph 2: Maria at the whiteboard: writing student contributions in a table to summarize and relate the locations, functions and structures of different animal tissues.



Both teachers organized their work around the use of the technical tools of photocopies and the whiteboard, regularly writing and drawing on the board to focus student attention and as an aid in developing a concept, as seen in the above photograph. These were the notes the students generally copied down, reflecting their perception that this was the legitimised knowledge that they required in order to pass exams. The two cases where Hector was observed to dictate notes directly from a text to the students, of definitions and algorithms in chemistry classes, clearly gave the message to the students that these were the key concepts to be memorized. Occasionally students were asked to come up to write answers on the board, but it was nearly always a very directed activity between the individual students and the teacher rather than a collaborative one, particularly in Hector's classes. Sometimes the class as a whole was asked to assist their peers when the answers were incomplete, giving certain validation to student contributions although the teacher legitimised the information by going over the answers as a group.

Regarding collaborative tools, both had intentions of a collaborative use of photocopies but neither appeared to have achieved this goal, as observations indicated that the students used them in an individual and rather mechanical fashion, to the point of initiating a game, trying to get the teacher to show them where the "correct" answers were. This was particularly noticeable in Maria's classes where she gave the students specific questions to answer. In a questionnaire at the beginning of the project both wrote that they used overhead projectors, Maria very frequently and Hector almost always, although neither was observed using one over these four years. Maria gave the reason that there were few in the school and that other teachers always took them first, again implying a lack of planning of resources.

In interviews Maria demonstrated a constant concern regarding control of her classes in every aspect, also shown in the answers to some of the questionnaires at the start of the project. This was reflected in her more careful planning, although over the school year of 2003 she declared that her fear had diminished somewhat, to the point that as of the spring semester of 2004 she did not even provide photocopies but had the students look for information from different books she recommended, still maintaining certain control (P16). Hector, on the other hand, never brought up questions of control, but on the contrary talked about his desire to give his students liberty and autonomy in class, possibly an unconscious rationale for his lack of planning.

Maria's new strategy (begun in 2003-2004) of distributing responsibilities amongst the students to find specific information in different books was a noteworthy transformation from her past practice of providing the same photocopies to each student (P16). She explained this was to cut their reliance on her to always provide the information, to make them more active participants in the process. She described that she checked each student's notes to make sure each brought some work to class and said it promoted their participation and made them more responsible. She said it enriched the class as each came with different information which they then compared and to which she added information when necessary, legitimising it by writing a synthesis on the board together with the students. This was a much stronger level of planned collaboration within the community than previously observed.

Interestingly enough, Hector also began to use a "new collaborative" strategy in his classes the same school year, one that he invited me to observe in October, 2003. The students were working with photocopies, and after giving them 15 minutes to read three pages, he had them identify the main points which he wrote on the board as a synthesis. He described in his follow-up interview (P40) that the photocopies the students were using were ones put together

by his brother who is also a high school biology teacher in the same university system; the notes were thus directly organized on the basis of the same study plan. Hector explained his decision to use them was to promote better participation and to teach the students how to read with comprehension, to pick out key words and phrases, to make conceptual maps and to synthesize texts, and hopefully, in the long term, to promote the habit of reading science texts and articles (P40:12). These strategies were coherent with his model of learning, of reading individually, picking out key phrases and discussing the concepts with an expert but in a more active manner.

In this class, he had intended for them to read the topic as homework, and then work in groups to write out a synopsis, the collaborative aspect, but as they had not prepared their work, he had to readjust his plan. This style of teaching was a considerable change from other classes observed over these years and would appear to have been stimulated by the opportunity to use his brother's notes plus his own dissatisfaction with the poor participation, in spite of his statements about the unchangeable obstacles involved. Undoubtedly it also greatly simplified his planning and teaching processes as all the study plan topics were covered in these notes. His previous use of photocopies had not included the joint writing of a synthesis of the content but a more mechanical reading of the information with his choice of notes to write on the board. He also mentioned that the new style of work was very similar to that used in the MEC classes, although at a simpler level (P40:22).

The above activity using his brother's notes was an apparent example of border crossing with other communities of practice, with those of his family-colleagues as well as with the MEC. He had extended his identity as a teacher through these notes that his brother had prepared, a recognized authority as a former director of the same high school. This was the clearest attempt seen on the part of Hector to promote more active participation along with a relatively specific teaching of skills through his modelling of how to write a synthesis. There was a certain level of negotiation of meaning with the students in terms of choosing the most important information to be written on the board, even if it was not always successful; this was the case in the following example when he was discussing with a class the role of proteins in cell membranes[34]:

[34] Key to all transcripts: M: teacher; H: Hector; Ao: student (1, 2 refer to different students, although these are not always identified in the transcript; they may also be male or female); Aos: several students speaking together; Aa: female student

H: What [other role do proteins in membranes have], besides transporting molecules across the membrane? It's to carry out functions, to catalyse them. Would that be the correct term?

Ao1: so that they don't join with others.

H: or that they cause chemical reactions.

Ao2: but the function of proteins is more catalysing, not selective.

H: at times, yes, or they catalyse reactions, in that sense.

Ao2: but the catalysing and the reaction can both be stopped. The catalysing is the acceleration of the process.

H: or accelerate them, too, not slow them down. Or rather, the process, the function of a catalyser could also be an enzyme in a specific form, yes? to accelerate or slow a chemical reaction, yes? Or a biochemical thing that can be carried out inside the cell, yes? Then in this case we can add, um, to catalyse chemical reactions, yes? We can use it like that.

H: ¿Qué, [otro papel tienen las proteínas en el membrana] además de, de transportar moléculas a través de la membrana? Es realizar funciones, catalizarlas, ¿sería este el término correcto?

Ao1: para que no se unan con otras

H: O sea, hacer que se produzcan reacciones químicas

Ao2: pero la función de las proteínas es más bien catalizadora, no selectiva

H: En un momento dado, sí, o sea, catalizar reacciones, en ese sentido

Ao2: pero la catalización y la reacción nos pueden detener igual, la catalización es la aceleración al...del proceso.

H: O acelerarlos también, no disminuirlos, o sea el proceso, la función de un catalizador que también podría ser una enzima en forma específica, ¿sí? es acelerar o retardar una reacción química ¿sí? o tipo bioquímico que se pueda realizar, este, en el interior de la célula ¿sí? Entonces en este caso podemos agregarle, este, catalizar reacciones químicas ¿sí? Podemos manejarlo así. (P41:1, 130-141)

In this interchange, it was seen that, at the outset, Hector's question was not well formulated and that he ignored the answer of student Ao1 and went on with his agenda, discussing with student Ao2 the role of enzymes in catalysing reactions, but neither directly answering nor correcting this student's interventions either. All together, the level of communication was very poor with errors in Hector's own statements that enzymes can slow down reactions, and his comments were more likely to cause confusion than illumination amongst the students. This type of interchange could explain the students' apparent recognition of the photocopied notes as having a much more legitimised knowledge than their teacher's and their observed lack of interest in this class in copying down what he was writing on the board. The activity, however, had the potential of developing a positive interdependence between most members of the community, of building relationships and of sharing and developing knowledge.

Both Maria and Hector frequently lamented the difficulty of getting students to participate in class, in breaking them out of their passive role, but their attitudes towards this problem

differed considerably, as discussed previously. Hector made only tentative plans to try to offset this as he accepted that the majority of the students were disinterested, marginal participants, stating that he worked with those who wanted to participate, leaving the others aside (P36:24). Maria, quite the reverse, constantly planned specific strategies to promote participation of the marginalized students (P5:32; P9:19):

> my challenge is with all of them but especially with those who don't want to work. (P7: 49).
>
> Mi reto es con todos y más con los que no quieren trabajar.

She said that she motivated them by giving them different activities as well as having developed her own strategy, which she described metaphorically as "being their aunt" (P7: 336-337):

> by reprimanding them, calling their attention, speaking to them directly or generally checking their work as I tell them that this will count for their final grade and this gives me good results as they all work and at the end I take into account their effort. (P4: 50).
>
> regañándolos, llamándoles la atención, hablándoles directamente o generalmente yo les reviso todos sus trabajos y les digo que al final esto les va a servir para su evaluación y eso me da resultado porque trabajan y al final sí les tomo en cuento todo su esfuerzo que realizaron.

She considered this "maternal" method to be reasonably successful in motivating them to work, particularly as she considered disinterested/poor students as ones who only lack motivation, that they only needed to put in more effort and then they'd have no trouble learning. Certainly Maria actively promoted their participation so that they should become less marginalized, moving from their very peripheral position to a more central one where they would begin to learn how to talk, in these cases, as a biologist (Lave & Wenger, 1991; Lemke, 1997). It could also be interpreted as a very initial stage necessary to build relationships amongst the students as well as to provide opportunities to modify student identities.

The contrast between the two teachers described above reflected their different attitudes towards students as legitimate peripheral participants in their classroom practices and their own identity as a teacher with its corresponding responsibilities. Both teachers were the central, expert participants with only a small group of somewhat active students and the rest essentially marginalized. Hector did not consider it his responsibility to attempt to improve the participant role of all of the members of his classroom, but only of those who were predisposed to do so. Maria, on the other hand, considered it an essential role to make the constant effort to motivate

all members to participate more actively. Specific examples will be discussed in the following section on interactions.

The laboratory work had its own particular characteristics in terms of the teachers' planning and organization. The concrete tables and the limited equipment necessarily required group work, but both the exercises and practices appeared to be very mechanical and ritualistic. Once again, the teacher was in control of the organization and coordination of the materials and all procedures to be carried out. Both teachers used as their basic laboratory guide a manual of practicals published by the *Academia Interescolar de Biología,* the biology academy of the state university, originally written for the period of 1997-2003 but approved for 2003-2004. Each practical was very prescriptive, with every detail given as to materials, procedures, and even the questions to ask the students. The tasks were set by the teacher and the students appeared to be more concerned with fulfilling the basic requirements than with understanding what they were actually doing. In one chemistry lab, Hector gave no explanation of the relatively simple chemical reactions that were being observed (P37), only strict procedural instructions. Another example was in one of Maria's biology labs (P6), where the students were more interested in how many foods they should include in their nutritional table, rather than investigating in depth. Maria reinforced this further by checking on the number of foods in their tables rather than the actual quality of the answers. Hector, however, had tried to broaden the laboratory experiences in an innovative manner: he asked the students to include in their lab reports applications of what they had done in the laboratory, or of related topics, such as when they were discussing animal tissues to look for the uses of stem cells (P29:29).

The observed style of group work in the laboratory was very traditional, with only some working and others chatting, and was promoted even further by the teachers' standard requirement of only one report per group. As there was no evaluated control of who worked or not, short of the teacher's passing comments during the laboratory that all should get busy and work, the standard work strategy in the groups was that only a few students carried out the practical but all got credit. Joint responsibility was shared and interdependence was seen within the group in a tacit fashion, by sharing the equipment to a certain degree as well as same grade, even though the actual work was not shared. In 2003-2004, Maria had begun to change this form of evaluation in her groups by asking for individual reports, although the revision appeared to be very cursory, simply that there was something written on a page. The school culture itself appeared not to promote interdependence or a culture of mutual responsibility in learning, but to implicitly support individual independence, both for teachers and students, in whichever context, the classroom or the laboratory.

Interactions

Observations of the interactions in the classroom are the basis for identifying a teacher's practices and for confirming or refuting inferred beliefs. In one classroom alone, they are of an extremely complex nature: they may vary enormously in quality and quantity, from asymmetric, purely normative interactions, to looking for an answer to a closed question in a given text, to broader opportunities to negotiate meanings. The following section analyses the variety of interactions observed in the classes, along with the teachers' explanations of them, followed by a brief section on the interactions in TACTICS.

Interactions in the classrooms

Maria and Hector both used questioning as a basic teaching strategy under very controlled conditions, each assuming the role of expert, closely organizing all materials and activities. According to their own descriptions, they had changed their teaching strategies from when they first became teachers when they simply dictated notes to the students. Their questions, both oral and in written form, were used for a wide variety of purposes, such as to focus attention of a distracted student or the whole class or to promote participation. They also used them to establish the limits of common knowledge, to remind students of the topic studied in the previous class in order to link the two, or to set up the basis of necessary vocabulary.

The following passage illustrates some of these strategies in one of Maria's classes (P1) where the students had been reading photocopies about the cell membrane and transport and answering questions in their notebooks that Maria had dictated to them. Towards the end of the class, Maria asked a student to come to the board and write her answer to the first question. She was at the front of the room by the whiteboard, beside the student:

M: (The teacher hands her the pen. She watches what she is doing and helps her, she says something but it is inaudible.) I only want you to see how it is (looks at the students). There it is (points to the board), the first question. Is it ok? Or is something missing? (She leans on the board, pointing to the first question. She gives the students time to answer). Is something missing or is it ok like that? (She covers her mouth to cough). It's ok, nothing is missing? Let's see, Javier (pointing to a student). Is something missing in the first question or is it ok like that? (She points to the board).
Ao: She's talking to you, Javier.
Ao: To me, teacher?
M: (She nods her head, indicating yes) He who doesn't talk... (she points to him), let's see, Javier.
Ao: Nothing else, what is missing is...
Aos: Not you!
Ao: Oh, not me? (P1:22, 27, 71)

M: (La maestra le da el marcador. Observa lo que está haciendo y la auxilia, le dice algo pero no se alcanza a distinguir). Nada más quiero que vean cómo quedó, (observa a los alumnos). A ver, ahí está (señala en el pizarrón) la primera pregunta ¿Está bien, o hace falta algo? (Se recarga en el pizarrón, señalando la pregunta número uno. Les da tiempo a los alumnos para que le contesten) ¿Falta algo o nada más está bien así? (Se tapa la boca para toser) ¿Está bien, ya no falta nada? A ver, Javier (señala al alumno), ¿le falta algo a la uno o está bien así? (señala en el pizarrón).
Ao: Te hablan, Javier,
Ao: ¿A mí, maestra?
M: (La maestra mueve la cabeza diciéndole que sí) El que no platica... (lo señala) a ver, Javier.

Ao: Nada más, lo que le falta, este..
Aos: A tí, no.
Ao: ¡ay!, a mí ¿no?

In this example, Maria initially promoted student participation by having one girl write her answer on the board, using the whiteboard collaboratively in a joint activity. Maria validated the student's participation, sharing the teaching-learning process even though she herself was in full control of it. She attempted to stimulate the engagement of the whole class, asking for their opinions about the answer, if anything was missing, directing the students' attention to the answer on the board, an effort to establish the degree of common knowledge in the group. Her normal style of questioning was clearly exemplified here, repeating her question, which was directed to the class as a whole, waiting for an answer but when she got none, asking again. Finally, she asked one particular student, Javier, who was talking, thereby trying to focus his attention to the work at hand. Some of the other students attempted to get his attention and block the intervention of another student, sharing responsibility with Maria for maintaining the class working environment. Her ironic answer to Javier amused the class, helping to engage them all in the exchange.

Later in this same class Maria carried out a demonstration of diffusion, establishing shared attention by means of the same strategy, trying to draw in all the students as well as some distracted ones, in this case the same Javier as in above example:

> Here we're going to add- Pay attention, eh! -watch how the water looks, and we'll add - Take the time, Javier. -some drops of methylene blue. (P1: 56, 601-611).
>
> Aquí le vamos a agregar.. fíjense ¡eh! Fíjense en el agua cómo se ve y le vamos a agregar.. Toma el tiempo, Javier..unas gotas de azul de metileno.

Here Maria was actively involving Javier as a means of control, to maintain his attention, but also so that he should share and contribute to the meaning of the demonstration.

Maria frequently and skilfully employed questions to involve her students, inviting them to participate. However, classroom observations showed the participation limited to only part of the class, with varying numbers of students distracted or marginalized, as seen above, a situation she tried to correct. She attempted to incorporate them into the class activities through reprimands, encouragement, special work assignments and by looking for interesting books to use, such as an "interactive" biology text. She found it difficult and time consuming to guide the students to a more active type of work as they have been trained by teachers who only dictated, a clear example of struggling against the prevailing classroom strategies in her school context:

> ...last semester another teacher taught them and they were used to him dictating to them.... At first I saw they were sort of surprised by the way I'd been teaching them. (P7: 13, 187-203).
>
> ...el semestre pasado, les dio otro maestro y estaban acostumbrados a que les dictaran... Primero los vi como extrañados con la forma como les he estado enseñando..

The reaction of student surprise is an example of what Bleicher (1998, pp. 92-93) called a "frame crash." He referred to the different frames of reference of teachers and students regarding their different expectations in a class. It was evident that the students' frame of reference was the traditional teacher who dictated, so that it was a cause of conflict in Maria's classes with each new group. In spite of this initial reaction and resistance on the part of her students, Maria had sufficient confidence in her strategies to continue using them, reporting that at least some students had definitely learned to prefer her more active way of teaching and that they felt they learned more (P7:201-203).

Time was often given in both teachers' classes for the students to read the photocopies that they had not read as homework, and sometimes to answer questions. Some students would move their desks to work together in small groups, but the majority worked individually. Maria moved amongst the students' desks, helping them to answer their questions, while Hector normally gave reading time without specific questions, telling them to pick out the important concepts as a summary. Here again it was clear that both attempted to control all aspects of their classes, from the presentation of materials and cognitive strategies for researching

information plus instructions for the methods of work, thus severely limiting student explorations. An exception to this could be Maria's new strategy described previously where the students looked for their own information.

Maria consistently used triadic dialogue techniques, commonly known as IRF strategies: teacher Initiation, student Response, teacher Feedback. The use of IRF is one of the most commonly found strategies in science teaching, one that favours the power of the teacher as s/he is in close control the whole time (Lemke, 1997). Maria used them extensively and effectively to build on the students' previous knowledge and experiences, and much more frequently than Hector. Her questioning techniques were fairly uniform and successful in promoting considerable student participation, albeit in a very controlled fashion, always maintaining her role of expert. Most of the questions she used were closed, asking for specific content, such as definitions of osmosis or diffusion, although a few were more open and of a higher cognitive level, comparing processes such as "How are passive and active transport different?" ("¿En qué son diferentes el transporte pasivo y el transporte activo?" P1: 11).

She also used IRF strategies for explicit summaries, such as when discussing with the students the movement of molecules in passive transport, and on a variety of occasions for a skilful relating of concepts, such as during the discussion on diffusion, relating it to energy:

M: Why [would there be faster diffusion in hot water]?	M: ¿Por qué [habría una difusión más rápida en agua caliente]?
A: because of the energy.	A: Por la energía.
M: because of the energy, but what does energy have to do with it? What is water made of?	M: Por la energía, pero ¿qué tiene que ver la energía? ¿De qué está hecha el agua?
A: of molecules.	A: De moléculas.
M: of molecules, right?, of what?, of H_2O, right?, and what happens if you boil water?	M: de moléculas ¿verdad? ¿de qué? de H_2O ¿verdad? y ¿qué pasa si ustedes hierven el agua?
As: it evaporates.	As: Se evapora.
M: Why does it evaporate? (P1: 64)	M: ¿Por qué se evapora?

She had just spent a large part of the class explaining the mechanisms of diffusion, using various examples of the diffusion of oxygen and carbon dioxide in water. This portion was at the end of the class after the demonstration on diffusion described above. Her line of questioning was coherent with her beliefs that the teaching of science requires interrelating concepts, in this case, physical-chemical issues that affect biological mechanisms.

The following example occurred during the laboratory exercise on nutrients in food where she was trying to get the students to hypothesize on the nutrient contents of an orange, in order for them learn to support their answers. Maria had been working on the groups of nutrients, and had taken advantage of several discussions with the students in the laboratory to review their supposed knowledge of the chemical properties of different nutrients, such as carbohydrates:

M: Let's see. What does an orange have?

A: Carbohydrates.

M: Carbohydrates. Why carbohydrates? How do you know it has carbohydrates?

A: Because it gives energy.

M: Because it gives energy. And what else? (P6:8)

M: A ver. ¿Qué contiene la naranja?

A: Carbohidratos.

M: Carbohidratos. ¿Por qué carbohidratos? ¿Cómo saben que tiene carbohidratos?

A: Por que da energía.

M: Por que da energía. ¿Por qué más?

In this case, she also explored the student's knowledge and reasoning orally. This example was coherent with her concept of learning, that it is of no use to give the students all the answers that they have to "construct" their knowledge.

Occasionally she called on past experiences: "But, imagine, right?, by its appearance, its flavour that you've tasted" (" Pero, ustedes imagínese, ¿verdad?, por su aspecto, por su sabor ya lo han probado." P6: 3). She recalled common knowledge with phrases such as "remember that...". She was well aware that it was necessary to reaffirm their past knowledge, as she mentioned in the interview after the laboratory session on nutrition:

Yes, that is, I notice problems regarding their understanding of the chemical composition of nutrients, as if they forgot them, right? So it's necessary to reaffirm them each time. (P7: 26).

Sí, o sea, sí se notan deficiencias en cuanto a de entender lo de la composición química de los nutrientes, como que se les olvida ¿verdad? Entonces hay que estar reafirmándoles cada vez.

In many cases, the data analysis highlighted the basic rules of classroom discourse as implicit, with the students looking for the "rules" instead of exploring different facets of the knowledge under discussion (Edwards and Mercer, 1987). Maria always maintained a firm control over discussions through the extensive use of the question sessions. These could often be considered as a "guessing game" with the students concentrating on trying to do and say what is expected, to discover the "right" answers by trial and error, essentially a ritualistic process rather than discussion of the concepts. The students had learned her basic rules, such

as if there was a silent pause or a repeated question as in the following example, the answer was incorrect so they would then try again. The following example occurred during the laboratory class on nutrients:

M: Does water have calories?	M: ¿El agua tiene energía?
A: No.	A: No.
M: Does it provide calories?	M: ¿...nos proporciona calorías?
A: Yes, no?	A: Sí ¿no?
M: Yes?	M: ¿Sí?
A: No.	M: No.
M: No. (P6: 16)	M: No

The student answered the initial question correctly by saying "no". However, to confirm his comprehension, Maria repeated the question in slightly different terms, which caused the student to uncertainly change his answer to yes. She then queried that answer by yet another questioning "yes?" With this he seemed to get the message that the correct answer was no, which teacher then repeated in confirmation. Through the IRF technique of discourse control she was judging the validity of the student's knowledge, although she did not ask for a clarification of the student's concept of calories. This also demonstrated Maria's belief that she must "lead" the student to the answer through questioning instead of directly telling them, consistent with her idea that it was wrong to give the answers as the students just forget what was told to them.

An interesting exchange continued with a second student who insisted that water did give her energy. She replied that water has calories because if she is thirsty she drinks it, that it is a "hydrate" of water. Maria didn't understand and asked her to clarify, but the student insisted that if she is dehydrated, water gives her energy. She even correctly answered Maria's question that the hydrates she was talking about were "carbon hydrates," or "carbohydrates," but Maria went on to ask about the chemical composition of carbohydrates. She then attempted to get the same student to realize that if water doesn't have carbon, it can't have carbohydrates, but at that point the class was over and the discussion was left there. This is a clear example of the different semantic relationship that the student had built of "carbohydrate – energy – hydration - water" and her problem of communication with the teacher who has her own "scientific" one (Lemke, 1997). It is also the most evident expression of a student's erroneous preconception but one that was not corrected.

The students were given no role to negotiate the meaning of their activities in the laboratory, but they accepted the standard rules, to carry out some measurements, make some

observations, fill out the lab report. Only a few in each group actually did the work, the rest generally spending the period socializing with their friends. At best, they were able to negotiate minor procedural and social details within their groups. On the basis of the laboratory observations carried out over these years, there was little indication of collaborative work of sharing and developing knowledge other than the technical competences of those few students who actually did the work. Even when microscopes were used on one occasion (one for up to 8 or 10 students,) there was little organization or coordination for its use, with a few students apparently dominating in each group, implying that it was a somewhat futile exercise in terms of all students gaining better understanding or the production of common knowledge of cell structure, the implicit objective of the laboratory practical (P13).

Photograph 3: laboratory work in the Prepa A

Maria made a definite effort to link ideas and concepts during her classes, as can also be seen in her reply when asked how she decided to move from one topic to another:

… when there is some relation, such as if I'm talking about the membrane, I can include concepts of nutrition. (P4: 46).	…cuando hay alguna relación, por ejemplo si yo les voy a hablar de la membrana, yo me puedo meter con los conceptos de la nutrición

Her answer highlighted the importance that Maria put on relating different biological topics instead of simply teaching the structure of the cell membrane. This was consistent with

her more contextualised views on the nature of science as well as with her constructivist beliefs of science teaching that the students should develop interrelated concepts.

One specific example of her interactions with a small group of students in a class showed her use of these skills. In this class the students were reading photocopies, answering questions she had given them about the structure and functions of the cell membrane. She circulated around the room helping different students, and stopped by a group of boys at the back of the room who had not been working well, who had been chatting a lot, so she stopped by them to answer a question and then remained to ask others, to promote their participation (on the following page):

M: (continues talking, gesturing with both hands) From the outside towards the inside, how did you all understand membranes are like? Where is the membrane?
Ao: Inside
M: (Making a circle with the index finger of the right hand, answers) Outside, outside. How?
Ao: There's the cell, around it.
M: Around it, right? Then you can write that there, no? There is a membrane around the cell
Ao: Yes, for example, there is the cell and the part around it...
M: It depends... depends on the membrane. Not all the cell is membrane and this is found... (She gestures with the index finger of the right hand in the form of a circle)
Ao: Around the cell.
M: Around the cell, it's wrapped around it, right?
Ao: Like the ozone layer, no?
M: (She wipes perspiration from her nose) The ozone layer is the structure that... what? (Again she gestures with her right hand) that covers, right? What else?
Ao: It protects the earth.
M: That protects the earth, the same as the membrane for the cell, in a cell it....what?
Ao: (The student rests his pen on his head and answers) that protects the cell.
M: that covers and protects the cell, right? And what does it protect it from? This is where the mechanisms of transport come in, right? And medicines, how do they come in?
Ao: through the mouth.
M: (she gestures to her mouth) through the mouth, right? And then?
Ao: (the student says something that can't be heard, but apparently it is incorrect)
M: that's why, but from there, where do they go?
Ao: to the blood.
M: to the blood (gestures) and then from the blood?
Ao: to the cells.
M: to the cells, and to get to the cells, where do they have to pass?
Ao: through the membrane.
M: through the membrane, right? (P14:18)

M: (Continuá hablando haciendo ademanes con ambas manos) De afuera hacia adentro ¿cómo entenderían que hay membranas? ¿Dónde está la membrana?
Ao: Adentro.
M: (Haciendo un círculo con el índice de la mano derecha contesta) Afuera, afuera ¿cómo?
Ao: Está la célula, alrededor.
M: Alrededor ¿verdad? entonces tú ahí puedes escribir ¿verdad? Hay membrana alrededor de la célula.
Ao: Si, por ejemplo, está la célula y lo de alrededor...
M: Depende...depende de la membrana. No toda la célula es membrana y esta se encuentra .... (Hace un ademan con el dedo índice de la mano derecha en forma de círculo)
Ao: Alrededor de la célula.
M: Alrededor de la célula, está envolviendo ¿verdad?
Ao: Es como la capa de ozono, ¿no?
M: (La maestra se limpia el sudor de la nariz con la mano) La capa de ozono es una estructura que ¿qué? (Nuevamente hace el ademán con la mano derecha) que cubre ¿verdad?, ¿qué más?
Ao: Protege a la tierra.
M: Que protege a la tierra, lo que hace en la célula, la membrana, en una célula que ¿qué?
Ao: (El alumno recarga la pluma sobre su sien y contesta) Que protege a la célula.
M: Que cubre y que protege a la célula, ¿verdad? Y ¿de qué la defiende?... Ahí entra lo de los mecanismos de transportes ¿verdad? y en los medicamentos, ¿por dónde entran los medicamentos?
Ao: Por la boca.
M: (Hace un ademán, señalando la boca) Por la boca ¿verdad? y ¿luego?
Ao: (El alumno responde pero no se distingue bien lo que dice, al parecer es algo incorrecto)
M: Por eso, pero de ahí ¿hacia dónde se van?
Ao: Hacia la sangre.
M: Hacia la sangre (hace ademanes) y ¿luego de la sangre?
Ao: Hacia las células.
M: Hacia las células, y para llegar a las células, ¿por dónde tiene que pasar?
Ao: Por la membrana.
M: Por la membrana, ¿verdad? (P14:18)

In this excerpt, Maria started out to establish the level of common knowledge about aspects of the cell membranes with the particular group of boys. When the first student gave the wrong answer, she corrected it without comment, but repeated the answer for emphasis. She validated his second answer, a repetition of hers, and told him he could write it down. She uses a symbolic representation of the membrane around the cell with her hand, a method to focus student attention and to emphasise the concept. When a student unexpectedly used the analogy of the ozone layer, she built on this image, asking him to explain its role. Through this, she explored and legitimised his knowledge as well as supporting and encouraging his elaboration of it, sharing it with his peers. She directed his thoughts by getting him to elaborate further, to link his example to that of the cell membrane. She then used a global strategy, relating the previous concept to that of transport mechanisms and to the entry of medicines. Even though the direction of the discussion was momentarily diverted when one student answered that they came in through the mouth, she persisted in following through, encouraging and guiding him to continue with his line of thought until she brought him back to that of the cell membrane. She exerted control over the interactions by means of IRF strategies, giving some tips in the form of partial statements, but overall she attempted to have the students consolidate their knowledge, stimulating modes of belonging within the group.

Maria was concerned that her students should learn concepts, to understand them well. In the following example, she had been discussing passive transport of water into a cell and how a balance was reached with the external environment. Here she emphasized the difference between *results* and *mechanisms*, a rather subtle concept for the students. She used contextualisation cues (Bleicher, 1998) by changing the pitch of her voice as well as through the repetition of phrases and a paused, strong stress on the key words (marked in black), a technique she used frequently:

.... It would be an internal medium, an internal equilibrium. Note that this is the **result** of passive transport, but they're not, but they're not **mechanisms** of passive transport, but **results** of passive transport. It has to be, it has to be diffusion.(P1: 47)	...sería un medio interno, sería un equilibrio interno. Fíjense como esto es un **resultado** de transporte pasivo, pero estos no son, pero estos no son **mecanismos** de transporte pasivo, son **resultados** del transporte pasivo. Tiene que ser, tiene que ser difusión.

Much of her teaching could be considered ritualistic in the sense of focusing on definitions and basic vocabulary, coherent with her goal to teach the official study plan as well with the traditional style of teaching biology. Many of the questions that she dictated

to the students were essentially definitions, such as: "What is the chemical composition of nucleic acids?", and "Give the name of two monosaccharides" (P1), although she also used comparative questions on occasion, as in the same class she asked the students to distinguish between the chemical structures of RNA and DNA. This undoubtedly reflected the strong influence of the institutional context but the above examples demonstrated that she also incorporated an attempt to teach a deeper comprehension of important concepts.

Hector used questioning for various purposes, as did Maria, to focus the attention of the class and to establish limits of common knowledge, and occasionally for review. In an interview at the beginning of the project he explained:

> We see the topic of photosynthesis and I try to question them, that is, to start the topic, what organelles carry out photosynthesis? As we already saw this topic, I start from there, questioning, and then I try to focus on the topic of photosynthesis, trying to simplify this topic. (P36:5, 22-26)
>
> Vemos el tema de fotosíntesis y trato de preguntarles, bueno, este, para comenzar el tema: ¿qué organelos realizan la fotosíntesis? Puesto que en este caso que en este semestre ya lo vimos y de ahí comienzo, a partir preguntando y ya después trato de irme enfocando al tema de fotosíntesis ¿sí? tratando de ser lo más sencillo ese tema en forma específica.

Often the questions were rhetorical, simply part of his discourse style of frequent monologues of explanation. There were few examples of comparative questions, one exception being that of asking the students to compare the structures and functions of the mitochondria and chloroplasts (P28: 50-113), an exercise to promote reflection on the material covered in the previous class. The questioning was very controlled; he himself was the source of expert knowledge, as well as a text he often consulted during class (one he used in a chemistry class which was from 1981). He used IRF strategies much less than Maria, and often rather formally for clarification purposes although occasionally to verify comprehension of a given topic or procedure as well as to build on student knowledge, such as when discussing the chloroplast:

H: What does the stroma contain?

Aos: enzymes

H: Enzymes that participate in the process of photosynthesis, right? Now this (points towards the blackboard) this would be inside the structure of, of the chloroplasts. What function does the chloroplast have?

Ao: carry out photosynthesis.

H: Ok, to carry out photosynthesis (point to the blackboard where he had drawn a sketch of a chloroplast), right? Then, in a few words, what is photosynthesis?

Ao: transform energy, solar energy into...(not clear what else he said)

H: Ok, the chemical energy to form ATP and thus the cell can function. (P28:10,228-244)

H: ¿Qué contiene la estroma?

Aos: Enzimas

H: Enzimas que participan en el proceso de fotosíntesis ¿sí? Ahora esto (señala hacía el pizarrón) sería dentro de su estructura de, de cloroplastos, ¿qué función tiene el cloroplasto?

Ao: realizar la fotosíntesis.

H: O.K. realizar la fotosíntesis (señala en el pizarrón un dibujo de un cloroplasto) ¿no? Así, en pocas palabras, ¿qué es la fotosíntesis?

Ao: transforma energía, la energía solar en.... (no se distingue lo que dice)

H: O.K. la energía química para formar ATP y de esa manera puede funcionar la célula...

Hector's questions were largely focused on basic biological terminology and, from the observations, limited on most occasions to only a very small part of the class, with the majority of the students distracted or marginalized, more so than in Maria's classes. In an interview in November, 2002 Hector accepted this lack of interest and poor participation as normal and beyond his capacities to change:

> Yes, two or three [participate], usually two or three, a few pay attention to me and are going to get the idea but the majority don't participate, with some completely passive, so to speak, and that I've never been able to change in any group. (P29:9, 230-23)

> Sí, dos o tres [participan] igual, normalmente dos o tres, algunos son los que me ponen atención y van captando la idea, y, pero la mayoría no participa, hay unos pasivos totalmente ¿no? en ese sentido, y eso nunca lo he podido quitar ni en un grupo ni en los otros.

In spite of this apparent acceptance, he had said in an earlier interview the same year that he actually had stimulated greater participation from students who had paid little attention before by giving them photocopies to read and discuss instead of just teacher talk and dictations:

Some of the people that were very chatty, that talked a lot during class, well now with this, they participate more....Maybe before they weren't interested in anything of what I said...and now with the simple act of having notes from which to talk, well, they participate.(P31:15. 142-147)	Algunas de la personas que eran muy habladoras, que platicaban mucho en clase, pues ya con esto ya participan más en ese sentido....A lo mejor antes no les llamaba la atención nada de lo que les decía... y ahora sí con el simple hecho de tener un apunte con que hablar, pues, participan.

However, at the start of the project in 2000, one chemistry class was observed that consisted of practice in the determination of the electronic configuration of specific elements with very enthusiastic participation of the students and considerable interaction amongst the students themselves and with the teacher, a clear sharing of knowledge and practices, correcting the work amongst all, although Hector gave the final validation of the answers:

H: (teacher watches a student who is working out an exercise on the blackboard and says) Sorry, it's reversed, no? it's reversed. This five should be after the 5p, it would be 2, 12...	H: (El maestro observa el ejercicio de la alumna que pasó a realizarlo en el pizarrón y dice) Perdón, está al revés ¿no? está al revés, este 5 sería después del 5 p, serían 2, 12...
Aa: (finishes the exercise)	Aa: (termina de elaborar el ejercicio)
Aos: (shouting answers)	Aos: (gritando respuestas)
H: O.K., then it only has to be corrected, please.	H: O.K. entonces nada más hay que corregirlo, por favor.
Aa: Teacher, in silver, wouldn't it be 6 instead of 5d?	Aa: Profe, en la plata ¿no sería en lugar de 5d, 6?
Aa: (discusses with the other students)	Aa: (discute con los otros alumnos)
Ao: (meanwhile a student goes up to correct the last exercise)	Ao: (en tanto un alumno pasa a rectificar el último ejercicio)
H: O.K., then that's correct like that, please...(P27:5, 127-145)	H: O.K. entonces así quedaría correcto, por favor.....

The contradiction between his statements and the observations regarding participation could have revealed in part a lack of critical reflection on his practice, undoubtedly affected by the factor of his many hours of teaching with numerous groups each semester, not to mention his second job as a dentist every afternoon. At one point he explained the problem of participation and motivation of the students as possibly being a result of rushing between his numerous groups and not having time to get to know the students on a more social level (P36: 22). Regardless of the reason, he appeared to be convinced of having improved participation. The first statement of not being able to get students' to participate may have been compared unconsciously with his earlier years of teaching, as there has been little or no change during these three years of observations until the end. As described by Wenger (1998, pp.88-89),

memory involves a renegotiation of meaning of reified forms in our memory due to changes in participation itself or in one's perspectives. Thus, it may have been that Hector had truly forgotten these past examples and simply called on his renegotiated, reified version of student participation, an acceptable account that aligned with and validated his current practices and explanations of them.

As described earlier, neither teacher discussed their educational goals nor objectives explicitly with their classes, nor did they incorporate more than an infrequent touch of the students' experiences and interests, again limiting the intersubjective character of the instructional discourse although they did attempt on occasion to bring in real-life examples, an attempt to border-cross into the broader community of practice. Hector, for example, used applications of topics being studied, relating them to daily life such as when he explained that mitosis replaced the dead cells of the epidermis that are rubbed off when a person bathes (P26:17, 278-282). In one class on metabolism, Maria saw that a student had cut his finger and used that to relate the topic to what happens when a wound is healing and then to the healing of a cut limb of a tree (P3), a very opportunistic linking of concepts to student experiences.

There were numerous examples, as well as the ones already given here, where Maria was promoting engagement at the social level, attempting to develop an appropriate climate, from calling their attention by saying she'd be asking questions, to letting them work in groups which she said they enjoyed. She said she also motivated them by giving them different activities as well as by offering help to those who needed it. She dedicated a great deal of time and energy to engage the students socially in activities, and would seem to have developed a somewhat greater positive interdependence along with more group cohesion and production in her classes than Hector.

Hector attempted to create an appropriate social environment by joking with the students occasionally, such as during a chemistry lab where students had to weigh out chemicals:

You wouldn't be a good employee in a *tortilleria*, you would sell a real kilo, no? A good employee takes off 100 grams and sells 900, no? (P37:4,57-58)	Tu no serías una buena empleada en una tortillería, venderías de en balde un kilo ¿no? Una buena empleada quita cien gramos y vende los novecientos ¿no?

Here he was very indirectly praising a student for his accurate weighing of the necessary chemicals. He was also observed to chat with students at the start of most of his classes, evidently enjoying a few moments of informal socialisation with them.

He also encouraged their participation by giving them photocopies to work on as already discussed above. He tried to motivate them by taking into account all their homework during

the semester and giving them credit for it in their semestral grade (P29:19). He asked them to clarify their doubts although there was little reaction observed from the students, usually replying that they had no doubts or just asking procedural questions (P26:2). However, in one chemistry (P44) class one student actually suggested that light is an organic substance, one of the rare student interactions clearly showing a serious misconception, but it was not corrected. This example puts in doubt his reasons for wanting greater interaction and participation. He said that he only occasionally directed questions to those who participated less (P36:19), a very nominal effort to interact with the more marginalized students, a statement that contradicted others previously described. He sometimes gave projects as group work, but there was little collaborative production, according to Hector, as only a few actually did the work (P36:14). He was certainly optimistic that with his new teaching method using his brother's notes the students would remain motivated to participate and actually learn more, although at the time of the observation he had no concrete evidence of this, which he said would be better grades on the semestral exams (P40:16).

There was little evidence of student collaborative work involving the critical aspect of positive interdependence for the elaboration of relationships amongst the students, as the interactions were essentially between each teacher and the individual students. The best example found in this study of what could be classified as an collaborative experience was one that Maria described when she had the students formulate questions together in a group as a review of a topic (P7:16). Her objective was to have them study the topic well in preparation for a formal exam by setting up groups, each given instructions to develop together ten questions related to the topic. After completing the questions, they interchanged them with another group, having to answer the questions of the other one. When they finished, they returned the questions to the original group with their answers and then corrected the answers to their own questions. She said both she and the students were very pleased with the activity and the outcome and that it developed responsibility within the groups. In spite of this being a direct adaptation of a collaborative exercise designed for its use in TACTICS in 2001, she was not certain if it classified as "collaborative work", an interesting case of transference of a strategy from TACTICS to the classroom without conscious intent.

Analysis of her description of this activity showed it to involve a shared common approach and participation amongst the students, to promote in a very explicit fashion the shared responsibility for the students' own and others' learning, although there was no

explicitly stated objective, and even if she had previously designed the activity and the framework of the exercise. It entailed co-construction of work in the formulation of the questions, with the planning and responsibility being given to the students. From her description of this activity, there was a developing sense of compromise and mutual engagement on the part of the students on the academic front, an initial start towards positive interdependence, and even enjoyment, an additional factor that Wenger (2002) also mentioned when describing a community of practice. Moreover, this activity gave the students the possibility of oral communication *between* peers, something not observed in other class activities, permitting them to practice their new scientific language (Lemke, 1997; Wells, 2000). It was also one of the few examples where the students presumably would have practice writing with scientific language, at least at a more creative level than simply copying answers out of a text as they usually did to answer questions. There would have been negotiation of meanings in the student development of the exam questions and their answers, and in the correction of the other group's answers, even though there was no direct evidence of this. In addition, Maria commented on the positive aspect of group work in terms of peer pressure among the students: all must work as they received only one grade per group (P7:48); this fostered greater participation and shared responsibility. She said in a more recent interview (Feb., 2004) that she had repeated the exercise various times with different groups but with very variable results, something she was at a loss to explain.

One interesting observation in one of Hector's classes showed the intention of carrying out collaborative work; the class was on the processes and functions of living organisms (P45). He had planned to have the students read their photocopies on plant and animal respiration and then to collaboratively elaborate a joint synthesis in groups of 4, followed by a general discussion of all the syntheses. However, the students took too long to read the material, so he had to adapt his plans; he had them read out their key ideas and he wrote them on the board where he had written the title "animals--- respiration---plants". In the following portion of the class, Hector asked the students about respiration as a general process and then introduced the role of organs:

M: An exchange of gases between the circulatory system and the outside. What else? Then, do these occur (writes on the board) in stages, steps, phases or what?
Ao: Processes
M: Processes. What kind?
Aos: (The students answer but it is inaudible on the tape.)
M: (He writes on the board.) 1°. is the passage from air or water. Through what? Excuse me?
Aos: (The studnts answer) The outer surface.
M: What?
Aos: The outer surface
M: Outer surface (He smilingly makes a comment that is not heard on the tape.) Ok. What else? 2°. Passage of oxygen, to circulating fluids and through the organism, ok. What else? It would be the third step, let's see (points to a student).

Ao; Cellular function and carbon dioxide.
M: (writes on the board) Cellular function.
Ao: And carbon dioxide
M. (continues writing on the board) and CO_2. (He looks at the students)
Aos: Production.
M: It's production, ah, sorry (he erases function and writes production and puts it as 4°) and the third (writes on the board: cellular production of carbon dioxide and points to the board). 3° use of oxygen in the cell. What kind of respiration would it be, aerobic or anaerobic?
Ao: Aerobic
M: Aerobic, right, as it's in the presence of oxygen. The other would probably be pulmonary respiration, we'll see that. Fine, ok. Up to here we can say that this is the introduction or the idea of what is respiration. Another point that is touched on here is respiration and the environment, in that sense. What can we say about that? (P45)

M: Un intercambio de gases entre el aparato circulatorio y el externo, ¿qué más?, entonces ¿esto se lleva a cabo (escribe en el pizarrón) en etapas, o pasos o fases o qué?
Ao: Procesos
M: Procesos, ¿de qué tipo?
Aos: (Los alumnos responden, pero no se les entiende en la grabación)
M: (El maestro escribe en el pizarrón) 1°. Es el paso del aire o agua, ¿a través de qué? ¿perdón?
Aos: (Los alumnos contestan) La superficie externa
M: ¿La qué?
Aos: Superficie externa
M: Superficie externa, (hace un comentario que no se alcanza a distinguir con una sonrisa en la cara) O.K. ¿qué más? 2°. Paso de oxígeno, a líquidos circulantes y por el organismo, O.K. ¿qué más? sería un tercer paso, a ver (señala a un alumno)
Ao: (Contesta al maestro) Función celular y bióxido de carbono
M: (Escribe en el pizarrón) Función celular
Ao: Y bióxido de carbono
M: (Continúa escribiendo en el pizarrón) y CO_2 (Ve a los alumnos)
Aos: Producción
M: Es producción, ¡ah! perdón (borra función y escribe producción y lo pone como 4ª.) y la tercera (escribe en el pizarrón: producción celular y CO_2;señala en el pizarrón) 3ª. Utilización de O_2 en la célula, que sería como la respiración aerobia o anaerobia?
Ao: Aerobia
M: (Señala en el pizarrón) Aerobia, ¿no? que es en presencia del oxígeno, ¿no? La otra sería probablemente respiración pulmonar, lo vamos a ver. Bueno, O.K. Hasta ahí podemos decir lo que esa es la introducción o la idea de lo que es respiración, este, otro de los puntos que toca ahí es respiración y medio ambiente ¿no? en ese sentido, ¿qué podemos hablar de eso?

In this excerpt, Hector stimulated the engagement of the students through questioning, inviting them to participate. He wrote their answers to his questions on the board as steps of gas interchange, building on the students' very brief replies, validating their participation but

also supplementing them slightly. He tried to lead them, controlling the direction or the alignment of energies with essentially IRF strategies, building a knowledge base, sharing the process to a certain extent but without discussion or negotiation. Together, with the participation of various students, he encouraged the elaboration of their knowledge, legitimising their interaction. The essential competence being validated was the students' ability to identify key concepts in the text but he also linked the topic with the cellular process of respiration which the students had studied the previous semester. His sudden mention at the end of the excerpt of the topic of pulmonary respiration was given no further explanation, but he went on to the topic of respiration and the environment. The semantic relationship of the types of respiration that he intended to point out may have suffered because of his jump in topics. This activity could be considered an initial step towards collaborative production, a legitimisation and reification together of the content, although there is no negotiation of the meanings themselves throughout the interaction nor questioning of the students' comprehension of the finished product. In the interview following this class (P40), Hector credited this method to what he had experienced in the MEC although it also had striking similarities to a portion of collaborative student work in TACTICS.

The example given above was the best one found of marginally collaborative work in Hector's classes, but as he had previously defined collaborative work, he barely distinguished between collaborative and traditional group work: "It's to do something with a group of persons for their mutual benefit." ("Es hacer algo con un grupo de personas para beneficiarse mutuamente". P36.7 46-47). There was little sign of positive interdependence observed amongst his students with the possible exception of the chemistry class solving electronic configuration problems, or the observation made in the fall of 2003 (P42) where he summarized notes together with his students. In the latter case, he explained that he had shared with his students his own need to make a synthesis of information in order to remember it, an example of authentic participation on his part. He considered the activity motivating for the students, that it presumably helped them gain reading and summarizing strategies (P40:7).

Hector believed his students to be conscious of what the expectations for them were even though the broader goals of the exercise were left unspoken. In the chemistry class described earlier, there was also a sharing of the accepted, common approach and a development of tools to describe electronic configuration. In that class Hector actually acknowledged his own

difficulties in explaining it, sharing and identifying with the students' problems, as well as inviting the students to check his own work that there were no mistakes (P27:9). Through this action he again became more of an authentic participant in the community, leaving aside his expert role, an example of both teacher and students learning together.

Maria supported and encouraged the elaboration of knowledge to varying degrees, but, as already discussed, she controlled it closely, only in 2003-2004 beginning to share this more with the students. Her strategies were still very in line with her concept of student learning, that students "learn best when they read, understand and one explains their doubts" ("aprenden mejor cuando ellos leen, entienden y uno les explica sus dudas." P4: 24), that a student has to be:

> in contact with the study material, that he is doing the work, elaborating the questions... and I only, nothing more, give them ideas, right?... and when I see they're too simple I help them complete them. (P7: 56)
>
> él mismo está poniéndose en contacto con el material de estudio, él es el que hace las cosas, él es el que elabora sus preguntas,...y yo simplemente, ya nada más les voy dando ideas, ¿verdad?.....cuando veo que están muy simples yo les ayudo a complementarlas.

In spite of the fact that Maria's described role here was more as a facilitator compared with other moments, there was little or no observed group negotiation over the years, and the validation of ideas and solutions was mainly of her knowledge or the text's, not the students', emphasizing her traditional position as the source of expert knowledge. As already described, her strategies of making notes with the students and having them check each others' answers did occasionally go beyond this position as it did validate the students' knowledge to a certain degree, thus partially sharing the negotiation and reification of common knowledge. Also in line with this slightly more constructivist position was her expressed concept of knowledge, as the ability to apply it to other situations, to relate ideas.

There was little indication of enrichment through multiple contributions of the students as both Maria and Hector followed the study plan very closely, focusing on the vocabulary, controlling all interactions. The validated, expert knowledge was theirs or that found in their books, a "static" reification, although they did at times accept and elaborate on students' answers, a more interactive reification as discussed above. Hector's role as the expert was even vocalized by one of his students in the chemistry class mentioned above when the students were arguing about the answer and a student said: "He's the teacher!" ("¡Él es el

maestro!" P27: 187), clearly indicating that Hector's argument was to be considered the only legitimate one and that there was normally little negotiation of meanings.

As in the case of Maria, Hector had developed a shared repertoire of discourse and artefacts. The students had learned to work with him and, most recently, had accepted his new teaching strategy. In one biology class he informed the students that they had to make presentations of topics of biochemistry (P26: 15), but this was more likely to be a formality as the students generally paid little attention to what their peers presented as they accepted the teacher and the books as the only legitimised knowledge, so that the degree of sharing teaching was minimal as was the negotiation of meaning (observations of 2000). Hector did use some global learning practices where he tried to relate topics to daily experiences. In one case he used the analogy of the energy requirements of a car with those of a cell (P28:7), or the streets of a city with the endoplasmic reticulum of a cell (P26:7). In another he related the study of animal tissues to stem cells that could be used to produce skin for burn victims (P31:13). With his new teaching strategy he hoped to invoke a love of learning and reading in his students, competences that later could serve them well in their careers (P40:23).

In terms of the use of scientific language, Maria commanded a clearer, more comprehensible use of the scientific vocabulary in her explanations and an apparently greater mastery of content than Hector as she rarely referred to notes or texts. There were several of Hector's classes where errors in content knowledge were noted, such as in his explanation of the roles of some cell organelles (P26). Maria attempted to guide her students to the correct answers through the use of suggestions, tips or partly finished phrases, such as in one class when Maria was trying to get the students to give her another characteristic of passive transport and was getting no responses, so said:

Exchange of....? (pause)... of....? (pause).... Someone over there said it..... The substances go from a place of...? (pause)... where there is...? (P1:35)	¿Intercambio de....? (pausa) ya lo dijeron por allí... ¿Las sustancias van de un lugar de.....? (pausa).. ¿donde hay...? ¿qué?

Hector, on the other hand, relied more on direct explanations. However, his constant use of linguistic "crutches" " such as: "en ese sentido", "en cierta forma", "en ese caso", "en un momento dado" made it very problematical to follow his explanations. For example, in an interview after a class observation he explained that the increase in student participation was likely due to his new teaching methods, which he described more like a guide for his students. When asked if that was the most probable reason, he replied:

Well, in a way yes, not 100% but, yes, you could say it's true in a given moment, that fact of having the record of how I used to give my class... and, um, now with certain modifications that we have been making little by little, even if used like tests, not precisely carrying them out always nor every day, specifically, in that sense, but yes I think that it has worked (P31:51).

Pues, en cierta forma sí, no al 100% pero sí, podría ser cierto en un momento dado, esa situación de que ya teniendo el antecedente de cómo daba mi clase y, este, ahora con ciertas modificaciones que hemos estado haciendo poco a poco, aunque sea como pruebas, no precisamente llevarlo a cabo siempre ni todos los días, específica, en ese sentido, pero sí siento que ha funcionado.

This answer was essentially a very long, complicated manner of saying yes, but it left the listener with a great feeling of uncertainty as to his true conviction. His form of communication was very often unclear, at times to the point of speaking for a long time using many words but without communicating any message (what in Mexico is colloquially called *cantinfleando*), such as when discussing evaluation of student work:

...the opportunities are earned by each [student], those who don't want to hand in the work, it won't affect them, nor benefit them, nor anything of the sort, but all the contrary. (P29:31, 615-617)

...las oportunidades se las gana cada quien, el que no quiera entregarme las cosas, ni le afecta, ni le beneficia, ni nada por el estilo, si no todo lo contrario..

The excessive use of many "crutches" was more apparent when he appeared most uncertain of his ground. This was mentioned in a questionnaire given to some of his students by another Master's (MEC) student in August of 2002, that his language was incomprehensible and that he didn't clarify doubts (Moreno, 2002). Along with his apparent difficulty in expressing himself initially, he often repeated the same questions without obtaining successful student response. These problems of expression made it unlikely to be an effective tool in his classes and as a consequence, as has been noted, his students gave more status and validation to reified, written knowledge rather than spoken.

Regarding collaborative work within the institution, Maria said from the outset of the project that she worked alone, never collaboratively with her colleagues. The only exception to this would be in the biology academy, which had the potential of stimulating collaborative work between the professors of a given subject, and of breaking the traditional isolation; apparently, however, this prospective benefit remains latent as it has only been used to date to formulate the semestral exams. On several occasions Hector stated that he used to carry out field trips with other teachers but that he no longer worked collaboratively with others, convinced that they wanted to work with others only for their own benefit and interests, with little sincerity (P36:9). He also said his students didn't work in a collaborative way either, as

when they did work in a group he didn't consider it collaborative as only a few did all the work (P40:4).

In TACTICS

Numerous informal observations were carried out of the two teachers with their students while working on the TACTICS project. The majority of these were made during the first two years when there were many technical problems and they had need of assistance, but there were also periodic observations during the other years. At the start of each year, some students required considerable guidance on how to open an email account, how to search for information on the Internet, even how to chat, but these skills were very quickly acquired. In all the observations carried out in both schools, when there were technical problems during the period of work, nearly always one of the other students was called upon for their expertise. The work amongst the students in each expert team and even between teams in the same school, as in the case of technical assistance, was thus collaborative, with active discussion of how to carry out different procedures, a sharing of competences. The students themselves explored and elaborated knowledge, even up to a certain degree evaluating the information before uploading their work.

Although only one formal observation was videotaped of each teacher with students during a TACTICS session, field notes were made of other sessions. Overall, the noted changes in both teachers over the four years were slightly more knowledgeable exchanges with the students about the stages and processes as well as in the use of the computers and Internet. As already explained, Hector was the more proficient and more confident of the two at the start, and at the end there was still the same relative difference between them, but both had become more comfortable with the project itself and the technologies, even though remaining quite peripheral in the daily operations.

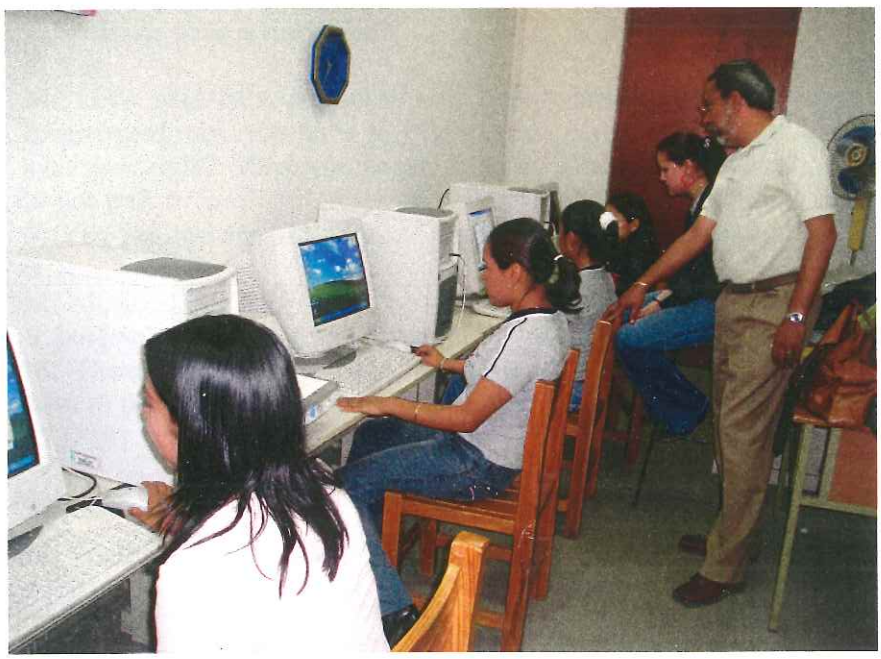
Typical interactions towards the end of a year's project included the students working quite competently at the computers, looking for information, taking photographs, uploading files onto their egroup, amongst other activities, with the teacher looking on, usually inquiring as to what stage they were at. In the following example, in April, 2002, Hector was with a group of students in the TACTICS' room:

M: ...and why did you download it?
A:.... to add something to...
M: ah, to add something to the information.
A: aha
M: okay
A:... (3 sec. noise)
M: Ah, then what you can do is select it and insert it into a file, no? In other words, some things that you consider important. If not, at least, um, leave it as it is, but you have to read it, no? especially as you can relate it to whatyou already looked for with this, no? (P46)

M: ....y ¿para que lo bajaron?
A:.....para agregar algo a.....
M:. ah, para agregarlo a la información.
A: ajá.
M: ok
A:.....(3 seg, ruido).
M: Ah, o sea, que lo puedes ir seleccionandolo e ir pegándolo en un archivo, ¿no? O sea, algunas cosas que ustedes consideran importantes. Si no, por lo menos, este, dejarlo como está, pero hay leerlo ¿no? sobretodo que ustedes lo pueden relacionar con lo que ustedes ya buscaron con este, ¿no? en ese sentido.

In this case, Hector was checking on what they were doing, partly to establish their degree of common knowledge, but also he himself learning from the students. However, he also reinforced the idea that they had to read and relate information, to decide whether they could use it or not, suggesting an important competence that the students supposedly were learning in their investigations. In the same observation, he asked another group how they had searched for information on cloning, and was told that they had used Google, getting them to express their competence in this field, sharing interest in their work. He was much more of an authentic participant here than in the classroom.

Photograph 5: Hector and students working on TACTICS project.



A similar example of a typical interchange of Maria with some students towards the beginning of a year's project, in October, 2002, was as follows:

M: Oh, very good, um, Daniel, come on and turn on a computer.
Ao: Why?
M: to check you diary.
Ao: my email.
M: yes, your email. What have you investigated in your topic?
Aa: well, we have something, only that the other day we didn't save it as they cut Internet. (P10)

M: ¡Ah! muy bien, este, Daniel, ándale, abre una máquina.
Ao: ¿Para qué?
M: Para que revises tu diario.
Ao: Mi correo.
M: Sí, tu correo. ¿Qué tal han investigado su tema?
Aa: Pues ya llevamos algo, nada más que ese día ya no lo guardamos porque nos cortaron el Internet.

This interchange was indicative of Maria's lack of knowledge regarding both the procedures and the technology, in spite of it being the third run of the project. It also pointed out the technical problems that they were still having with Internet, presumably due to one of the computer teachers cutting their connection, according to the students and Maria. In the same period of observation, Maria had a brief discussion with one of the girls on another team:

M: Sarahi, what have you investigated of your topic?
S: Well, I've already saved most it, except for the prenatal diagnosis.
M: Yes?
S: Yes.
M: Can we open your page and see how it is, what you have investigated?
S: Yes.
M. Let's see, let's see what you have investigated, um, you have to begin your synthesis, right? Have you begun to do it or not yet?
S: Yes, yes, we are just going to organize it.
M: Ah, good.
S: but [we're going to do it] now.
M: There are the dates, right, when you have to hand everything in. Have you read it? (P10)

M: Sarahi, ¿qué has investigado de tu tema?
S: Eh, bueno, la mayoría aparte del de diagnóstico prenatal ya lo tengo guardado.
M: ¿Ya?
S: Ajá.
M: ¿Podríamos abrir tu página para ver qué tal, qué es lo que has investigado?
S: Sí.
M: A ver, vamos a ver qué es lo que has investigado, este, tienen que empezar a hacer ya su síntesis, ¿verdad? ¿Ya la empezaron a hacer o todavía no?
S: Ya, no, apenas la vamos a ordenar.
M: ¡Ah! Bueno.
S: Pero ya.
M: Ahí están las fechas, ¿verdad? de cuando deben entregar todo. ¿Ya lo leyeron?

Maria was checking the procedural instructions that the students were to follow but was genuinely interested in seeing the girl's work and later expressed admiration for the images they had downloaded. In this passage she was again acting in a very supervisory category,

checking dates and progress, definitely not the expert here, but neither as much as an authentic participant as Hector.

Both teachers expressed concern for developing their students' cognitive skills as well as to learn to learn although, as already discussed, these goals were never made explicit to their students nor specific strategies developed in their classes. At the cognitive level of engagement, Maria considered TACTICS to be an experience that ought to develop cognitive skills, to investigate, analyse and apply information, but she did little to promote the transfer of these strategies and experiences from that community of practice to her classroom. Hector said that some of the former participants of TACTICS used the project's computers to do school work (P25:4), possibly a transference of specific skills gained during TACTICS and certainly an application of competences outside the regular class schedule. Maria and Hector both considered the use of the computers in TACTICS and the possibility of being in touch with other schools the key motivating factors for the students (P2:9; P34:17) although there was no use of these technologies in their classrooms, the primary barrier being lack of access.

Hector considered that the students in TACTICS worked in a collaborative fashion, interchanging ideas and sharing skills (P34:21, 370-374), but, as in the case of Maria, had not attempted border-crossing between the TACTICS and classroom communities. Neither teacher attempted to have the students involved in TACTICS share with the rest of their classmates their collaborative techniques based on the computer and Internet interactions. This is considered to have been a lost opportunity of border crossing between the two communities of practice in terms of students' new technical competences and scientific knowledge, a chance to legitimise their experiences in TACTICS and to enrich the class community. However, particularly in Maria's case, this could be related to her own marginal participation in TACTICS, which could put at risk her identity as a good teacher as she had developed little expertise regarding the technological aspects of TACTICS. In Hector's case, however, it would appear to more a lack of reflection and planning, as he evidently felt comfortable with his technical skills at the end of the four years and felt a certain reflected prestige from his participation in the project.

Evaluations of learning

Learning is the basic joint enterprise between a teacher and a group of students in a classroom; a consequence of this is the need for verification of the types of learning that occur. Studies have provided evidence that the institutionalised focus in Mexican secondary schools is

on evaluation as the privileged form of control of student learning rather than as feedback for teaching (Quiroz, 2000). It is focused on the giving of grades, seen as the accumulation of information from the study plan and texts, reified in exams designed to test only that. As Wenger suggseted (1998), when knowledge is codified in texts and curricula, evaluation becomes a series of closed circuit processes that reflect the structure of the reified curriculum where the students reproduce the reified knowledge without any ownership of meaning.

In this investigation, evaluation in class was observed to be carried out almost exclusively on an individual basis, through questioning, in spoken or written form, but as already discussed, principally through the institutionally relevant standardized semestral exam. This common practice reflected the dominant, traditional ideology in the schools that learning is an individual process (Lemke, 1997). Both teachers said they included participation, effort and homework in the final semestral evaluation (P5:14 and 37; P29:17 and 18), but as neither used any systematic record in the observed classes other than signing the homework, nor did they know each student by name (in one of Hector's classes there were 52 students) this would appear to an area very open to individual student negotiation with each teacher. Maria said that by just generally checking the students' work and by telling them that it would count for their final grade gave her good results as they all worked. Both teachers intuitively evaluated the level of learning by the students' responses to their questions as well as by the students' infrequent questions to them, but the teachers, the students and the institution all gave formal importance to individual exam results.

In the daily classroom practices, Maria encouraged a certain amount of critical reflection and provided feedback through her continual questioning and interaction with the students, largely with the *IRF* strategy. She focused on the content in order to improve comprehension, attempting to consolidate knowledge through the review and the linking of concepts, establishing a base of common knowledge. Hector involved his students to a lesser degree, although his recent innovation of jointly writing syntheses on the board had the potential of stimulating greater student reflection. Both teachers evaluated group reports of laboratory work in a rather ritualistic fashion with no attention to processes nor to any student self-evaluation of the individual contributions to the group product. Hector's innovation of requesting applications of what they had studied had the prospective of being an evaluation of cognitive, globally related products.

Another innovation in Hector's work in the fall of 2003 was the use of a diagnostic exam with his new groups of first year students, to see what they remembered from their secondary school biology, a strategy he attributed to the Master's program. He encouraged engagement and a certain amount of feedback and reflection through this activity:

> We went over the questions together and I told them where they were wrong, where they had confused things, um, some terms they definitely did not know (P40:28, 319-322).
>
> Vimos las preguntas entre todos y les, les mencioné en qué estaban mal, en qué estaban equivocados, en qué confundían las cosas, este, algunos términos definitivamente no, no los sabían.

Hector explained in an interview in November, 2002 (P29) that he had changed his manner of evaluating work over the past two years, that he now included participation and work during the term, not only the more formal exams as he had done in the past. However, he left himself open for negotiation with the students for the amount of credit given for different amounts of work, saying he gave preference to students who had shown themselves interested in the class (P29:32). He even permitted students to go from a failing grade on their exams to an A (10) on the basis of the number of homework assignments that they had completed, something that Maria said she couldn't do, saying she would raise a grade by only a small amount in similar circumstances.

The importance of the semestral exams and having students do well was clearly present in both their teaching agendas. For example, when asked about the main challenge with a group, Hector said "Well, that at least they get a better grade in the semestral exam." ("Bueno, que por lo menos en el examen colegiado puedan sacar una mejor calificación". P29:11, 248-252). Maria measured her success as a teacher by the low number of students who failed the semestral exam (P4:58). Yet again, the negotiation of identities for both teachers and students was evidently based on student results in the semestral exams. The social and institutional climate of both schools and the classrooms fully promoted this, creating conditions that encouraged traditional coverage of curricular material, which Hector complained of being far too extensive (P38:19).

Contexts

The classroom ecology or context is the result of the complex interactions of many distinctive factors and determines to a large degree what occurs in a classroom. Although the various contextual factors of this study have been identified indirectly, their mediating influence cannot be underestimated, such as the defining role of material or social aspects on

social interactions and on the social construction of knowledge. All of these factors, plus the characteristics of the teachers themselves, their beliefs, past experiences, their knowledge, and their identities interacting with those of the students make it an extremely broad and multifaceted area of analysis. This study is limited to only certain noteworthy aspects of the context within which these teachers work.

Class, school and institutional contexts

Both schools were very similar in terms of their respective possibilities and limitations when it came to material conditions. With regards to the physical classroom space and structures, all the rooms and laboratories had a raised platform at the front with a desk for the teacher, a time-honoured arrangement, one that symbolizes the traditional power and authority of the teacher (Shapiro, 1998). The rooms were filled with individual student chairs with a side arm, a style that could facilitate group work, although there had been little intentional use of this strategy during the observations. Most of the time the chairs were scattered around the rooms and the students sat wherever they wished, indicating a relaxed attitude to that specific behavioural aspect. In the laboratories the large, concrete tables created an obligatory environment for group work. However, due to a lack of equipment that necessitated a high degree of sharing, along with the type of organization of the work before mentioned, the observed laboratory exercises were essentially symbolic investigations, a fulfilment of institutional norms.

As described previously, the laboratory guide used by all the teachers was a manual of practicals published by the *Academia Interescolar de Biología* of the university. Both Maria and Hector's names appeared as members of the Academy. At the back of the manual was a list of the literature used, consisting of a biology book from 1973, one from 1976, and three from 1984 taken from lab books prepared for the high schools of the national university (UNAM). A list of recommended references was also given, including a genetics book from 1972 up to more modern ones by Curtis and Villée, both of 1998. The adoption of this manual with its outdated basis was undoubtedly one of the major factors in accounting for the lack of recent, more innovative, student-centred laboratory work in the high schools. The manual presumably reflected the official conceptualisation of biology teaching of this community of practice within the university. The design of the semestral exams, also done by the biology academy, emphasized it even further, to a much more significant degree.

The social and institutional climate of both schools and their respective classrooms promoted the negotiation of identities for both teachers and students based first and foremost on student results in the semestral exams (interviews with directors of Prepa B, 2003, and of Prepa A, 2004). All were valued in proportion to these results, within the school as well as in comparison to the other preparatory schools affiliated with the university system. Thus, as the semestral exams were developed exclusively with multiple-choice questions, principally at the lowest cognitive levels of definitions and recognition, a reification of the study plan, the emphasis continued on the teaching of the official study program with little or no deviation, along with the promotion of memorization of isolated, decontextualised facts.

This official classification of the "quality" of each teacher's work by their students' results on the semestral exams was a matter of great concern to both Maria and Hector, and was a fundamental part of their tacit teaching agenda. Both teachers worked essentially on an individual basis with little interaction with their colleagues in the same school, both trying to cover the curriculum every semester in the best way they saw fit. Within the classroom, Maria, in particular, attempted to promote student participation and more effective, comprehensive learning, trying to motivate students who had been ignored or labelled by others as poor students, but at the same time had to work within these institutional restrictions, worried about her own reputation as a teacher on the basis of her students' results in the semestral exams. It is important to note that even with the high level of teacher control observed over materials and activities, both teachers' efforts to make the students more active participants in their learning were in sharp contrast to the cultural niche in which they worked where there were many teachers who primarily dictated, sustaining the traditional "standard" culture of teaching with passive students (P31:10 and 34; interview with the director of the Prepa B, 2003).

Both schools had a predominant culture of the individual teacher's independence and control over what occurred in each classroom (*libertad de cátedra*), although this was beginning to change with the evaluation of each teacher by his students' grades, at least in terms of the products of their teaching. Hector described the general climate of his school as being one of individualism amongst both teachers and students (P36:49), with essentially no sense of collaboration amongst the staff (P25:9) but rather political struggles most of the time for class hours, for recognition, for positions of "power" (P31:29; 36:12; P36:39). The interview with the school director (2003) essentially confirmed this view. The only example Hector could give of collaboration was the manner in which he had worked with the other biology teachers for field trips (P36:11). In the case of the Prepa A, there appeared to be more of a concerted effort on the part of the director to promote responsibilities of the individual

teachers but also amongst the members of the school community (interview, 2004) although there was no evidence found that this was successful.

The analysis highlighted the observations of the ecology or classroom context of each teacher, that they were mediated in a remarkably similar fashion by the institutional norms of behaviour and responsibilities of students and teachers, making it normal for both to work under complicated situations, having to tolerate recurrent noise and movement both within the classroom itself and outside in the school patios, as well as high levels of absenteeism. In their regular classes it was evident that there was an implicit sharing of a casual acceptance of the institutional norms with respect to attendance and discipline, as students entered at different times, up to 15 minutes late, at times moving around and talking quite openly amongst themselves during class. A few students participated in the attempt to establish and maintain a good working environment within the class, trying to keep their peers quiet and respectful, particularly in Maria's classes.

Maria appeared to comply fairly closely with the school rules, such as taking attendance on a regular basis, more than Hector, although she seemed more open to negotiating the timing of work with the students. Hector often began his classes late and did not take role call in spite of the fact that it was a school rule, saying it took up too much time but also stating that he didn't like rules as they restricted the freedom and autonomy that he tried to give to his students (P36:16). A possible consequence of this was that in one class there were only 28 of 52 students present (P31). As attendance must be at least 80%, students were overheard to negotiate with each teacher, asking not to be marked late or absent. Hector also had his own rules that allowed students to enter late but only up to a certain point (P37: 295 and 380) and that he would accept work only on the pre-established dates (P29:20). Here it was evident that both teachers had negotiated their own application of rules with the students, finding a coping strategy to deal with the tensions created between their practices and the context of the institutional norms.

The students shared the implicit objective of taking notes from the whiteboard, viewing it as the "legitimate" knowledge that they needed for their exams. They also accepted the teachers' manner of having them read and look for the answers to questions rather than just dictate notes as many other teachers in the school. The majority worked from their photocopies without major problems, indicating a shared agreement on a common approach to their work. Again, the implicit objective of these activities was clear, that these questions covered the legitimate knowledge that the students required for their exams.

Identity formation

Identities within communities of practice

Wenger (1998) incorporated identity and modes of belonging at the very centre of educational communities, suggesting that they must open spaces for the negotiation and transformation of identity of the members of the community of practice. He considered identity to be one of the four indispensable components of any theory of social learning, the other three being meaning or domain, community and practice. The essential element of identity construction in classrooms was also emphasized by Littleton (2000). The teachers themselves continuously negotiate their identities within their own professional and personal "constellation of practices" (Wenger, 1998: 126-127), a dynamic process always involving both subjective and collective aspects. This section analyses both teachers in terms of their sense of identity in each of the principal communities of practice that this study has examined: the classroom, the school, and TACTICS, with border crossings from the MEC.

Both Hector and Maria had membership in different communities of practice within their professional sphere that included the classroom itself, the school (including colleagues, other students and the administration), the biology teachers' academies, the university, TACTICS, as well as the group of teachers in the masters program (MEC). Both had developed different identities in the different communities of practice, some of which could create conflicts. For example, Hector had a self-identity as a fairly successful teacher compared to what he considered his identity within the school administration as a rebel, an outsider. He had yet another identity within TACTICS, as an apprentice investigator, as a facilitator of the students' work. The particular moment and context are determinant as to which identity comes to the fore but this requires at the same time an accommodation in terms of the other identities.

Identity within the school and institution

Both teachers felt they had earned their membership in the teaching community where they worked and that they had a certain status of respect and recognition from their colleagues within it (P25:18 and 19), even though they had little or no voice nor power of negotiation within the broader institutional context. Hector particularly emphasized the political context while Maria was more concerned with what occurred within her classroom. She felt her status within the school community was quite good, principally due to her students' exam results (P4:39), some semesters amongst the highest in the university high schools.

Over these four years, she had played a more active role as a member of the biology teachers' academy than Hector, but this could be a reflection of her concern to be able to help her students by taking part in the decisions made by the academy, such as in evaluation, rather than of a political interest. Maria was even the president of the academy within her school, a position she left in 2002, but she continued active in the university biology academy after that date. She said that there were few teachers from all the affiliated high schools who were active, but that those who participated were working on lab manuals, writing exam questions as well as developing objectives for the study plan to help the teachers know the depth of knowledge expected for each topic. She stated that they did this all without supervision or assistance, implying a feedback of more of the same even though their stated objective is to improve teaching and learning. According to Maria, they judged success by means of the grades on the semestral exams although, since feedback was limited to the total points obtained by each student, they had no way of knowing which areas of the study plan caused more problems for the students.

Hector personally felt very little recognition from the administration, neither for his efforts in the class nor the favourable exam results of his students nor for his work in TACTICS (P29:39; P36:22), although he declared it didn't matter as he did have the respect of the teachers (P25:20). Nevertheless, as this had been a repeating theme over the four years of observations which included two different school administrations, it would appear to be of considerable importance to him, especially when he compared the reflected prestige and responsibilities he had had when his brother was the director of the high school. He said there were teachers in the school who had very little motivation, who just dictated notes and didn't even finish covering their curricular material each term (P31:28 and 29; P40:29 and 33), implying that he should have greater recognition than they. He felt so distrustful at the start of TACTICS that he said he was going to go to the university to talk to the authorities, to get their recognition of his role within the project (P36:59), a notable case of crossing borders between three different communities of practice: TACTICS, the school and the university. The importance of recognition by the institutional community was evident in his sense of identity as a good teacher.

Identity within the classroom

At the start of the project both Maria and Hector answered various questionnaires on different aspects of teaching and learning, reflecting in part their identities as teachers at that

time. Hector's answers on one in particular (App. B: I) revealed a somewhat greater sense of confidence than Maria in his own leadership qualities as a teacher, in use of constructivist strategies, and, in particular, in use of collaboration and technology, although observations have not supported these assertions. Both demonstrated a moderate degree of confidence in their own teaching. Over the four years, they acknowledged that they still have weak areas as teachers but were convinced that they had improved enormously throughout their teaching trajectories, basing their judgements in part on improved student participation, but principally on exam results. Hector was somewhat less confident than Maria to call himself a good teacher at this point of his professional development, but felt he was much closer than at the start of his career.

Both credited their improvements as teachers to their classroom experiences as well as with variable effects from what they learned in the MEC, a good example of the development of pedagogical content knowledge (PCK) (Shulman, 1989; Mellado, 1998) or professional knowledge (Montero, 2003). Maria particularly acknowledged the influence of the MEC for diminishing her fear of losing control of her groups when using more active strategies (P4:84-88), a transfer of competence between communities of practice. On the other hand, Hector based his identity on different external "success" factors, such as the fact that his chemistry students obtained as good grades on the semestral exams as those who had a teacher who was a chemist by training (P29:34). He also measured his success by the fact that students in the school whom he had taught in previous years came to him for academic help (P29:33) and that former students stopped and greeted him in the street (P36:37).

Maria described herself at the beginning of her career as a traditional teacher who dictated from one book without giving any responsibility to the students (P4:2). She further explained that she had changed this traditional form for another strategy that she had used for years, of providing books for the students to use to answer questions that she formulated (P7:66). This was observed to be her chief strategy over the four years of this investigation.

Her present identity as a teacher, beyond her good subject matter knowledge, was the students' recognition of her as a person:

> Well, at times I feel that [the students] value the character of the teacher... that the only thing that I wanted for them was for their own benefit, their well-being in terms that they be better persons and that they learn. (P4:31)

> Pues, a veces siento que [los estudiantes] valoran la forma de ser del maestro....que lo único que quería de ellos es su bien, su bienestar en cuanto a que sean unas mejores personas y que aprendan.

Maria expressed satisfaction that she was achieving her goals as a teacher, to keep up-to-date in her subject, to give confidence and the will to learn to her students, although she still measured her success to a large degree by students' grades, aiming for only a small number to fail any given exam, in particular the semestral exams (P4:39).

Even though she demonstrated her constant concern that her students do well on the semestral exams, she also expressed concerns beyond that, that the students truly learn how to work and learn, to change their habits formed in the traditional classes of dictation with the teacher explaining everything:

> I, in spite of the students not doing so well on the semestral exams, I have to continue, uh, with this idea, right? Because, because it is good, in the future it can be of use to them. (P9:20)
>
> Yo, a pesar de que no salen muy bien en los colegiados, tengo que seguir, este, con esta idea ¿verdad? Porque, porque sí es buena, en el futuro pues les va a servir.

This passage also showed her continued doubt as to whether her methods were really effective, given the context of the exams, whether the traditional means were not better to pass the exams with good grades. Several times over the years, in informal conversations with me, she asked me why the students of a completely traditional teacher sometimes did better than hers.

Maria consistently demonstrated an ethics of care for the students, such as when she described her positive points as a teacher as:

> Well, I try to understand the student...if I see that a student responds but doesn't have much capacity, but I see that he made an effort, I take it into account. (P4:36)
>
> Pues, que trato de comprender al alumno…si yo veo que un alumno responde pero no tiene mucha capacidad, pero yo veo que se esforzó, lo tomo en cuenta.

She wanted to teach her students to respect each other and to be honest in their learning, not to cheat on exams, but to earn their grade, whatever it may be. (P4:29 and 30). She also further demonstrated her concern for the students' learning:.

> I like to learn new things to be able to teach them to my students, that sometimes I spend my own money and it doesn't matter to me that I don't earn much as long as they can do things and learn a little more. (P4:37)
>
> Que me gusta aprender cosas nuevas para poder enseñárselas a mis alumnos, que pues a veces gasto de mi dinero y no me importa que no gano mucho con tal de ellos hagan las cosas y aprendan un poquito más.

These factors of her ethics of care have been interpreted here to be indications of a student-centred orientation, or belonging to an early constructivist position (Salish II, 1998).

Hector described his identity as a teacher and the effort it cost him to reach this level in the following statements:

At the beginning of these 15 years, I didn't even feel like a teacher, but now, little by little, I consider that I have gained the right to call myself a teacher, in that sense.... I try to be flexible... but at the same time demanding... but I feel that I am learning to be a teacher more each time, in that sense. I don't feel like an extraordinary teacher but neither do I feel so deficient now as a teacher, in that sense. (P38:1, 7-13)	Al principio de estos 15 años, ni siquiera me sentía maestro, pero ahora, poco a poco, considero que sí he ido reuniendo el derecho de llamarme maestro, en ese aspecto... Trato de ser flexible... pero a la vez exigente... pero me siento que voy aprendiendo a ser maestro cada vez más, en ese sentido. No me siento el *plus ultra* de maestro ni tampoco ahora me siento tan deficiente como maestro, en ese sentido.
Yes, after 15 years, yes [I feel well prepared to teach the content of biology.] At the beginning, maybe in the first years, yes, it cost me a lot of work, but after 15 years, yes, I like to teach the subject. (P36:28, 199-200)	Sí después de 15 años, sí [me siento bien preparado para enseñar el contenido de biología]. Al principio a lo mejor en los primeros años, sí me costó mucho trabajo pero después de 15 años, sí me siento a gusto dando la materia.
I consider that I have always tried to improve many things and I always tell that to my students... Maybe I am going, little by little, and maybe at the end of the 25 years that are a requisite [to retire] I'll be able to consider myself a good teacher. Right now I don't consider myself that, I am learning more all the time, more and more. (P36:35, 280-285)	Me considero que permanentemente he tratado de ir superando muchas cosas y siempre se los digo a mis alumnos... A lo mejor voy poco a poco y a lo mejor dentro de los 25 años que se cumplen como requisito [para jubilarse] yo me puedo considerar como un buen maestro. Ahorita no me considero como tal, voy aprendiendo cada vez más, más y más.

This self-description showed satisfaction with his work, that he was confident that he had improved steadily on the basis of hard work and his experiences, and that he had the desire to become a truly good teacher by the time of his retirement in another ten years.

In summary, Maria's identity as a good teacher was fundamentally related to her students' learning as she measured it, while Hector's was essentially school-based, related to the recognition he received from the school community as a whole.

Identity: the influence of the MEC

Part of Hector's successful identity he credited to the MEC as well as TACTICS, mainly in terms of the recognition within the school community:

> Over these 10 years maybe it didn't matter to me nor was it important to consider that aspect, but now, with all of the MEC, with all this of the TACTICS project, yes, I am very interested in not being one of so many that have entered the preparatory here; at least to try to improve and to be a bit better so that I can gain a certain place or a certain recognition. (P25:16, 410-416)

> Durante 10 años a la mejor no me importó ni me valió considerar ese aspecto, pero ahora con todo eso de la maestría, con todo esto del proyecto de TACTICS, sí me interesa mucho no ser uno de tantos más que han entrado ahí a la preparatoria; sino por lo menos tratar de mejorar y ser un poquito mejor para que pueda yo tener cierta ubicación o cierto reconocimiento.

He also acknowledged the MEC as having influenced him in different ways, such as in promoting the use of diagnostic exams, in broadening his form of evaluation to include homework and participation, as well as encouraging him to relate concepts more consciously; all these changes have eventually given him more confidence in his teaching practices (P29: 543-618). He went on to give examples of some of these changes:

> ... my way of giving my class... not to shout at them so much anymore,... to explain to them or to be talking and talking, nor anything like that, but that with all that we have reviewed and acquired in the MEC...well, it is important to make them [the students] aware that they are the most important people in the classroom, right? Because we are no more than guides of the things, no?(P3113, 129-134)

> ...mi manera de dar mi clase... ya no es de gritarles tanto, ... de explicarles o estar hable y hable, ni nada por el estilo, sino que con todo esto que hemos estado revisando y adquiriendo dentro de la maestría, ... bueno es importante hacerles notar que ellos son la gente primordial en un salón de clase ¿verdad? porque nosotros nada más somos así como guiadores de las cosas ¿no?

However, he described in an interview in March, 2002, after two years of MEC, having completed all the coursework, that he had given a homework assignment to the students to summarize some topics that he didn't have time to cover, so that they could discuss it quickly in class:

> ... to me, they are experimental modifications that I have been making in my class, without having, eh, determined my goal properly, nor my objective, nor my methodology, in that sense. I achieved it almost experimentally, in that sense. (P31:35)

> ...para mí son como modificaciones experimentales que he estado haciendo a mi clase, sin tener, este, bien cimentado mi propósito, ni mi objetivo, ni mi metodología en ese sentido. Lo logré así como casi experimental en ese sentido.

This statement put in serious doubt the effects of the MEC on the methodological facets of his teaching practices. It should be noted here, however, that numerous courses of the MEC were given as frontal expositions, thus providing little in way of role models for change. The knowledge assimilated from the MEC was much more likely to be "static" rather than "dynamic" knowledge that is acquired through experience (Mellado, 1998).

At a slightly later date, in December, 2002, he reiterated his beliefs regarding the importance of the MEC in his teaching, even while admitting his lack of planning, but that he could invent things more readily, related themes more and was generally more confident of his teaching due to his studies:

> ... after having studied the MEC, it has given me a more ample panorama, more ample in many things, right? I had no formation as a teacher before studying the MEC, in other words, I gave my classes as best I could, right? (P29:27)

> ...a través de haber estudiado lo de la maestría, me ha dado un panorama muy amplio, muy amplio de muchas cosas, ¿si? Yo no tengo la formación o no tuve la formación docente antes de estudiar la maestría, o sea, yo daba mi clase a como me podía entender, dar a entender, ¿no?

He went on to say that the MEC had been more important in promoting these changes than his participation in TACTICS or his participation in this project. He said:

> Definitely the MEC is a factor like that [in my changes], essential for people to really become conscious of the professional development, of what it is to teach, right?, to be a teacher. (P29)

> Definitivamente la Maestría sí es un factor así [en mis cambios], como esencial para que las personas puedan realmente, tener conciencia de la profesionalización de lo que es enseñar ¿verdad? de ser maestro

Maria's sense of professional identity as a teacher clearly manifested itself in the transcripts as that of a teacher who was satisfied with her work, suggesting that her changes were at least in part due to the MEC:

> I describe myself as a person who is concerned that her students learn something and in these moments after the courses that I have taken in the Master's [program], I have changed my way of teaching a bit. I try to not be the same as before and I want to see if it gives me results in the learning of my students. (P4:1)

> Me describo como una persona que se preocupa porque quiere que sus alumnos aprendan algo y en estos momentos después de los cursos que he tomado en la maestría, he cambiado un poco mi forma de enseñanza. Trato de no ser la misma que antes y quiero ver si me da resultado el aprendizaje de mis alumnos.

She went on to describe how she had assimilated and applied strategies that she learned in courses of the MEC, that she learned about taking into account previous knowledge, to help the students relate it to their new knowledge as well as the importance of letting the students construct their own knowledge through their own discovery and not give it to them all

elaborated, to be more creative (P5:34). She was now more confident to try new methods, to experiment, fearing less the loss of control over the class (P4:34).

She further explained the importance of the courses she had taken, to support her intuitive creativity as a teacher:

> Well, for quite a time I had these ideas but didn't know how to develop them. I had them, I wanted to work in those ways, and I even at times created different exercises or activities to motivate my students. But at times they worked out and at times not, and attending those courses, well, they facilitated that creativity to be able to carry out different types of activities that motivate the students to work. (P4:43)

> Pues desde hace tiempo yo ya tenía como esas ideas pero no sabía como desarrollarlas. Yo ya tenía esas, quería trabajar de esas formas, inclusive a veces yo creaba diferentes ejercicios o actividades por mi misma, me lo pedían para poder motivar a mis alumnos. Pero a veces me salían, a veces no, y ya asistiendo a esos cursos como que se va facilitando esa creatividad de poder llevar a cabo diferentes tipos de actividades que motiven a los alumnos a trabajar.

From these excerpts, it was apparent that both teachers had undergone significant transformations of identity over the years, a continuous development of their professional knowledge as teachers with certain influence of their experiences and knowledge gained in the MEC. It is probable that the courses in the MEC were the major source of their concepts regarding constructivism, although it is impossible to estimate the overall, relative influence of the MEC on their beliefs and practices as compared to that of their classroom experiences themselves.

Identity within TACTICS

At the start of TACTICS, Maria expressed doubts about her own skills regarding the new educational technologies to be used and saw many obstacles to their implementation, principally regarding computers and Internet. She held mixed views as to its value and her expectations of success (App. X) as compared with her vision of the many practical constraints. Even though Hector had certain reservations about his skills at the outset, he also expressed confidence with regards to the use of computers, and was much more convinced of the possibilities of success. Thus, in contrast to Maria, from the start Hector had the basis to more readily define his own identity as an active participant, a co-learner within the project along with the students.

During the TACTICS project Hector was much more closely involved with the students and their use of the computers, and admitted freely to having learned a lot from the students

who knew more about computers than he (P25:6; P34:28; P39:7). He said his role in TACTICS was as a coordinator and facilitator and that the students actually became self-taught, using their creativity, aptitudes, capacities (P34:11), but also went on to say he supervised their work in procedural matters. (P34:14 and 15). This was confirmed in the observations made with TACTICS groups. He was confident enough of his role to ask the director to invite two investigators from TACTICS to give a presentation of the project to all the teaching staff in 2003, with Hector also sharing his experiences with his colleagues. Moreover this greatly enhanced the recognition of his efforts from the school community.

In terms of TACTICS, Hector had a definite feeling of ownership of meaning and of membership in the project and described being motivated by it and its effect on the students:

> I feel that I am a collaborator in TACTICS, in a way, in other words, not a member in certain manner, but yes, I collaborate with your group who are the investigators. (P25:11, 357-360)

> Siento que soy un colaborador de TACTICS, en ese sentido, o sea, no un miembro en cierta forma, pero sí colaboro con el grupo de ustedes que son los investigadores.

> ...I feel that, yes, little by little, I have become more involved in the project, uh, seeing the magnitude at some moment given the situation, and that has given me more direction, no? (P34:9, 99-101)

> ..siento que sí, poco a poquito me he ido adentrando más al proyecto, eh, viendo la magnitud en algún momento dado de las cosas, y eso me ha ubicado más ¿no?

When asked how his participation in TACTICS had affected him, he said that he has learned:

> in one way or another the use of a totally different methodology, that can be used in a classroom...to be able to stimulate the students to learn. (P34:25491-498).

> en una u otra manera el utilizar una metodología totalmente diferente, a lo que puede ser un salón de clases... para poder hacer que los alumnos aprendan.

Maria, on the other hand, developed an identity based primarily on non-participation, leading to a marginality of both competence and experience (Wenger, 1998: 216), which undoubtedly shielded her against what she was not, that is to say, not a computer expert. In an interview at the beginning of TACTICS she said her major concern was:

> to not be able to tell my students how to use the computer, right? how to use it, to be able to help them in an efficient way... that worries me and to see that they know more than oneself...(P2:13)

> no poder yo decirles a mis alumnos cómo usar la computadora ¿verdad? cómo utilizarla, poder auxiliarlos de una manera así eficaz para ellos... eso me preocupa y ver que ellos a lo mejor saben más que uno.

Her quiet refusal to take an active part, to take risks, to share the experience with the rest of the school community all indicated this position, undoubtedly diminishing her personal sense of social competence, in conflict with her perceived status as a good teacher. This was reflected by her very high levels of concern with regards to her professional status at the start of the project. The observations confirmed this very tentative position, even in the third run of the project. In an interview at that time, in October, 2002, she said that she didn't think her participation in TACTICS had had any effect on her as a teacher (P11:19) although she went on to say she had gained skills in looking for information which she considered could motivate the students knowing that she was up-to-date in her knowledge (P11:20 and 21). She had also learned to "communicate with people", meaning via emails and chat, but she didn't consider that important as a teacher. She had not recognized the only clear example detected of the appropriation of a TACTICS strategy, the exam exercise described earlier. In another interview in December, 2002 (P14), she again demonstrated her ethics of care, that she spent most time with TACTICS students who were having difficulties and who were not very motivated. She attributed part of the problems to their lack of interest in reading information, but also took some of the responsibility herself, for her lack of knowledge about computers. She repeated that she didn't have time to attend to the groups directly, that she had many other responsibilities in the school.

Over the years, it was evident that her TACTICS' identity was in conflict with her identity as a good teacher, which had led her to continued marginality, a justification for her lack of sense of ownership of meaning. Hector, on the other hand, had developed a strong feeling of membership and the consequent motivation to continue in his more active role. He had such a positive identity that he felt this had increased his status within the larger university community, a point of considerable importance to him.

VI. Discussion of Results and their Implications

In the previous section of analysis, the observed patterns in the two teachers' beliefs and practices are examined and interpreted, emphasising evidence of coherency or conflict between them. Attention is also called to perceptible changes or transformations, in particular any that might be related to their experiences in TACTICS. This section of the thesis summarizes the analysis within the chosen theoretical framework in an attempt to provide answers, even if partial, to the research questions originally posed[35]. The discussion is thus organized around the teachers' beliefs and practices, all in relation to the three major levels of analysis of common knowledge, collaborative learning and communities of practice. The mediating context within which these teachers work is also underscored along with the various constraints, both personal and institutional, that appear to be amongst the principal limitations to these teachers' efforts to implement change in their professional practices. The chapter ends with concluding remarks as to the relevance of the study as well as outlining unanswered questions and new ones that have arisen.

General summary

Common knowledge in the classroom

The analysis of the development of common knowledge begins to uncover the complex layers of interactions between the teachers and students within the institutional context, providing a more precise description of what could, at first glance, be termed essentially traditional classrooms. Although it is evident throughout the period of observation that both Hector and Maria use teacher-centred, conventional practices involving teacher control of content, activities, student attention and conduct, it is also apparent that their roles as teachers vary over time. Closer analysis shows numerous examples of attempts to enter intermediate or transitional regions, apparently reaching towards a model that consists of more student-centred teaching and learning or a transitory model pointing in the direction of early constructivism[36]. There is sufficient evidence in their practices to support this assessment, even if these aspects are found primarily in their expressed beliefs and intentions; overall Maria has undergone a greater transformation.

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[35] See pages 56-57.

[36] See App. IX: the descriptive STAM matrix for the analysis of high school science teachers, Salish I.

Over the period of observation, both Maria and Hector have articulated a desire to change and improve the teaching-learning processes in their classrooms, gradually modifying their strategies. This desire appears to be more consistent and more organized in Maria's case whereas in Hector's it is possibly more opportunistic, but both invest considerable effort in their attempts to increase student participation. Both have managed over the four years to progressively develop student involvement by jointly making notes on the board, principally based on their major strategy of having the students read texts (photocopies) and answer questions or make summaries. Even this desire to break out of the traditional model is notable when the institutional context is taken into consideration.

Conceptualising teaching and learning:

One of the basic beliefs analysed in this work is each teacher's conceptualisation of learning, one that is considered to explain many of their teaching practices. For the last four years both Maria and Hector repeatedly express the belief that learning occurs when an individual reads a text followed by explanations from the expert teacher. Nonetheless, their discourse from the outset, plus information obtained from the questionnaires, contain elements of constructivist teaching and learning. Over these four years, I have come to the conclusion that their very conceptualisation of what it means to learn or to construct knowledge is imprecise, thus explaining their adherence to fairly traditional practices in spite of their occasional discourse of intentions to the contrary.

However, during the final interview in the fall of 2004 (P17) Maria presents an unexpectedly evolved conceptualisation of learning[37]. When once again asked how students learn, she reiterates her previous active transmission model, that they must want to learn, that they must be active. She then goes on to say the students should talk and work in order to learn, that by talking they are using their own words and their brain, thus forming new ideas and improving their learning. This evidence shows a much closer approximation to constructivist concepts than she has previously expressed, indicating not only an assimilation of constructivist discourse, as I tentatively interpreted it earlier, but an apparent appropriation of this into her system of beliefs with specific intentions to change her practices, as I describe

[37] The intention had been to make a final classroom observation in the fall of 2004 as well as the interview, but this was not possible due to the prolonged strike of two months of the state university that closed all schools.

shortly. Up to now, her teaching practices are quite coherent with her explicit beliefs regarding learning, thus making it feasible to forecast changes in her future practices in accordance with this recently evolved conceptualisation of learning.

In contrast, up to the conclusion of the study Hector quite consistently expresses a very traditional conceptualisation of learning with no demonstrable change (P47). In the final interview in the fall of 2004 (P47), his definition does not show any transformation as he still expresses the belief that students learn through *his* explanations and by reading and memorizing. His observed practices are also very congruent with this definition, although with a gradual progression to stimulate more active student participation in their own learning, albeit with his explanations at the core of the class.

Teaching objectives

Both express at different moments two main objectives for their classes: that their students successfully pass the course and that they learn in the fuller sense of the concept. However, they appear to oscillate between them and both recognize in informal discussion that they are not necessarily linked. Through tacit negotiations, they try to strike an adequate balance between these two, to cover both objectives, but they do not seem to be sufficiently explicit for the development of an actively formed common knowledge base. Their ideal student, one with interesting active-passive characteristics, reflects a somewhat more constructivist definition of knowledge, considerably beyond a student who carries out the traditional memorization and repetition of isolated facts. Their use of questioning to promote participation could be described in the words of Mellado (1998) more as "a mission of motivation and encouragement to participate than being a step in the constructivist strategy" (p.207), but it could also be considered as a possible intermediary stage of transformation from teacher-centred concepts of learning to student-centred ones (Kember, 1997; Salish II, 1998; Samuelowicz and Bain, 2001). The analysis tends to support the inference that Hector is most likely in the first category but that Maria is closer to the second.

However, in spite of their discourse and some practices, both teachers still express doubts about the best strategy in terms of exam success, at times explicitly and at others, implicitly. Certainly, the institutional context with the all-inclusive emphasis on grades is a constraint on attempts to change from what is generally considered a successful

method: that students memorize the information that the teacher chooses and transmits. Learning for learning's sake would appear to be a very distant second goal in the classroom. As Quiroz points out (2000), the material and institutional conditions do not determine specific teaching practices, but they delimit the space and rules within which the teacher works. In this study, it is patent that the results on the semestral exams are a very limiting factor in both teachers' context.

In specific interviews, both teachers clearly articulate the traditional objective of teaching their students the basic vocabulary of biology for exam purposes, an essentially disciplinary-based inventory of terms and concepts. Hector demonstrates little concern or intentional effort to teach the required terminology through discussion, although on occasion he expresses the importance of students using the new biological terms, but implying that it is more through their written work than oral. His questioning techniques are more limited than Maria's, giving less opportunity for the students to practice, thus remaining much more within the traditional, teacher-centred framework. From the evidence of both teachers, it is possible to surmise only a minimal level of negotiation of scientific meanings during the teaching-learning processes as there are few opportunities for the active development of semantic relationships that are considered essential in an effective science class. The student interactions that occur are largely related to discovering the implicit conversational rules instead of developing communicative competence of the scientific language that is being taught (Bleicher, 1998; Lemke, 1997).

The use of both spoken and written language is a complex and subtle matter in the analysis of the teachers' communications with their students. As discussed earlier, both employ numerous didactic strategies to promote student interaction in their classes, mainly through questioning and triadic dialogue (Wells, 2000). Maria, in particular, places great importance on the oral discussion of topics as a basis for the students to develop their own understanding and in a more interactive fashion than Hector. Conversely, the observations indicate that the students normally give a greater validation or status to written text rather than talk, to the point that teacher talk is often ignored by many, but they all record the notes. This sharply highlights the teacher's acknowledged expert role as the dispenser of legitimised knowledge, but only when presented in a formally written or dictated fashion. Once again, the institutional context is visible, where the study plan and verbal knowledge, either from the

teacher or in a text, are the legitimised knowledge that the students are expected to memorize in order to pass exams, exemplifying what Edwards (1993) has called "talk and text". The lack of in-depth discussion, of negotiations of meaning and of student opportunities to simply use the biological language that they are to develop all severely limit the intersubjectivity that might be developed (Joiner et al., 2000; Rogoff, 1998; Wells, 2000).

However, Maria's tacit intentions to teach biology in what could be called a "student-friendly" manner, in an attempt to make it more comprehensible to the students, diverge markedly from the formal, stylistic norms of scientific language (Lemke, 1997). It is discernible from the data analysis and from the examples given in the previous chapter that Maria has the implicit goal of teaching the students the basic vocabulary through "talking" biology as she spends a considerable amount of her class time on this, attempting to link the usage of scientific terminology to more familiar terms in the construction of common knowledge. Nevertheless, due to her constant control over discourse, students have had limited opportunities to practice this new language and even less to negotiate meanings. However, as already discussed, her recently articulated intentions have shifted notably towards a more student-centred position. Consequently, although the intersubjectivity or the building of shared common knowledge to date is perceived to be at a superficial level in her classes, this situation may evolve. It should be noted that it is highly unlikely that any transformation of Maria's practices will be rapid as all those described to date have occurred slowly and somewhat erratically, but it would appear that the seeds of change are firmly embedded in her beliefs with the verbalized purpose of implementing them in her practices. Hector's efforts in this area remain undefined.

A secondary joint goal of teaching of both Maria and Hector is inferred to be that of introducing their students to the biological way of knowing the world (Scott, 1996). A frequently articulated objective is the presentation of "correct," updated biological information in a simplified yet "scientific" form that the students can relate to their own lives. Maria does not deny common sense answers nor the students' own experiences but rather includes them on occasion in attempts to make science accessible to them with an informal style, trying to "humanize" scientific language (Lemke, 1997, p.148). Previous examples of this can be seen, such as the group of boys discussing the plasma membrane with her and their references to the ozone layer or that medicine enters

through the mouth. Maria's style also includes touches of humour as writing and reading out her own *calvera* about the students (P8), or the personification of biological phenomena, such as a cell "drinking" water (P1), an attempt to bring the scientific concept of osmosis closer to the students. This style tends to demystify science, while on the other hand her discourse and strategies of using exposition and controlled discussion reflect what Lemke calls the ideology of scientifically objective truth. Hector's practices tend to reflect this same ideology. Once again we see Maria striving for a more student-centred style, but still retaining her traditional origins, while Hector is apparently less concerned with this facet of his teaching.

Maria's and Hector's lack of explicitly stated objectives may reflect their personal educational ideology that students are individuals who develop their own potential and should learn things by themselves, as well as their implicit belief that the ultimate accountability for success or failure lies with the students themselves, on their own intrinsic motivation to work, thus basically negating their own responsibility for the success or failure of their students (Tardiff, 2004). The general institutional ideology appears to support the concept of learning as an individual and mechanical process seen as the inevitable result of being in a classroom with a teacher. This ideology also justifies the homogeneous treatment of large groups of students, of an encyclopaedic curriculum that is reified in the evaluation system, where collective control is much more important than learning itself (Quiroz, 2000). This context gives status or legitimisation to the texts and to the teacher's knowledge, whereas student contributions are encouraged only superficially, at best.

Maria, however, expresses in her final interview (P17) a recent shift in her view of her own responsibility as a teacher, articulating intentions to change the learning environment when the students don't respond well to her teaching. She says that in the past she used to get angry, blaming them for not trying, a very conventional response within the traditional teachers' perceptions. This explicit aim could be a sign of a greater appropriation of a new role, a further indication of a shift towards a more student-centred, constructivist position. Again, there is no evidence of a change in Hector's beliefs in this respect.

In the case of both teachers' theoretical views of the nature of science, their beliefs ostensibly lean towards the positivist side of the epistemological balance with their

teaching strategies also indicating a definite propensity towards verbal control of the class, as described by Richardson (1996). Their discourse also generally implies a unique scientific solution or answer to their questions with the teaching of content at an essentially ritualistic level of teaching the basic vocabulary. Both teachers' choices of topics are controlled by the official study plan so it is not possible to assess the aspect of personal selection of topics. Their practices in the laboratory indicate the traditionally positivist position, encouraging the students to deduce from their experiences and formulate hypotheses that confirm what was taught in class, all inferring an infallible scientific method. Nevertheless, it has been noted that on occasions they both attempt to relate concepts to the students' previous experiences, above all Maria, another example of a slightly more relativistic position, demonstrating once again an eclectic mix of views.

According to the theoretical positions on common knowledge described in this thesis, it is essential that teachers motivate students towards intersubjective attitudes through a transfer of the specific knowledge to a more generalised, applicable knowledge. This should be accomplished by means of an interpretive discourse with the teacher, all of which incorporates the students' interests and priorities and gives them a role in the social creation of common knowledge. The analysis, however, presents a vision of educational processes with only traces of these factors, where a common knowledge base is developed with each group of students, one that is unquestioned by them, with no explicit discussion of goals or objectives in class, one that may be very superficial with many misunderstandings left unattended, as illustrated previously. The situation is considered to be insufficient to establish an *effective* common knowledge that would permit the transfer of competences and autonomy to the students described by Edwards and Mercer (1987). Consequently, the common knowledge base that is developed follows the traditional focus on teaching-learning processes, with close teacher control over discourse, with only brief glimpses of shared perspectives at an academic level. When there is a shared perspective of teacher-student responsibilities, it is more directed towards normative matters such as the coverage of the official curricular program, attendance and acceptable behaviour in class, and above all else, passing the all-important semestral exams. This may also reflect a deeply held belief that the traditional methods are more effective in terms of exam success, creating a

conflict between more recently developed beliefs and/ or discourse, a topic only mentioned very obliquely in their interviews.

Teaching roles

At different moments Maria, notably more than Hector, expresses the importance of her role as a motivator of student participation and learning. She believes that students should discuss ideas, but recognizes that she provides neither specific context nor structure to promote this. There are varying levels of student participation with both teachers, with virtually all verbal exchange controlled by their frequent use of IRF teaching strategies, a traditional teacher's role in the centre of the dialogue. Except for one example, there is normally minimal opportunity for the students to express their own ideas or to share and transfer control and competences from the teacher to the students. Two examples are identified where student misconceptions are clearly vocalised but neither teacher recognizes nor corrects them. Thus, it would appear that the transfer of information that occurs is principally the traditional transmission of the teacher's knowledge to the students by means of what is essentially a pseudo-discussion that doesn't, in actual fact, probe students' preconceptions in spite of discourse of intentions to the contrary. The roles are thus much more consistently the traditional ones, with only occasional shifts to facilitator or conductor in discourse, and even less in practice.

In summary, the observations throughout this study demonstrate that the cultural organization of access to learning resources is based on that of the teacher as the expert, but without opening channels of communication that could give access to practices with truly active student participation which, in turn, could lead to intersubjectivity and autonomy in learning. Both teachers intuitively seek a manner of changing this in their own classes by developing their own model of active transmission. This model appears to have improved student participation in developing a common knowledge base in class, and gives the impression of having the potential to promote change even within a very traditional context. Even though Maria appears to encourage somewhat more active student participation than Hector, neither can be considered to advance the development of either student control over their own learning or of a truly effective common knowledge base.

Collaborative learning in the classroom

The analysis based on the theoretical framework of collaborative learning brings to light further facets of both teachers' beliefs and practices. The use of the categories chosen from this analytic perspective make it evident that both teachers attempt to create an appropriate social climate in the class in order to engage the students in their own learning, although Maria appears to be more concerned than Hector about the motivation and the engagement of *all* her students. However, neither teacher communicates their goals clearly, although they occasionally explain their strategies. On the cognitive level, their objectives are, at best, touched on in a very peripheral manner. Both teachers promote group cohesion in laboratory exercises, but in the very traditional manner of group work, with no sharing of roles nor responsibilities. The only interdependence that is developed during the laboratory work is through the shared grade for the work that is usually carried out by only one or two members of the group. Thus, the engagement of the students is partial, ostensibly not sufficient to overcome the typical high school student's over-riding social interests (Weiss, 2004) nor the institutional context (Quiroz, 2000).

Both teachers encourage the exploration and elaboration of knowledge to varying degrees, on occasion validating student contributions, but again under their control when choosing the strategies or pointing out the links between ideas and concepts, with virtually no group negotiation. Semantic relationships may be built up, but not necessarily as intended by the teacher, as seen in the example given earlier of the girl who is convinced that water gives her energy. Maria describes her objective of intentional learning, of developing an ecology of activities to transform information into knowledge, although the activities may not always be sufficient to fulfil this goal. In spite of her aim, student competences frequently appear to be reduced to pleasing the teacher and getting good grades, without the development of a collaborative strategy between the teacher and students and even less among the students themselves.

As already discussed at length, the best approximation to collaboration between Maria and Hector and their students is their customary writing of notes on the board. Both habitually take the students' responses, incorporating and modifying them to fit their own agenda, a partial legitimisation of student knowledge. However, the students don't question the teachers' expert knowledge, but rather focus their powers of

negotiation on class rules, on whether they have do their homework, on attendance and grade records, on the use of resources, on the organization of time, all typical types of collaboration seen in the most teacher-centred, traditional classrooms.

In his final interview (P47), Hector says that his intuition is that students learn best by themselves, partly due to prevailing custom, and that he has no evidence that they learn better in groups. He states that collaborative learning facilitates the learning process by presenting different explanations and discussions, so that if we don't understand the first, then maybe the second or third one will make sense. This is interpreted as an inherently traditional concept of learning that ignores the essence of collaboration. But he insists that he is most likely the only one in the school who works in such a manner, that the other teachers simply give notes for the students to memorize individually, expressing an apparently firmly fixed identity as an innovative teacher.

Both teachers evaluate student comprehension intuitively during class, principally on the basis of their responses to questions, but they do not involve the students in any type of self-evaluation nor do they include any evaluation of processes. It is possible that the inclusion of students in reviewing peers' answers and contributions to the jointly formed notes on the board may be a tentative promotion of critical reflection, but in a very preliminary, implicit manner. Both teachers infrequently use diagnostic exams at the start of a new topic, Hector being the first to mention their use. Maria more recently initiated the practice in the fall of 2004 (P17), one that she plans to continue. She intends to not only apply diagnostic exams but also later to go over the conceptual errors with the students, a significant improvement in terms of feedback on comprehension of the content. She says she will even let the students redo the exams so that they can learn better and also raise their grade. However, both teachers rely on the traditional, standard exam evaluation of content as the "real" measure of learning, a traditional, cognitive view of learning as an individual process, neither distributed nor collaborative. Rogoff et al (2003) point out that the assessment practices within this model tend to thwart educational innovations that are designed to promote student participation in their own learning as they are designed only to measure "receipt and retention of transmitted information" (p. 193), largely for the purpose of classifying and certifying people, which certainly appears to be the case here.

Nevertheless, it would seem that each teacher has formed his/her own concept of collaborative learning and works quite coherently within that framework over the years of

observation. Hector's still remains on an essentially traditional level of group work although he now includes a greater level of discussion than at the start (P47). Hector explains that he left copies of his brother's notes for his students to work on during the university strike[38] with instructions that they should read them together in groups of 2 or 3 students. However, this was not for collaborative learning purposes, but because he is convinced that this will force them to do the reading, which they wouldn't do on their own. Nonetheless, he does express tacit intentions of using collaborative learning, such as discussing articles on applications of genetics together with the students.

On the other hand, Maria's conceptualisation of collaborative learning has evolved as expresses in her final interview (P17) when she says that it is learning in common with someone, interchanging ideas, interacting, sharing knowledge and improving comprehension and one's manner of thinking. This is a notable change from her earlier definition, which was a group of students working under her control and assessment, one she has repeated over the years until now. She has also implemented a new form of questioning, instead of the factual questions used typically over the years of observation, now using more indirect, reflective questions that the students discuss in groups. She gives the example that when they were studying human systems, she had them discuss "Can you live without your reproductive system?" She says it provoked interesting speculation on the part of her students.

Analysis also highlights the limited use of technical collaborative tools for the mutual production of shared knowledge, principally photocopies and the whiteboard on which they often develop tables to compare and contrast different concepts. Hector has, in the last year or so, begun to use flow charts to summarize his notes on the board, to show the relationship of different concepts, also including more student participation. In terms of the critical verbal tool, spoken interactions have the greater status with Maria for her teaching, but the written notes on the board appear to have a greater status or mediating character for the students. As already described, Hector's periodic difficulties in explaining concepts further complicates his interaction with the students, putting additional emphasis on the written expert information, principally as reified in texts.

Both the class and school contexts generally indicate a very traditional philosophy of teaching, learning and evaluation, along with all the constraints identified by Quiroz (2000) in secondary schools: the labour conditions, such as the low salaries for teachers,

[38] The strike lasted two months, September and October of 2004.

which mean they require extra jobs in order to survive, which at the same time leads to conflicts in time to prepare classes, to attend courses offered by the schools. The school's organization of time and space and its priorities are also influential, as well as the didactic resources and physical infrastructure. Quiroz called this the "curriculum de facto" (pp.158-9), the institutional and material conditions of the schools that delimit the teaching practices and learning opportunities in terms of what is and is not possible. This institutional climate, analysed within the social structure and the cultural resources of the learning context, is considered here as a critical factor for teachers such as Maria and Hector in their attempts to be innovative. The tradition of minimal student engagement in the teaching-learning processes does not permit the exploitation of the common knowledge that is developed. Instead, the negotiations that have been identified and the co-construction of common knowledge generally occur within the traditional roles of teacher/expert transmitter and student/passive receptor. Many students only pay close attention when there is an officially recognized manner of presenting the knowledge that is interpreted as necessary to succeed, that is, to pass the exam, a characteristic also found in secondary schools (Quiroz, 2000).

As described from a semiotic perspective, patterns of interaction in the classroom are affected by the physical arrangement of furniture, the allotment of time and space in the lesson design, the discourse formation, all within the broader social and political patterns (Shapiro, 1998). Although the physical spaces exist in these schools, the institutional climate does not promote productive joint engagement and could even be considered to constrain the motivation of the potential participants given the types of activities. A context with these characteristics that clearly legitimises only certain types of knowledge and behaviour must be considered an obstacle to change. Many of the observations presented in this thesis exemplify what Rogoff et al (2003) call the assembly-line model of school (or transmission model) that does very little to stimulate student participation or motivation. In brief, the observed usage of collaborative learning strategies occurs within the personally developed definitions of each teacher, promoting correspondingly limited student participation with virtually no improvement in the formation of positive interdependence and shared responsibilities for learning amongst the students.

The classroom as a community of practice

The richest portion of the analysis is the comparison of the classroom to the model of a community of practice. This permits an in-depth analysis of the classroom as a whole, which

leads to a more comprehensive image of these teachers, their beliefs and practices. The analysis uses the chosen categories of communities of practice, but also builds on the analysis of the more specific perspectives of common knowledge and collaborative learning, both of which are necessary but not sufficient facets of a community of practice.

The analysis again underscores many traditional aspects of the classroom communities of practice of each teacher, such as a learning emphasis on reified subject matter, on the teacher-expert's legitimised disciplinary, curricular knowledge and the traditional form of evaluation. There are some observed improvements in the levels of interaction and the building of relationships with the students, but all initiated and controlled by the teacher. There is little global context in the engagements, nor opportunities for individualized content within the class, again limiting negotiation and identity transformation of both the teacher and students, giving them little chance to explore or to "cross boundaries", to share knowledge and experiences between communities to which they belong. The teacher carries out essentially all the coordination, so that the students have little empowerment within the class to share experiences, to negotiate or change the course of the activities. The institutional context promotes this by authenticating identities and accountability of both students and teachers according to the official grades, by defining success-failure in this extremely limiting, traditional manner. As expressed by Wenger (1998), teaching and learning are linked, not as cause and effect but through participation and negotiation: access to information without negotiation leads to non-participation. According to Wenger, information will be transformed to knowledge only if there is an identity of participation, which has been noted as a very partial characteristic at best of these classrooms when analysed as communities of practice.

Regardless of the context, Maria specifically demonstrates the firm conviction that students need to "build" their own learning, and continues to explore interactive strategies, a sign of developing competencies on part of both the teacher and her students within the classroom. Maria attempts to engage the students through a tentative, rather sporadic communication involving the global context and the students' own interests, but the students are given no responsibility nor role in creating their own meaningful activities. Hector also expresss these convictions but to a considerably lesser degree. However, as described by Wenger (1998), the joint enterprise of learning is not simply a stated goal, but one that creates amongst the participants relationships of mutual responsibility and mutual engagement as an essential part of the classroom practices. Both teachers tentatively promote this through the

collaborative development of notes on the board. As these include student contributions, the reification here is in line with Wenger's concept, that it should reflect the interactions that take place. It may also be considered a balance of the tensions described by Wenger (2001, 2003) between the processes of sharing knowledge and those of reifying common knowledge.

Previously I analysed the initial "frame crash" between new students and Maria, when they found her teaching style very surprising, a situation also described by Hector. However, both describe each new group of students' eventual acceptance and even appreciation of the new strategies, indicating the development of a mutually understood and accepted repertoire in terms of a teaching-learning style and shared artefacts such as the use of the photocopies, the type of board work or the style of discourse. The development of this shared repertoire, history and norms of behaviour, involves certain tacit negotiations of procedural and normative matters. For example, student dissent over homework assignments is interpreted as an implicit negotiation of strategies that reinforces both teachers' practice of having the students read and answer questions in class under their control without increasing the students' homework load. However, this lack of student responsibility hinders the teachers' intended strategies to develop knowledge by means of student discussions since valuable classroom time has to be dedicated to reading.

Both have shown certain inventive, intuitive changes in their work over these four years, Maria more than Hector, but the imaginative opportunities do not appear to have been shared with the students in class. Through these activities they engage their students in their own learning, but most likely at a level that is only meaningful to themselves as they choose the activities on the basis of their own implicit objectives. There is scarce evidence of providing the students with reflexive activities, with opportunities to explore, to gain a sense of possession, all part of the imaginative aspect considered necessary to create a sense of belonging, essential for identity formation within the community of practice. The students have no control over their academic destiny to share knowledge and to interact, to enable an effective participation, all part of what Wenger (1998) terms *alignment*. Instead, student energy is directed to the use of political and social power within the classroom and school communities of practice.

The role of the students within the classroom and the school is a key factor as they evidently have powers of negotiation that strongly influence the overall environment. The students, as the teachers themselves, have multimembership in numerous

communities of practice, within the school and outside. The students' traditional passivity may be accounted for by their long-term membership in traditional schools. Their powers of negotiation may be considered a result of using their experience and competence from another community of practice, their student association, creating situations that promote their social identity within the classroom (Wenger, 1998). As other studies point out, high school students' interests are principally social, aiming only at fulfilling academic requirements in order to continue within the educational system (Weiss, 2004). The social negotiations that occur, the accommodation or disregard of school rules, result in the teacher accepting the rather chaotic but tolerable environment for a more active student participation of a small part of the group, but one without demanding further student responsibility, such as doing homework. The relatively little sense of student commitment or sense of belonging that isobserved may be due in part to their lack of power of negotiation on academic matters, along with the lack of peer interactions or of opportunities to share teaching and to find a voice. In spite of this, there are also some signs of working towards improving the levels of interaction and the building of relationships with the students, but as already emphasized throughout this study, all initiated and controlled by the teacher.

The overall role of both teachers within the classroom is seen more as institutional than as authentic participants in the community of practice (Wenger, 1998) although there are hesitant attempts to break out of this mould, as Hector exemplifies periodically over the years. For the first time, in the fall of 2004 (P17), Maria portrays a much more intentional effort of her own: she describes how she is becoming a more authentic member of the community of practice by explicitly explaining certain objectives to her students and by asking permission, for example, to use them as "guinea pigs" for her thesis research[39], by telling them that she is the teacher but only to help them learn, thus assuming the role of a facilitator instead of the expert always in control. Over the last two years, Maria's fear of losing control has greatly diminished, according to her own description, undoubtedly an essential factor in this expressed transformation.

Certainly, the role of both teachers in TACTICS remains marginal, very much so in the case of Maria, although she is somewhat unexpectedly the teacher with the only detected

[39] As of the summer of 2004 both Maria and Hector have begun their theses for the Master's degree, work that had been suspended since 2001 due to bureaucratic problems in the university.

transference of a TACTICS strategy to her classroom practices, albeit unconscious of its origin. An interesting observation is that Hector expresss an authentic attitude of legitimate peripheral participation within his professional community of practice of dentistry, to observe and imitate experts in order to learn techniques as a dentist. He appears to have appropriated the same model to a certain extent in TACTICS although without practising his skills fully to become an expert, but there is no evidence of a transference to his classes. Possibly the institutional context and his own traditional experiences as a student and teacher have been the obstacle here.

The style of student participation in both teachers' classes, generally limited to one or two word answers to their questions, could be interpreted as very marginal participation. A transfer of autonomy to the students is not evident in the observed classes as there is little shared teaching and essentially no negotiation of meanings of the scientific knowledge presented and even less possibility of negotiating the definitions of success and failure as students. As the role of the teacher is institutionally legitimised, student contributions are largely ritualistic and usually ignored by their peers. The low levels of student participation could also be construed as a response to implicit rules of discourse established in the school system by traditional teachers who maintain the student as a passive, silent recipient of knowledge. In both Maria's and Hector's classes, I regard it more as a legitimate peripheral participation, given the specific institutional context (Lave and Wenger, 1991), of the students slowly learning a new manner of working in class, a situation that Kalman (2004) suggests to be the case in her studies of Mexican secondary schools[40]. In this study, the absence of more significant student interaction and discussion is considered to be due to lack of opportunities to participate more fully in the community of practice; but this, in its turn, is a hindrance to the formation of an effective community of practice whose implicit aim is to develop the scientific language and knowledge of the students, a very difficult cycle to break.

Identity, according to Wenger (1998), is our own definition of what we are and what we are not, a constantly evolving social experience, one of negotiation, of ownership of meaning, an inevitable consequence of belonging to a community of practice. The data collected on both Maria and Hector, analysed on this basis, focus attention on the exceptional importance of their identities in their professional communities of practice. Within their classroom communities,

[40] Kalman, Judith (personal communication, July 15, 2004).

each one has developed the identity as a *satisfactory* teacher, even as a *good* one in Maria's case, each having travelled a long route from very traditional origins. Maria recently articulated a further development in her identity as a teacher (P17), inferring that she now shares to a greater extent the responsibility for the students' learning: she intends to make a conscious effort to improve the learning environment, such as recently choosing a Mexican text book with local examples that she feels will motivate them. This is a significant change in her identity, to one as a more authentic participant in the community of practice, as well as her acceptance to a much greater extent of her own responsibility for her students' successes or failures.

Both teachers feel recognized within their inclusive school communities to one degree or another, although Maria's identity in the classroom with her students seems to be the most relevant one for her. Their sense of membership, of participation in their professional communities undoubtedly accounts for at least part of their continued motivation and efforts to improve their teaching-learning processes, even after so many years of teaching. Both teachers credit their participation in both the MEC and in TACTICS for improved competences, for more confidence and more knowledge of effective strategies that they can apply professionally, although both also acknowledge their long years of experience as an essential basis of their evolution. Definitely Hector has the greater sense of ownership of meaning and of membership in TACTICS, as tentatively predicted at the start due to his expressed concerns, skills and values as compared to those of Maria. Maria's identity within TACTICS contradicts her overall identity as a good teacher, possibly accounting for her continued marginality in the project over the four years.

The analysis of a classroom in terms of a community of practice thus permits a much more comprehensive vision of the essential importance of both teachers' and students' identities of participation. Identity formation should be at the heart of educational concerns but if institutional norms and classroom practices limit or actively obstruct the transformation of identities, the level of learning is likewise affected, as is the impression in this case study. The excessive emphasis on reified knowledge and the lack of opportunities to negotiate, to develop a sense of ownership of meaning through a shared, active participation in joint projects are all considered to be the basic constraints to change within the social configuration of the observed classroom practices. It would appear that the existing social processes within the classroom are thus essential factors to be considered if there are to be changes in identity of a teacher, an

example of Lemke's argument (2001) that conceptual change is a social process, not a rational choice.

Factors that promote or impede change

One of the most significant results of this research is the highlighting of transformations that have occurred in Maria and Hector's beliefs and practices, discovering them, however, to be fewer than originally anticipated. I had hypothesized, for example, at the outset of the investigation that there would be notable changes in the teachers' beliefs and practices related to the educational technology that both experienced during their participation in TACTICS. On the contrary, as I describe at length throughout this thesis, this is not observed to be the case. Thus, it is considered of the utmost importance to attempt to identify factors that appear to either promote or impede change within a classroom.

Motivating factors for change

A reconsideration of the data identifies positive factors that appear to promote certain changes in both teachers. Both teachers express a strong, intrinsic, very personal motivation to improve their teaching practices, to improve student participation and learning over the years. Some of this reflective attitude they attribute to the MEC, to the broad range of pedagogical information with a socioconstructivist view to which they were exposed, but it appears to include even more personal aspects. Maria, for example, says she gets bored doing the same thing, and has always looked for new ways of working with her students, means to improve their learning (P17). The teachers' own sense of efficacy, values, levels of concern, expectations of success and cost in terms of time and energy, to say nothing of their teaching culture, also influence their possible implementation of any innovation. Maria's fear of the computer limits her expectations and has kept her in a position of marginally legitimate peripheral participation throughout TACTICS, constraining her learning process of the new technology, although she now admits that she did gain from the experience. Hector's problems of time and energy are more of a limitation for him with regards to TACTICS as from the start he valued the use of the computer and had considerable expectations of success.

Hector has an additional motivating factor, that of improving his own identity and image as a teacher within his school community of practice, to be not just another

teacher. Both teachers evidently value their work as teachers and believe their efforts to be reasonably well rewarded by improved student participation and exam results, encouraging them to continue on this path. Here there is an evidently intimate link with the institutional definition of success and failure.

Hector also adds that part of his motivation has come from his contact with the educational investigators, both in TACTICS and in this study, an opportunity to see how to carry out a project over time, plus the constancy and energy required (P47). He has expressed numerous times that he would like to become an investigator, and that he felt as one at the start although he now says he's only a collaborator. He says he doubts he ever will become one, but this also reflects the much greater prestige given to teacher-investigators than to those who are "just" teachers within this context.

Maria has always been highly motivated to take nearly all the courses offered by the university for high school teachers, whereas Hector has only taken those of the MEC. Obviously the fact that Hector has his second job as a dentist in the afternoons greatly limits any time to attend extra courses. In spite of that, he does say that all teachers should be forced to take teacher-training courses at the very least, even if not a master's degree, a recognition of the importance to him of his exposure to new ideas, of his reflections of what it means to be a teacher (P47). An example of the influence of courses on Maria is shown when she describes that she took a course at the university in the summer of 2004 on critical, comprehensive reading and that she began to apply it in her classes this fall, before the strike (P17). Although she doesn't identify it as such, the strategy is definitely a collaborative one as she gives a text to the students in groups, and together they have to formulate a conclusion. At the end, each group has to explain the conclusion to the class, a technique which she finds very promising as the students are motivated to read with more care. Both teachers also mention that as well as taking specific courses, reading articles and books, even watching TV programs are sources of new ideas that they've tried out at different times.

Both teachers also say that all aspects of collaborating in this research project, be it through the classroom observations, interviews or questionnaires, have stimulated them to reflect on their own practices, eventually giving them a degree of confidence to try new strategies. Maria goes on to say that all new experiences help her to improve and grow as a person. Their joint participation in TACTICS has had little direct influence

on their teaching, but both recognize the positive factor of their widely expanded technological knowledge about the use of the computer as a result of this experience, especially Maria. Both say this allows them to look up information, to be up-to-date, as well as to facilitate the general work as a teacher, such as in writing exams and recording grades. Maria also notes that her greater familiarity with materials on Internet helps her to evaluate the quality of cut-and-paste work of many students that she had previously judged to be excellent. There are also tacit changes that are described that may be attributable to their exposure to concepts and practices of collaborative learning, as is the one example of Maria's unconscious transfer of strategies. Hector also mentions that the fact of belonging to a group such as TACTICS creates a certain pressure for him to be more constant in his own work as a teacher (P47).

One advantageous circumstance identified within the institutional context is teacher autonomy over what they do in the classroom, thus allowing them to organize their time and activities as they see fit, albeit within the institutional constraints of the prescriptive study plan and the type of evaluation. At the very least, this gives them the opportunity to try out any new strategies when ideas occur to them without fear of administrative restrictions.

Obstacles to change

Certain impediments to change have already been identified throughout the analysis, but it is critical to reiterate them in this final discussion because of their broader implications. The institutional context as such provides numerous major obstacles, such as the official, encyclopaedic study plan and the system of evaluation with standardized exams. Both teachers are in agreement that these two factors are barriers to change in their teaching practices, with their practices reflecting many aspects of these restrictions. Part of this is a matter of *time* as they are forced to cover the official curriculum over a closely specified period of time, training the students so that they can do well on the standardized exams, pressured to complete the list of topics by a given date. This leaves them with very little leeway to try more interesting strategies other than just teach the students to memorize biological definitions, with the consequence of limiting access to a full range of activities and possibilities for learning. The official system of evaluation totally ignores participation and negotiation, exclusively emphasizing the reification of legitimised, decontextualised knowledge from

the study plan and repeated on the exams, a perfect example in terms of the identity formation of both teachers and students of what Lave (1996) calls the "rituals of legitimisation or degradation and exclusion" (p. 10). The fact that the evaluation is based on the semestral exam that is composed solely of questions at lower cognitive levels makes the matter even more serious when one considers the implications of identity formation by means of this ritual.

However, beyond the curricular and evaluative constraints, there are the problems of power and control, considerations that Hector has mentioned throughout the study. He judges the school and greater institutional context to be full of political and personal competition, providing little or no support to the teachers. Maria does not appear to be so concerned with this aspect, with her interests and energy mainly focussed on what occurs in her own classrooms. Certainly the teaching culture promotes norms of non-interference and professional autonomy, which benefit individuals who are highly motivated, but it would appear to be an obstacle to collaborative work, which does not appear to occur at any level. Hector recognizes in the last interview (P47) that the university academies have the potential of promoting the sharing of teaching experiences and collaborative learning amongst the teachers, but that all they deal with are the administrative, normative matters related to teaching of each specific subject. He says there is no collaboration within the school either, just small groups within the larger, and that not even the small groups collaborate between the members (P47).

Nonetheless, Maria, once again an exception to the general observations, describes in her final interview (P17) a personal initiative to collaborate with another biology teacher who has had difficulties with his students as he just dictates from the same notes that he's been using for years. She very tentatively approached him to share some ideas, to show him a recent textbook that she likes. She says that he has been most grateful, has listened to her suggestions and has had excellent results using them, something that gives her great satisfaction for having shared her experiences with him. However, she says she wouldn't do it with other teachers in her school even if she thinks it could benefit them, as they are unapproachable, another reflection of the general teaching culture of the school.

Within the school context is also the traditional training of the students as passive note-takers. The fact that the students are reluctant participants at the outset, all too well

trained in their submissive role, is another obstacle that they have to face. In spite of the initial protests of the students when first exposed to Maria and Hector's more active teaching strategies, their final responses provide evidence that they are ready and able to change, even though Hector says it's very difficult to change the students' mental scheme of work. Maria says that the fact that the students work in a different way in her class doesn't cause conflicts for them in their other classes as they learn to adapt to each teacher, something that she asserts to be their part of their job as students. These conditions be taken into consideration by anyone promoting change within these schools, as well as what Hector calls the mentality of the administration and the other teachers; he believes that they are more interested in their own power and political status rather than in academic improvement, and that you can never be sure they'll fulfil what they promise.

One more factor has been recognized here as a constraint to change: the personal identity of each teacher. This is obviously a very difficult factor to deal with, but it must be taken into consideration. One essential aspect is each teacher's persistence in carrying through with their ideas. In this study, Maria has been seen as the more persistent, although it could also be attributed in part to her having one job (albeit in different areas, but all within the same institute) and fewer working hours, thus with more time to develop new strategies than Hector. Other factors are their attitude to change and their own self-confidence. Maria, for example, has demonstrated a very cautious approach to change, a certain lack of confidence in her own skills, as shown on the questionnaires, although at the same time, considerable tenacity regarding her beliefs. She appears to prefer to avoid confrontation, such as when she told me that a few years ago she'd tried to improve the level of the multiple choice questions on the semestral exams. She took to the biology academy meeting a question that I had given her from an International Baccalaureate exam that involved analysis, a higher cognitive level than the exams written by the group. The teachers in the academy could not understand it and became so incensed that she has never tried another one. Hector, on the other hand, seems to relish taking on the image of a rebel, an outsider, although he says they often don't take him into account because he thinks differently from the others, thus marginalizing himself in many aspects of the communities of practice to which he belongs.

Concluding remarks

The descriptive analysis of the data presented in this study indicates that both teachers have very strongly held systems of beliefs that lead them through their daily web of activities, as demonstrated by the notable degree of coherency of many of their beliefs and practices. Both teachers have shown continuous growth over the four years of collaboration with TACTICS and this research project, with changes in their expressed beliefs and observed actions, or, as defined by Lave (1996), with evidence of continued learning in both cases. These observed transformations also support Richardson's (1996) description of the interaction of the beliefs and practices, ones that are based on experience and reflection, all leading to progressive development of each teacher's personal practical knowledge and professional growth. While it seems clear that both teachers' beliefs provide the foundation on which they develop many of their teaching activities, or that their beliefs drive their practice, there is also evidence that their experiments with new strategies have led them to adjust their beliefs. This is further evidence of the interactive relationship between the two domains and of a gradual process of reconstruction of their model of teaching and learning of science. It is inferred that among their identified beliefs, the basic, most closely held ones continue to be that of teacher control with the teacher as the source of expert knowledge but also requiring student participation for its transmission, together with an essentially positivist conception of science. These beliefs act as the filters through which they have unconsciously viewed their exposure to new models. From the analysis, it becomes evident that both Maria's and Hector's conceptualisation of their role as a teacher and their corresponding practices are a fascinating, eclectic amalgamation of the traditional transmission of their expert knowledge with that of an interactive, constructivist touch, the "active transmission" model.

Overall, this exploratory study presents a richly detailed profile of the two Mexican high school biology teachers in terms of their beliefs and practices, both attempting to improve the teaching and learning processes in their classroom, both firmly embedded within their particular contexts but with clear indications of changes. Over these four years both have shown a transformation away from the fully teacher-centred, traditional model; Maria in particular appears to be in a transitional stage towards a more student-centred one[41] while Hector is still more on the traditional side of the balance. Their beliefs seem to be well

[41] See App. IX for the STAM matrix.

entrenched in their previous educational experiences, both as students themselves and as teachers, but these beliefs are constantly negotiated, or in some cases reinforced, with new experiences.

In the case of Maria and Hector, and indeed the entire institutional context, the teaching curriculum emerges as having far more relevance than the learning curriculum. Lave and Wenger characterize the learning curriculum as constantly evolving "situated opportunities" or a "field of learning resources...viewed from the perspective of learners" (1991, p 97) whereas the teaching curriculum is a set of instructions for learners that controls both the access to and the meaning of what is learned through the mediation of the teacher. The analysis presented here reveals a common teaching culture that exists throughout the specific context, one that is based on the teaching curriculum and that it is largely shared by Maria and Hector. The degree to which they share all the norms, beliefs and practices varies according to the particular context and the particular teacher, but the overall similarities are clearly visible. In general, the relationships of legitimisation of knowledge, of asymmetry of power, of perceptions of what it means to teach and to learn, are all similar elements that I have been able to identify. It would appear that the majority of the students give priority to getting passing grades and to the social context rather than worrying about a more significant level of learning, as has been seen in secondary students (Quiroz, 2000). Maria's ethics of care, a sincere concern for all her students, appears to be a very personal aspect of her teaching, based on her own system of values.

The theoretical framework of the three different but interrelated perspectives and the methodological procedures developed here provide a wealth of information with which it is possible to form a knowledge base of high school biology teachers in Mexico. The general methodology developed for this investigation is also applicable to other teachers independently of their subject matter, even though there is a certain emphasis here on science teaching. There are many avenues that could be investigated using the same data collected during the four years of the study, such as examining in depth specific pedagogical issues, as to which teaching strategies were more effective. Different research focuses could also be used on the data presented here to shed more light on the same extremely complex and highly significant issues. Also, in order to confirm the results presented here, an expanded investigation would necessarily include case studies of other biology teachers.

Despite the obvious limitations to the conclusions that may be drawn from such an exploratory study, the relevance of presenting these two teachers' beliefs and practices is evident. Even if the initial knowledge base is necessarily particular to their specific context, with more information one might formulate a model for more generalized conditions. The type of information provided by this study is also critical for planning courses for professional teacher development, as such courses should be based on the teachers' skills, knowledge, practices and the realities of their work context if they are to be effective (Lessard, 2004). Any strategic planning for institutional growth and reform necessitates an understanding of the level of commitment and identity of the professors with the institution (Árias, 2004). Their beliefs, their willingness to work, their objectives and values, their norms, sense of belonging, desire to continue are all essential to the degree of commitment.

In addition, this study supports the premise that during any processes of change or innovation within a school system, or even within a particular teacher's teaching practices as is the case here, it is essential that the teachers involved have sufficient, continuous support and enough time to try out the new strategies, to discuss them with colleagues, to reflect on them. In other words, they should have the possibility of forming an effective community of practice within which they can learn safely and productively. This extremely complex issue must be addressed, since it lies at the core of the healthy implementation of any educational system.

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Appendices

Appendix A: Examples of Discourse Analysis of Data with Atlas.ti

Figure 4: example of Atlas.ti analaysis of P31 (Hector)

This shows a portion of the analysis of the transcript of the interview with Hector after observing a class (P31). The transcript appears on the left side of the screen and the codes on the right side of the red line. The first window at the top shows the list of primary documents, the second isthe list of quotations, the third isthe list of codes and the fourth, the list of memos. The phrase that is marked in blue in the transcript corresponds to the code "school culture":

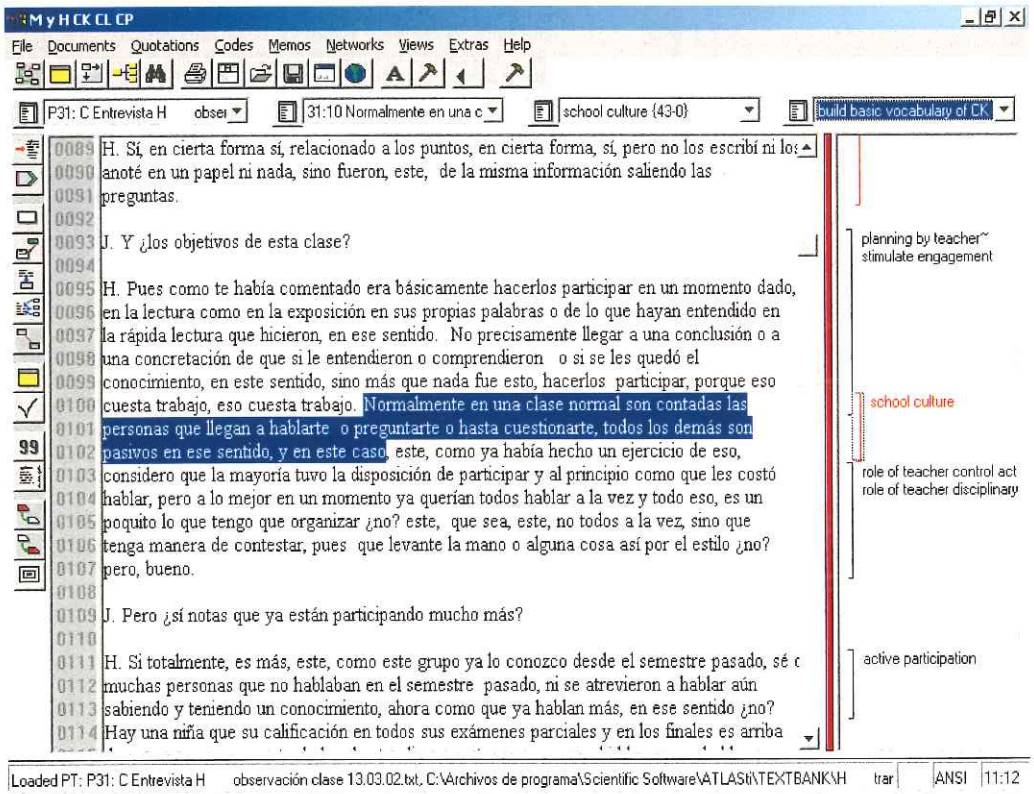
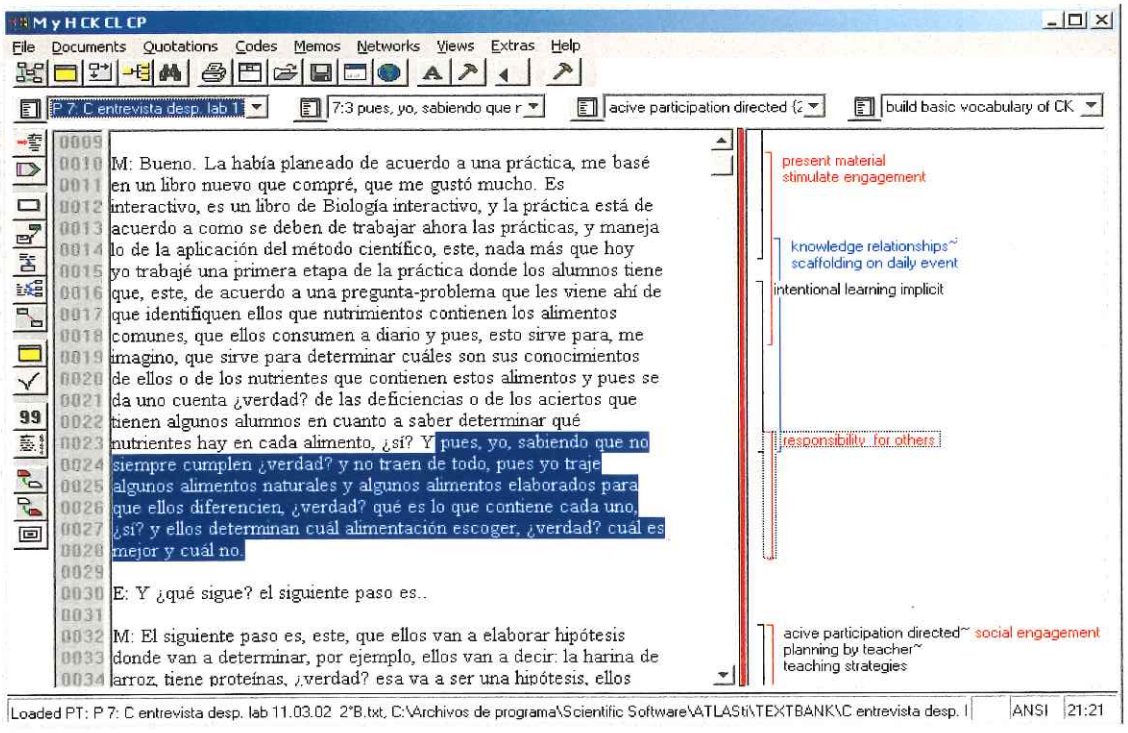


Figure 5: Example of Atlas.ti analaysis of P7 (Maria)

This shows a portion of the transcript of the interview with Maria after observing a laboratory practical (P7). The quotation marked in blue corresponds to the code of "responsibility for others".



Appendix B: Questionnaires

App. I: Cuestionario para profesores de ciencias

(Teacher Enhancement Assessment Instrument (TEAI), Dass, 1998)

Nombre:_____ Escuela:_____
Materia_____ Grupos:_____
Este cuestionario te ayudará examinar varios aspectos de instrucción , para dar evidencia de los aspectos en los cuales tu y tus alumnos están cambiando.
Usa la siguiente escala para indicar la frecuencia de las actividades en tus clases de ciencias: **N**: nunca, **P:** pocas veces, **O**: ocasionalmente, **F:** frecuente, **M**: muchas veces/siempre. Marca la columna que mejor describe la frecuencia de cada situación.

Escala de frecuencia: / Pregunta:	Nunca	Pocas veces	Ocasionalmente	Frecuente	Muchas veces
Mis alumnos usan la computadora para recoger, manipular y reportar data/información.					
Mis alumnos usan redes de computadoras.					
Mis alumnos usan una variedad de programas comerciales para computadoras.					
Mis alumnos usan la videocámara en investigaciones científicas.					
Mis alumnos usan el CD Rom.					
Mis alumnos usan el disco laser en sus investigaciones.					
Mis alumnos experimentan con tecnologías más allá de los listadas arriba.					
Mis alumnos diseñan experimentos para comprobar sus propias preguntas.					
Como profesor de ciencias, yo digo "No se".					
Mis alumnos usan el libro de texto.					
Los alumnos son permitidos o requeridos a expresar sus propias ideas y opiniones.					
Me siento bien trabajando sin un libro de texto.					
Me gusta enseñar la ciencia.					
Me siento cómodo involucrando a los alumnos en un tema de lo cual yo siento una falta de conocimiento.					
Permito a mis alumnos a investigar problemas y cuestiones que ocurren no pretendidos.					
Siento que mis conocimientos en ciencias son adecuados.					
Me siento cómodo tratando con diversas opiniones expertos que están en conflicto una con la otra.					
Me siento cómodo trabajando con otros profesores para mejorar mi programa de ciencia.					
Uso autoevaluación para mejor mi enseñanza (p.e. videograbación, audiograbación, evaluación de pares, etc.)					
Estimulo a los alumnos a coleccionar y evaluar información.					
Los alumnos generan preguntas en el aula					

Escala de frecuencia: Pregunta	Nunca	Pocas veces	Ocasionalmente	Frecuente	Muchas veces
1. Trabajo cooperativo con problemas y situaciones es parte de mi clase de ciencia					
2. Como maestro, yo aprendo junto con mis alumnos.					
3. Conciencia de carreras y exploración es una parte integral del aprendizaje de los alumnos.					
4. Como maestro de ciencias, quiero que mis alumnos tomen acción en los asuntos que investiguen.					
5. Valoro yo creatividad como parte del proceso científico.					
6. Relaciono ciencias a otros áreas del currículo, como matemáticas, idiomas, etc.					
7. Relevancia es una consideración primordial para mi en mi enseñanza de la ciencia.					
8. Mis alumnos identifican y usan recursos aparte de su libro de texto.					
9. Me encuentro usando técnicas más autenticas para evaluación.					
10. Mis alumnos determinan cuales actividades o investigaciones tomarán parte de sus estudios científicos.					
11. Mi programa de evaluación incluye autoevaluación de los alumnos.					
12. Mis alumnos están retados a aplicar conceptos en situaciones nuevas.					
13. Conceptos y principios científicos son evidentes en mi enseñanza.					
14. Mis alumnos ven la necesidad de cambiarse, ellos mismos y otros.					
15. La aplicación de conceptos y principios científicos es de la más alta prioridad para mi.					
16. Destrezas procedimentales son incorporados en forma natural en las investigaciones de los alumnos.					
17. Utiliza una variedad de estilos e estrategias de enseñanza en mis clases.					
18. Yo doy conferencias (yo presento los conceptos, etc.) como parte de mis clases de ciencias.					
19. Mis estudiantes están estimulados ver la conexión entre tecnología y su importancia en el futuro.					
20. Veo la necesidad de cambiarme a mi mismo y a otros.					
21. Los padres de familia están activamente involucrados en mi programa de ciencia.					
22. Trabajo con otros maestros en proyectos escolares.					
23. Involucro a los administradores en mi programa de ciencia.					
24. Expertos forman un recurso importante para mi programa de ciencia.					
25. Hago uso de científicos de las universidades o de la comunidad como recursos en mi enseñanza.					
26. Trato de integrar química, física, y biología todas las veces posibles.					
27. Prefiero enseñar la ciencia más que cualquier otra materia.					

Escala de frecuencia: Pregunta	Nunca	Pocas veces	Ocasionalmente	Frecuente	Muchas veces
28. Leo revistas profesionales.					
29. A veces me gusto enfocar actividades sin la necesidad de llegar a una conclusión.					
30. Investigo cuestiones o respuestas que ocurren sin previsto.					
31. Identifico temas tecnológicos actuales y los uso como un enfoque para mis clases.					
32. Hago el intento de que mis alumnos visualicen la ciencia en todo.					
33. No me preocupo cuando los alumnos hacen preguntas que no puedo contestar.					
34. Me gusta involucrar miembros de la comunidad en mis clases.					
35. Ayudo a mis alumnos a aprender hacer preguntas.					
36. Mis alumnos tienen la oportunidad de explicar sus ideas y razonamientos.					
37. Me entusiasma cuando los alumnos están en desacuerdo.					
38. Cuento con ideas y opiniones propias de mis alumnos.					
39. Contesto las preguntas de mis alumnos.					
40. Cuento con la planificación de los alumnos para solucionar problemas.					
41. Doy retroalimentación individual a mis alumnos.					
42. Hago preguntas.					
43. Ayudo a los alumnos comprobar sus propias ideas.					
44. Mis alumnos comparan ideas unos con los otros.					
45. Ayudo a los alumnos encontrar problemas y temas en la vida real para estudiar.					
46. Hago preguntas que estimulan el razonamiento de alto nivel.					
47. Participo en talleres que me ayudarán a mejorar mi enseñanza de ciencia.					
48. Me gusta compartir ideas de temas científicos y la enseñanza con otros profesores.					
49. Me satisface crear mis propias actividades de enseñanza.					
50. Es gratificante plantear una explicación de un fenómeno por primera vez.					
51. Involucro a los administrativos cuando necesito el apoyo de probar algo nuevo en mi clase.					
52. Cuento con los alumnos para aplicar lo que han aprendido en su clase de ciencia fuera del ámbito escolar.					

Indica en la línea correspondiente a cada ítem el número promedio de días durante el año escolar que has utilizado cada tipo de tecnología en tu enseñanza de las ciencias:
Tipo de computadora que utilizas más frecuentemente_____
Computadora _____
Base de datos de computadora _____
Modem _____
CD Rom _____
Videocasetera _____
Camera de vídeo _____
Otros (específica cuales) _____ _____
_____ _____
_____ _____
Nombres de programas de software que has usado:
_____ _____
_____ _____
_____ _____

Indica con el código de números con que frecuencia utilizas las siguientes formas de evaluación y cuando:

anualmente, 2- semestralmente, 3- mensualmente, 4- semanalmente, 5- diariamente, 6- nunca

Forma de evaluación	Cuándo	**Frecuencia**
Preguntas y otro material del libro de texto		
Portafolios		
Presentaciones/proyectos de los alumnos		
Diarios de trabajo de los alumnos		
Exámenes del libro de texto		
Mapas conceptuales		
Exámenes colegiados		
Autoevaluaciones		
Coevaluaciones de pares		
Observaciones del maestro		
Registro/evidencias anécdotas		
Instrumentos de evaluación diseñados por los alumnos		
Pre/post evaluación en estas áreas: conceptos destrezas procedimentales aplicaciones actitudes comprensión de la naturaleza de la ciencia creatividad		

Indica con una X los recursos que tú y tus alumnos utilizan en sus experiencias científicas:
Cartas escritas por Uds. _____
Teléfono _____
Entrevistas _____
Encuestas _____
Medias de comunicación (periódicos, radio, televisión) _____
Trabajo de campo _____
Miembros de la comunidad _____
Software comercial _____
Padres de familia _____
Científicos _____
Otros:

_____
_____
_____

Escribe los nombres del material curricular que utilizas, incluyendo el libro de texto, más otros libros, software, etc.:

_____
_____
_____
_____
_____

Estima el número de recursos humanos que has utilizado en tus clases en el último año:
Científicos: _____
Expertos del área _____
Padres de familia _____
Personas de la industria o comercio _____
Profesores _____
Administradores _____
Otros: _____ _____
_____ _____
_____ _____

Conocimientos aprendidos por mis alumnos por medio de proyectos, se comparten con:
El maestro (yo) _____
Los otros alumnos de su clase _____
Los alumnos de otros grupos _____
Administradores _____
Los padres de familia _____
La comunidad _____
Reuniones especiales _____

Indica las formas de comunicación que tu y/o tus alumnos han utilizado como: cartas, publicaciones, posters, etc.:

Forma	**# de veces usada por el maestro**	**# de veces usada por los alumnos**

Análisis del Desarrollo Profesional en 6 áreas:

Calidades de liderazgo: ítems 14, 15, 19, 30, 49, 50, 52, 55, 69, 71

Uso de estrategias constructivistas: Items 8, 11, 20, 21, 22, 29, 31, 33, 37, 38, 58, 60, 62, 65, 66, 67

Actitudes acerca a la enseñanza: ítems 13, 19, 23, 24, 25, 26, 27, 28, 36, 41, 48, 51, 59, 74

Confianza en su enseñanza: ítems 12, 16, 17, 34, 47, 49, 54, 67, 71, 72

Evidencia de colaboración: ítems 18, 42, 43, 44, 45, 46, 56, 70, 73

Integración de tecnología: ítems 1, 2, 3, 4, 5, 6, 7, 40, 53

Escala: nunca = 0.00, pocas veces = 1.00, ocasionalmente = 2.00, frecuentemente = 4.00, muchas veces = 4.00

App. II:Cuestionario de SoCQ

(Stages of Concern Questionnaire, 2000) con respecto a las innovaciones de la tecnología educativa:

Este cuestionario es para determinar las preocupaciones de personas que van a implementar nuevas innovaciones. Las frases fueron desarrolladas de respuestas de maestros con y sin experiencia con las innovaciones.
Por favor, contesta según tus preocupaciones que se te presentan **en este momento** tu participación o tu participación potencial en la tecnología educativa, en este caso, el uso de la computadora e Internet. Las frases que sí describen cuestiones relevantes para ti, escoge según el grado de intensidad, con más preocupación a la más alta en la escala. Escoge el número que mejor corresponde a tus intereses según la escala y escríbelo en frente del número de cada frase.

Escala de contestar:

0	1	2	3	4	5	6	7
No me preocupa ahora			Me preocupa algo ahora			Me preocupa mucho ahora	

1. Me preocupa las actitudes de los alumnos acerca de la tecnología educativa.
2. Yo ya conozco otras formas de trabajar que podrían funcionar mejor.
3. No se nada de esta tecnología educativa.
4. Me preocupa que no tengo suficiente tiempo en el día para organizarme bien.
5. Me gustaría ayudar a otros colegas en el uso de esta tecnología educativa.
6. Tengo conocimiento muy limitado acerca de la tecnología educativa.
7. Me gustaría saber ¿cuál sería el efecto de la implementación de la tecnología educativa en mi estatus profesional?
8. Me preocupan los conflictos entre mis intereses y mis responsabilidades.
9. Siento la necesidad de revisar mi uso de la tecnología educativa.
10. Me gustaría desarrollar relaciones de trabajo con los colegas de mi escuela o de otros centros educativos utilizando la tecnología educativa.
11. Me preocupa el efecto de la tecnología educativa en los alumnos.
12. No me interesa la tecnología educativa.
13. Me gustaría saber quiénes van a tomar decisiones acerca de la tecnología educativa.
14. Me gustaría discutir la posibilidad de usar la tecnología educativa.
15. Me gustaría saber cuáles recursos son accesibles, si decidimos implementar la tecnología educativa.
16. Me preocupa mi falta de capacidad que requiere la tecnología educativa.
17. Me gustaría saber, cómo mi forma de enseñar debe cambiar.
18. Me gustaría familiarizar otros departamentos o personas en el progreso de esta nueva forma de trabajar.
19. Me preocupa como evaluar mi impacto sobre los alumnos.
20. Me gustaría revisar la forma de enseñar con la tecnología educativa.
21. Estoy completamente ocupado con otras cosas.
22. Me gustaría modificar nuestro uso de la tecnología educativa según las experiencias de nuestros alumnos.

23. Aunque no conozco la tecnología educativa, me preocupan ciertos aspectos relaciones con la misma.
24. Me gustaría motivar a mis alumnos para involucrarse en esta tecnología educativa.
25. Me preocupa el tiempo usado en los problemas no-académicos relacionados con la tecnología educativa.
26. Me gustaría saber qué necesidades en el futuro inmediato necesitarán la tecnología educativa.
27. Me gustaría coordinar mi esfuerzo con otros para maximizar los efectos de la tecnología educativa.
28. Me gustaría tener más información del tiempo y energía requerido en el uso la tecnología educativa.
29. Me gustaría conocer qué están haciendo otros colegas en esta área.
30. En este momento, no tengo interés en aprender la tecnología educativa.
31. Me gustaría saber cómo complementar, mejorar o sustituir la tecnología educativa.
32. Me gustaría usar la retroalimentación de los alumnos para cambiar el programa.
33. Me gustaría saber cómo cambiar mi rol cuando uso la tecnología educativa.
34. En este momento la coordinación de trabajos y personas toma demasiado de mi tiempo.
35. Me gustaría conocer el beneficio que presenta el uso de la tecnología educativa.

Las Etapas de Preocupación: (SoC: stages of concern)
(Concerns Based Adoption Model (CBAM): Dass, 2000)

SoC 0: Concenciación (awareness)

etapas 0 y 1 al principio del programa

SoC 1: Informacional (informational)

SoC 2: Personal: Capacidad para llevar a cabo las innovaciones, estímulos correspondientes al tiempo y energía utilizados en la implementación, conflicto con prácticas de evaluación, si es cambio permanente, si hay apoyo administrativo e institucional

SoC 3: Administrativa (management) los aspectos de implementar la innovación, como organizar factores de tiempo (para organizar, planificar, evaluar, etc.), recursos (acceso a computadoras, etc), organización y control de los alumnos

SoC 4: Consecuencia (consequence): impacto de la innovación en los alumnos, evaluación del aprendizaje/productos de los alumnos y la necesidad para mejorar resultados (p.e. de resultados de exámenes colegiados)

SoC 5- Colaboración (collaboration): coordinación y cooperación con otros y a todos los niveles

SoC 6- Ajustar (Refocusing): relacionado con beneficios más universales como la posibilidad de mejorar los procedimientos para desarrollar e implementar las innovaciones

App. III: Evaluación del Desempeño Docente

(ANUIES, 2000, pp. 193-197)

Nombre del Profesor:_____

Curso:_____

Semestre:_____ Año:____ Colegio/Escuela:_____

Instrucciones: La universidad, con el objeto de poder ofrecerte una educación de calidad, requiere de tu colaboración en la evaluación del desempeño de tus profesores. La información que nos proporciones nos permitirá tomar las medidas necesarias para mejorar la docencia en los programas de estudio, con el objeto de que nuestros estudiantes cuenten con las condiciones óptimas para su formación.

Lee cuidadosamente cada uno de los enunciados de la columna del lado izquierdo y marca con una X en la columna de la respuesta que más se ajuste a lo que piensas sobre tu propio trabajo (preguntas 1-5) y del desempeño de tu profesor (6-38). Por todas las preguntas que no tengan una respuesta especial , utiliza las respuestas que vienen en el principio de cada columna (totalmente de acuerdo, etc.). Al final del cuestionario hay un espacio para que expreses cualquier otro aspecto que consideres de importancia sobre tu profesor y otro para que nos comentes cualquier preocupación o sugerencia sobre el programa y su organización. La información de este cuestionario se manejará en forma estrictamente confidencial.

Autoevaluación del estudiante:

Pregunta	**Totalmente de acuerdo**	**De acuerdo**	**Más o menos de acuerdo**	**En desacuerdo**	**Totalmente en desacuerdo**
1. Tuve un desempeño adecuado en la asignatura impartida por el profesor.					
2- Asistí a todas las sesiones del curso.					
3. Llegué puntualmente a todas las sesiones y permanecí hasta el final de cada sesión.					
4. Realicé todas las actividades y entregué todos los trabajos solicitados por el profesor.					
5. Número de horas que dediqué a la semana al curso impartido por el profesor.	Menos de una hora	1-2 horas	3-4 horas	5-6 horas	7 horas o más

Evaluación del desempeño docente:

Pregunta	Totalmente de acuerdo	De acuerdo	Más o menos de acuerdo	En desacuerdo	Totalmente en desacuerdo
6. ¿Domina el profesor los contenidos de la materia que enseña?					
7. ¿Prepara el profesor las clases o sesiones?					
8. ¿El profesor es ordenado en la exposición de los temas?					
9. ¿El profesor sigue una secuencia lógica en el orden de los temas del curso?					
10. ¿Procura el profesor relacionar los nuevos conocimientos con lo visto anteriormente?					
11. ¿Elabora el profesor síntesis o resúmenes de los revisado y de lo que se va explicar?					
¿12. ¿El profesor verifica al término de las sesiones, si los alumnos han comprendido lo estudiado?					
13. ¿Es claro el profesor en sus exposiciones?					
14. ¿Usa el profesor medios variados de apoyo al aprendizaje?					
15. ¿Cumple el profesor el horario establecido de clase y de tutorías?					
16. ¿El profesor motiva a los alumnos para asistir a tutorías y resolver dudas?					
17. ¿Demuestra respeto el profesor a los juicios y opiniones de los alumnos?					
18. ¿Dedica el profesor a los alumnos el tiempo necesario fuera de clase?					
19. ¿El profesor brinda una atención individual a los alumnos que la solicitan?					
20. ¿Trata respetuosamente a todos los estudiantes?					
21. ¿Promueve el profesor la participación de los alumnos en la elaboración y exposición de los temas?					
22. ¿Motiva el profesor a los alumnos para preguntar y participar en clase?					
23. ¿Impulsa el profesor el trabajo en grupo?					
24. ¿Fomenta el profesor el diálogo, la reflexión y el debate sobre los temas tratados?					
26. ¿Es justo el profesor en las evaluaciones?					
27. ¿Usa el profesor diferentes mecanismos de evaluación según los objetivos a evaluar?					

Pregunta	Totalmente de acuerdo	De acuerdo	Más o menos de acuerdo	En desacuerdo	Totalmente en desacuerdo
28. ¿Entrega el profesor con oportunidad los resultados de las evaluaciones realizadad?					
29. ¿Informa el profesor a los alumnos sobre los problemas detectados en la evaluación?					
30. ¿Entrega el profesor oportunamente el programa de la materia y los criterios de evaluación?					
31. ¿Distribuye el profesor adecuadamente el tiempo y las actividades para cumplir todos los objetivos del curso o unidad de enseñanza aprendizaje? (porcentaje)					
32.. ¿El profesor asiste a las sesiones programadas?	100%	Del 90%al 99%	Del 80 al 89%	Del 70 al 79%	Menos del 70%
33. ¿El profesor inicia con puntualidad las sesiones programadas? (porcentaje)	100%	Del 90%al 99%	Del 80 al 89%	Del 70 al 79%	Menos del 70%
34. ¿El profesor termina puntualmente las sesiones programadas? (porcentaje)	100%	Del 90%al 99%	Del 80 al 89%	Del 70 al 79%	Menos del 70%
35. ¿Se lograron los objetivos en el curso?					
36. ¿Considera muy importante para su formación lo aprendido en este curso?					
37. ¿Recomendaría a otros alumnos inscribirse en los cursos que imparte el profesor?					
38. ¿Cómo evaluaría globalmente el desempeño de su profesor?	Excelente	Muy bueno	Más o menos bueno	Malo	pésimo

Comentario sobre cualquier otro aspecto que consideres de importancia sobre tu profesor:_____

_____

_____

_____

_____

_____

Comentario sobre cualquier preocupación o sugerencia sobre el programa y su organización:_____

_____

_____

_____

_____

App. IV:Encuesta del Ambiente de Aprendizaje Constructivista

(Salish I, 1997)
Forma para el Profesor de Ciencias

Fecha:_____ Nombre del Profesor:_____
Escuela:_____ Nombre del Curso:_____

Instrucciones: para cada frase, marca la columna que mejor describe como te sientes en tu clase. Por favor, considera cada ïtem con cuidado y contesta cada uno.

En esta clase...	**Casi siempre**	**Frecuente mente**	**A veces**	**Ocasional mente**	**Casi nunca**
1. Los alumnos aprenden del mundo fuera de la escuela.					
2. Los alumnos aprenden que las teorías científicas son invenciones humanas.					
3. Está bien que los alumnos pregunten "¿Porqué tenemos que aprender esto?"					
4. Los alumnos me ayudan a planificar qué van a aprender.					
5. Los alumnos tienen la oportunidad de intercambiar ideas.					
6. Los alumnos esperan con ansiedad las actividades de aprendizaje.					
7. El aprendizaje nuevo empieza con problemas del mundo externo de la escuela.					
8. Los alumnos aprenden que la ciencia está influenciada por los valores y opiniones de la gente.					
9. Los alumnos se sienten con libertad de cuestionar la forma en que les están enseñando.					
10. Los alumnos ayudan al maestro a decidir cómo va su aprendizaje.					
11. Los alumnos hablan entre ellos de cómo resolver problemas.					
12. Las actividades en esta clase son de las más interesantes en la escuela.					
13. Los alumnos aprenden cómo la ciencia puede ser parte de su vida fuera de la escuela.					
14. Los alumnos aprenden que las opiniones de la ciencia han cambiado con el tiempo.					
15. Es conveniente que los alumnos expresen inconformidad de actividades que son desconcertantes.					
16. Los alumnos ayudan a decidir las reglas para las discusiones en clase.					
17. Los alumnos tratan de entender las ideas de los otros.					
18. Las actividades hacen que los alumnos se interesan más en la ciencia.					
19. Los alumnos entienden mejor el mundo externo de la escuela.					
20. Los alumnos aprenden que hay diferencias en la ciencia que utiliza la gente con diferente cultura.					

En esta clase...	Casi siempre	Frecuente mente	A veces	Ocasional mente	Casi nunca
21. Está bien que los alumnos manifiesten sus dudas de cualquier cosa que no les permita aprender.					
22. Los alumnos ayudan a decidir cuánto tiempo van a necesitar por cada actividad.					
23. Los alumnos solicitan a los otros que expliquen sus ideas.					
24. Los alumnos disfrutan de las actividades de aprendizaje.					
25. Los alumnos aprenden cosas interesantes acerca del mundo externo de la escuela.					
26. Los alumnos reconocen que es posible cuestionar el conocimiento científico.					
27. Los alumnos son libres de expresar sus opiniones.					
28. Los alumnos participan explicando sus ideas a los demás.					
29. Los alumnos se sienten confundidos.					
30. Lo que aprenden los alumnos no tiene relación con su vida externo de la escuela.					
31. Los alumnos aprenden que la ciencia revela los secretos de la naturaleza.					
32. Es correcto que los alumnos apoyen los derechos de los demás.					
33. Los alumnos ayudan a decidir qué va a incluir en un examen.					
34. Los alumnos explican sus ideas a los demás					
35. Las actividades de aprendizaje son una pérdida de tiempo.					
36. Los alumnos ayudan a decidir qué actividades van a hacer.					
37. Qué los alumnos aprendan no tiene nada que ver con el mundo fuera de la escuela.					
38. Los alumnos aprenden que el conocimiento científico es verídico, sin dudas.					
39. Los alumnos se sienten sin la posibilidad de cuestionar lo que acontece en el aula.					
40. Los alumnos ayudan a decidir cómo su aprendizaje va a ser evaluado.					
41. Los alumnos ponen atención a las ideas de los demás.					
42. Los alumnos se sienten tensos.					

Guía para Calificar la Forma:

Este instrumento consiste en frases positivas y negativas de las cuales los maestros deben contestar en la escala desde "casi siempre" hasta "casi nunca". Para los ítems positivos el "casi siempre" recibe 5 y el "casi nunca" recibe 1. En un ítem negativo, el valor es contrario.

Ejemplo:
1. En esta clase...los alumnos aprenden del mundo externo de la escuela.
Es un ítem positivo. La respuesta "frecuentemente" equivale 4 puntos, empezando con "casi siempre" con 5 puntos.

2. Lo que los alumnos aprenden no tiene nada que ver con el mundo externo de la escuela.
Es un ítem negativo y "frecuentemente" equivale 2 puntos, empezando con "casi nunca" de 5 puntos.

I. ESCALA DE RELEVANCIA PERSONAL (RP)

Esta escala se evalúan las experiencias de los alumnos acerca de la relevancia personal de la ciencia escolar como percepciones de los maestros. Desde la perspectiva constructivista, el ambiente del aula no debe promover una discontinuidad entre la ciencia escolar y las vidas externa de la escuela de los alumnos, por medio de una imagen abstracta y descontextualizada de la ciencia. O sea qué, el ambiente del aula debe involucrar a los alumnos con oportunidades de:
a) tener la experiencia de relevancia de la ciencia escolar en sus intereses y actividades cotidianas.
b) usar sus experiencias cotidianas en un contexto con sentido para el desarrollo de su conocimiento científico formal.

Items:

1. (+)	30. (-)
7. (+)	37. (-)
13. (+)	
19. (+)	
25. (+)	

II. ESCALA DE INCERTIDUMBRE CIENTÍFICA (IC)

Esta escala se evalúa como perciben por los maestras las concepciones de sus alumnos de la ciencia como una actividad humana falible. La escala está diseñada para medir hasta qué punto los maestros perciben que sus alumnos conciben la ciencia como una actividad sin certeza y evolucionando dentro de un contexto cultural, englobando valores e intereses humanos. Desde la perspectiva constructivista, el ambiente del aula no debe promover: 1. Un punto de vista "scientifistic" de la ciencia como una actividad suprema universal y mono cultural que es independiente de intereses y valores humanos; ni 2. El mito "objectivist" que la ciencia da a una representación exacta y cierta de la realidad objetiva (p.e. una teoría correspondiente de la verdad). O sea qué, el ambiente del aula debe promover oportunidades para que los alumnos aprendan a ser escépticos y críticos de la naturaleza y del valor de la ciencia. En particular, aprender que:

a) conocimiento científico está evolucionando y es provisional;
b) el conocimiento científico está formado por influencias sociales y culturales;
c) el conocimiento científico inicia de los intereses y valores humanos.

Items:

2. (+) 31. (-)
8. (+) 38. (-)
14. (+)
20. (+)
26. (+)

III. ESCALA DE LA VOZ CRITICA (VC)

Esta escala trata el desarrollo de los alumnos como aprendices autónomos. En particular, esta escala ha sido diseñada para que los maestros evalúen las percepciones de los alumnos a tal grado que puedan ejercitar legítimamente en voz crítica sobre la calidad de sus actividades de aprendizaje. Desde una perspectiva constructivistas, el ambiente del aula no debe favorecer intereses curriculares técnicos (p.e. cubriendo el contenido del currículos) a tal punto que la responsabilidad por las actividades es principalmente dirigida hacia una autoridad externa. O sea que el maestro debe estar dispuesto de mostrar su responsabilidad a su clase promoviendo actitudes criticas de los alumnos hacia las actividades de enseñanza-aprendizaje. Esto se puede realizar creando un clima social en el cual los alumnos sientan que es legítimo y benéfico:

a) Cuestionar los planos y métodos pedagógicos del maestro.
b) Expresar los problemas que son obstáculos para su aprendizaje.

Items:

3. (+) 39. (-)
9. (+)
15.(+)
21. (+)
27. (+)
32. (+)

IV: ESCALA DEL CONTROL COMPARTIDO (CC)

Esta escala trata otro aspecto importante en el desarrollo de la autonomía del estudiante, o sea, los alumnos comparten con sus maestros el control del ambiente de aprendizaje en el aula. En particular, la escala ha sido diseñada para medir hasta que nivel el maestro involucra a los alumnos en el control del ambiente de aprendizaje en la aula. Desde una perspectiva constructivista, los alumnos no deben estar presionados para adoptar el papel tradicional de receptores pasivos de una pedagogía predeterminada completamente controlado por el maestro. O sea qué, el maestro debe motivar a los alumnos a compartir el control de aspectos importantes de su aprendizaje por medio de oportunidades de participación en los procesos de:

(a) diseñar y controlar sus propias actividades de aprendizaje
(b) determinar y aplicar criterios de evaluación
(c) negociar las normas sociales del aula.

Items:
4. (+)
10. (+)
16. (+)
22. (+)
33. (+)
36. (+)
40. (+)

V. ESCALA DE NEGOCIACIONES ESTUDIANTILES (NE)

Esta escala ha sido diseñada para medir las percepciones de los maestros acerca del nivel de interacción verbal entre los alumnos, con el propósito de construir su conocimiento científico dentro del aula. Desde una perspectiva constructivista, el ambiente del aula no debe requerir que los alumnos aprendan en aislamiento social de los otros alumnos, tampoco deben pensar que el maestro o el libro de texto son las fuentes principales de la verdad del conocimiento científico. O sea que el ambiente del aula debe fomentar en los alumnos para:

(a) explicar y justificar sus ideas nuevamente desarrollándose a otros alumnos.
(b) entender las ideas de otros alumnos y reflexionar en la veracidad de ellas.
(c) reflexionar críticamente en la veracidad de sus propios ideas.

Items:
5. (+)
11. (+)
17. (+)
23. (+)
28. (+)
34. (+)
41. (+)

VI. ESCALA DE ACTITUDES (AC)

Esta escala ha sido incluida para dar una medida de la validez del cuestionario. La escala de actitudes ha sido utilizada mucho en investigaciones sobre las clases prácticas de ciencia y tiene una fiabilidad. La escala mide las interpretaciones de los maestros acerca de las actitudes de los alumnos hacia aspectos importantes del ambiente del aula, incluyendo:

1. su anticipación de actividades
2. su sentido de la utilidad de las actividades
3. el impacto de las actividades en los intereses, gustos y comprensión de los alumnos.

Items:

6. (+)	29. (-)
12. (+)	35. (-)
12. (+)	42. (-)
24. (+)	

App. V: La Naturaleza e Implicaciones de Ciencia/Tecnología

Forma para los Maestros
(Salish I, 1997)

Fecha_____ Nombre_____

Escuela_____ Curso_____

Instrucciones: Por cada oración, marca la columna que mejor describe tu opinión sobre la declaración. Por favor considera cada ítem con cuidado y contesta cada uno.

	Muy de acuerdo	De acuerdo	No estoy seguro	Estoy en desacurerdo	Muy en desacuerdo
1. La ciencia en su forma básica es de cuestionar, explicar y comprobar.					
2.La ciencia es un intento humano de conocer más del mundo alrededor.					
3. La tecnología es nuestro intento de manipular el mundo físico para resolver problemas prácticos.					
4. La ciencia está limitada a trabajar con varios objetos y materiales en el aula o laboratorio.					
5. La ciencia es frecuentemente el peor enemigo de la humanidad.					
6. Teorías y/o conceptos básicos de la ciencia nunca se deben desafiar.					
7. La ciencia está vista en forma general como una manera de estudiar el universo y cómo funciona.					
8. La tecnología hace la vida mejor para la humanidad.					
9. La ciencia ofrece una manera de entender la naturaleza.					
10. Este país gasta demasiados recursos en el avance de la ciencia básica.					
11. La ciencia es una actividad que se debe llevar a cabo en un laboratorio.					
12. La mayor parte de los científicos se preocupan por los efectos potenciales, benéficos y perjudiciales, que podrían resultar de sus descubrimientos.					
13. Las conclusiones de científicos pueden cambiarse en el futuro.					
14. Los científicos deben tener la responsabilidad por los daños que podrían resultar de sus descubrimientos.					
15. Los descubrimientos científicos se hacen mejor por medio de experimentos bien planeados.					

	Muy de acuerdo	De acuerdo	No estoy seguro	Estoy en desacurerd	Muy en desacuerdo
16. Conocimiento de ciencia y tecnología ayuda a individuos tratar con problemas cotidianos.					
17. Tecnología no tiene mucho que ver con investigaciones científicas.					
18. Ciencia y tecnología ayudan a resolver problemas sociales.					
19. Los que desarrollan la tecnología deben tener la responsabilidad por los daños que podrían resultar de sus esfuerzos.					

Guía para calificar las respuestas:

Este instrumento contiene oraciones positivas y negativas de las cuales los alumnos deben contestar en una escala desde "muy de acuerdo" hasta "muy de desacuerdo". En las oraciones positivas, el "muy de acuerdo" equivale 5 hasta "muy de desacuerdo" equivale un punto. En oraciones negativas, el valor es contrario.

Por ejemplo:
La primera oración es positiva: "La ciencia en su forma básica es de cuestionar, explicar y comprobar." Aquí una respuesta "de acuerdo" equivale 4 puntos, y una de "muy de desacuerdo" equivale 1, etc.

La cuarta oración es negativa: "La ciencia está limitada a trabajar con varios objetos y materiales en el aula o laboratorio." Aquí una respuesta "de acuerdo" equivale 2 puntos y una de "muy de desacuerdo" equivale 5, etc.

El total de puntos es la suma de los valores.

La Naturaleza de Ciencia (I)

1. +
2. +
4. -
6. -
1. +
9. +
11. –
13. +
15. +

La Naturaleza de Tecnología (II)

3. +
17. -

Implicaciones Sociales de la Ciencia (III)

5. -
10. -
12. +
14. -
16. +
18. +

Implicaciones Sociales de Tecnología (IV)

8. +
16. +
18. +
19. –

I. **El Perjuicio de Ciencia/Tecnología**

14. (-)
19. (-)

La puntuación de este escala se calcula sumado los puntos del ítem 14 con los del 19 con un total de 2 hasta 10 puntos, con la puntuación baja indicando que los científicos deben ser responsables por daños de sus esfuerzas. La consistencia interna es .78.

II. **Las Implicaciones Sociales de la Ciencia**

2. (+)
3. (+)
5. (-)
7. (+)
8. (+)
9. (+)
10. (-)
12. (+)
16. (+)
18. (+)

La puntuación de esta escala se calcula sumando los puntos de los ítems 2, 3, 5, 7, 8, 9, 10, 12, 16 y 18, con un total de 10 hasta 50 puntos. La consistencia interna de esta escala es .61.

III. **La Naturaleza de Ciencia**

1. (+)
4. (-)
6. (-)
11. (-)
13. (+)
17. (-)

La puntuación de esta escala se calcula sumando los puntos de los ítems 1, 4, 6, 11, 13, y 17 con un total de 6 hasta 30 puntos. La consistencia interna de esta escala es .55.

App. VI: Su perfil de la naturaleza de la ciencia (NOS)

(Monks and Dillon, 1995)

Este cuestionario está diseñado para dar una idea de su filosofía de la ciencia. Por favor, lea cada oración cuidadosamente. Otórguele a cada frase una puntación que vaya de "muy de acuerdo" (+5) a "muy en desacuerdo" (-5) y escríbala a lado de cada frase. Una puntación de 0 indica que se tiene una visión balanceada sobre la cuestión planteada en la frase. Una puntación de +3, por ejemplo, sería "bastante de acuerdo", -2 sería "en desacuerdo", etc.

Escala:

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
muy en desacuerdo					balanceada				muy de acuerdo	

CUESTIONARIO

1. Los resultados obtenidos por los alumnos en sus experimentos son tan válidos como los de cualquier otra persona. (RP)
2. La ciencia es esencialmente una materia para el sexo masculino. (CD)
3. Los hechos científicos son aquellos sobre los cuales los científicos están de acuerdo. (CD, RP)
4. La meta de la ciencia es descubrir la realidad. (IR)
5. Los científicos no tienen ni idea de cuáles vayan a ser los resultados de sus experimentos hasta no hacerlos. (ID)
6. La investigación científica está determinada por factores políticos y económicos. (CD)
7. La educación en las ciencias debería de estar más relacionada con el aprendizaje de los procesos científicos que con el aprendizaje de hechos científicos. (PC)
8. Los procesos de la ciencia no tienen que ver nada con consideraciones éticas y morales. (CD)
9. La parte más valiosa de la educación científica es la que permanece después de que los hechos han sido olvidados. (PC)
10. Las teorías científicas son válidas si funcionan. (IR)
11. La ciencia procede extrayendo conclusiones generalizables a partir de los datos disponibles. (ID)
12. No existen teorías científicas verdaderas. (RP, IR)
13. Las emociones humanas no tienen ningún papel en la creación del conocimiento científico. (CD)
14. Las teorías científicas describen un mundo exterior real que es independiente de la percepción humana. (RP, IR)
15. Es necesario que un joven científico tenga un conocimiento sólido de los hechos científicos básicos y de la tradición científica heredada para que pueda hacer descubrimientos propios. (PC)
16. Las teorías científicas han cambiado a través del tiempo sencillamente porque las técnicas experimentales han mejorado. (RP, CD)

17. El método científico puede transferirse de una investigación científica a otra. (PC)
18. En la práctica, se escoge entre teorías rivales solamente sobre la base de los resultados experimentales. (CD, RP)
19. Las teorías científicas son resultado tanto de la imaginación y la intuición como de la inferencia a partir de resultados experimentales. (ID)
20. El conocimiento científico es diferente de otros tipos de conocimiento en cuanto a su mayor prestigio. (RP)
21. Existen algunos eventos físicos en el universo que la ciencia nunca podrá explicar. (RP, IR)
22. El conocimiento científico es moralmente neutro- solamente la aplicación de este conocimiento está éticamente determinado. (CD)
23. Todos los experimentos y las observaciones científicas están determinados por las teorías existentes. (ID)
24. La ciencia se caracteriza esencialmente por el método y los procesos que utiliza. (PC)

PARA ANALIZAR EL PERFIL:

Utilice sus respuestas, usando nuestro sistema de puntuación, para encontrar su concepción de la naturaleza de la ciencia. Busque las iniciales que están entre paréntesis al final de cada frase. Coloque su respuesta en la columna apropiada (algunas respuestas se colocarán en dos columnas distintas). Algunas respuestas tendrán que ser cambiadas de signo (multiplicadas por –1) antes de poder ser usadas. Esto será indicado en la columna correspondiente por un signo de menos ("-") junto al número de la frase. Por ejemplo, si su respuesta a la frase 1 es –3, entonces tendrá que colocar en la columna marcada RP un +3 en el lugar asignado.

RP			**ID**			**CD**			**PC**			**IR**		
Oración		puntos	Oración		puntos	Oración		puntos	Oración		puntos	Oración		puntos
1	-		**5**	-		**2**	-		**7**	-		**10**	-	
3	-		**11**	-		**3**	-		**9**	-		**21**	-	
21	-		**19**	+		**6**	-		**17**	-		**4**	+	
12	+		**23**	+		**8**	+		**24**	-		**12**	+	
14	+		**total**			**13**	+		**15**	+		**14**	+	
16	+					**16**	+		**total**			**total**		
18	+					**18**	+							
20	+					**22**	+							
total						**total**								

Sume el total de cada columna y transfiera el resultado al lugar correspondiente en el eje apropiado. Una los puntos de cada eje. Este es su perfil en este momento.

Relativismo **RP** Positivismo

- 40 - 32 - 24 - 16 -8 0 8 16 24 32 40

Inductivismo **ID** Deductivismo

-20 -16 -12 -8 -4 0 4 8 12 16 20

Contextualismo **CD** De-Contextualismo

-40 -32 -24 -16 -8 0 8 16 24 32 40

Impulsado por el proceso **PC** Impulsado por el contenido

-25 -20 -15 -10 -5 0 5 10 15 20 25

Instrumentalismo **IR** Realismo

-25 -20 -15 -10 -5 0 5 10 15 20 25

App. VII: Inventario para Evaluación Demográfica de Escuelas y Programas de Formación de Docentes (Salish I, 1997)

Nombre _____ tel._____
Dirección _____
_____
Nombre de laEscuela _____

1. Edad_____ sexo: F o M

2. Estudios profesionales con los años correspondientes:

_____
_____
_____
_____
_____
_____

3. Indica las materias, el número de grupos y el nivel de cada materia que estás enseñando este semestre:

Materia	# grupos	Nivel
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

¿Cuántas horas estás en frente al grupo cada semana?_____

4. ¿Qué otras responsabilidades y/o actividades no académicas tienes en la escuela?

_____
_____
_____
_____
_____

5. En los últimos tres años, ¿Has asistido a algunas conferencias o cursos sobre la enseñanza de ciencias? ¿Cuál era el título? ¿Dónde? ¿Cuándo?

_____
_____
_____
_____
_____
_____

6. ¿Usas un libro de texto en tus clases?_____
¿Cómo se llama el libro? _____
¿Cuáles otros materiales utilizas? (videos, manuales,etc.)_____

7. En promedio, ¿Cuántas horas dedicas a la semana para preparar tus clases?
Ninguna_____ 1-5_____ 6-10_____ 11-15_____ 16-20_____

8. Indica cuáles métodos utilizas para medir la comprensión de tus alumnos
Trabajo grupal _____ Pruebas de opción múltiple_____
Hojas de trabajo_____ Pruebas de falso-verdadero_____
Discusiones con alumnos _____ Preguntas de complementación_____
Ensayos o respuestas cortas _____ Proyectos_____
Reportes orales _____ Reportes escritos de laboratorio _____
Portafolios de trabajos _____ Tareas _____
Mapas conceptuales _____ Investigaciones _____
Otros_____

9. Escribe en orden tus tres metas principales para el aprendizaje de tus alumnos:
La más importante:

La segunda más importante:

La tercera más importante:

10. Describe tus experiencias con el uso de computadoras en tu enseñanza:
_____
_____
_____
_____
_____

11. ¿Cómo podrías clasificar la comunidad de tu escuela?
_____ rural; población < 2,000
_____ pueblo pequeño; población 2,000-5,000
_____ pueblo mediano; población 5,000-10,000
_____ ciudad pequeña; población 10,000-25,000
_____ ciudad mediana; población 25,000-100,000
_____ ciudad grande, periferia; población > 100,000
_____ ciudad grande, central; población > 100,000

12. ¿Cuáles son los niveles socioeconómicos de la mayor parte de los alumnos en tu escuela? (en %):

_____ nivel bajo
_____ nivel medio baja
_____ nivel medio
_____ nivel medio alto
_____ nivel alto

13. ¿Cuántos alumnos hay en tu escuela?_____

Video Portafolio y Observaciones en el Aulas
1. Diario del Contenido de la Unidad (Salish I)

Contenido de la Unidad (hechos y conceptos principales, procesos, aplicaciones, actitudes, formas de pensar como un científico en la unidad.) Puede ser un bosquejo, una mapa conceptual o cualquier otra representación que quieres. Por favor de incluir suficiente detalle para que otra persona pueda crear una imagen mental de la unidad.

2. Diario

Fecha_____ Nombre_____

Escuela_____ Curso_____

Día 1 2 3 4 5 # de la vídeo cinta_____

Planificación de la Clase: Completa las preguntas 1-4 antes de enseñar la clase.

Tema de la clase_____

1. Contenido (hechos y conceptos claves, procesos, aplicaciones, actitudes, formas de pensar como un científico incluidas en la clase).

2. ¿Cuáles son tus metas, propósitos, objetivos? ¿Cómo contribuye esta clase a tus metas por la unidad?

3. ¿Cuáles conocimientos, destrezas, actitudes, etc. tenían tus alumnos antes de la clase? ¿Cómo los puedes diagnosticar?

4. Materiales y/o textos para usar:

Reflexión: Completa la preguntas 5 y 6 después de la clase.

_____ número de alumnos presente

5. Resume las actividades que duraron cuando menos tres minutos:

Actividades	Cómo esta actividad contribuyó a tus metas

6. ¿Cómo sabes que tus alumnos aprendieron lo que querías que aprendieron?

Completa la siguiente pregunta al final de la unidad de estudio.

7. Se podrías rehacer esta unidad de estudio, ¿qué cambiarías?

App. VIII: Entrevista sobre la Filosofía Pedagógica de los Maestros

(Salish I)

Nivel I: Preguntas de la Entrevista

1. ¿Cómo te describes a tì mismo como maestro?
2. ¿Qué modelo tienes para tì como maestro?
3. Describa un aula bien organizado. Cuando tienes tu aula funcionando como te gusta, ¿cómo es?
4. ¿Cómo formulaste este modelo de un aula bien organizado?
5. ¿Cuánto tiempo tardaste para desarrollar este modelo de enseñanza?
6. ¿Qué consideras como los principios más básicos de enseñar?
7. ¿Cómo aprendes mejor?
8. ¿Cómo sabes cuando haz aprendido algo?
9. ¿Cómo sabes cuando entiendes algo?
10. Cuando imaginas un buen aprendiz, ¿qué características consideras de esta?
11. ¿Cómo decides qué enseñar y qué no enseñar?
12. ¿Cómo decides cuándo mover de un concepto a otro?
13. ¿Cuál aprendizaje en tu aula crees que sea valioso para tus alumnos fuera del aula?
14. Describe la mejor situación de enseñanza/aprendizaje que has tenido.
15. ¿Cómo intentas modelar esta situación en tu propia aula?
16. ¿Cuáles son las limitaciones para implementar este modelo en tu aula?
17. Menciona algunas estrategias que usas para vencer estas limitaciones.
18. ¿Hay algo a nivel local/escolar/estatal que influya en la forma que enseñas? Da unos ejemplos.
19. ¿Cómo crees que tus alumnos aprenden mejor?
20. ¿Cuándo sabes que tus alumnos entienden un concepto?
21. ¿Cuándo sabes que hay aprendizaje en tu aula?
22. ¿Cómo transformas el ambiente educativo para maximizar la comprensión de los alumnos?
23. ¿Qué conceptos de ciencia crees más importantes para que los alumnos entiendan al final del curso?
24. ¿Cómo quiere que tus alumnos piensen de ciencias al final del curso escolar?
25. ¿Qué valores quieres desarrollar en tus alumnos?
26. ¿Qué crees que tus alumnos valoran más de su experiencia educativa en tu clase? Cuando salen de tu aula, dicen "Me gustó mucho esta clase porque _____."
27. ¿Cómo comparas tus estrategias de enseñar este año con las del año pasado? ¿Porqué son las mismas/diferentes?
28. ¿Cómo trabajos con alumnos con necesidades especiales?
29. ¿Cuáles crees que sean tus puntos más positivos como maestro?
30. ¿En qué áreas te gustaría mejorar como maestro?
31. ¿Cuándo te diste cuenta qué tuviste un efecto positivo en tus alumnos,y qué estabas mejorando como maestro?
32. ¿Han sido provechosos los cursos de pedagogía que has tomado en la Maestría? ¿En qué manera?
32. Fueron provechosos los cursos de ciencias que tomaste en la universidad cuando empezaste a enseñar? ¿En qué manera?

33. ¿Qué cambios harías en los cursos de pedagogía en la Maestría para hacer la experiencia más relevante?
33. ¿Qué cambios harías en los cursos de ciencias en la universidad para hacerlos más relevantes?
34. De los siguientes cursos o factores, ordénalos según el impacto de cada uno en la formación de tu modelo de enseñanza:

_____ cursos de licenciatura
_____ los cursos de la Maestría
_____ otros cursos
_____ tus experiencias en el aula
_____ cualquier otro factor.

App. IX: Matriz de Análisis del Maestro de Secundaria: Versión Ciencia

Secondary Teacher Analysis Matrix- Science Version: STAM
Salish I: Michigan State University, 1995 (Sent by J. Gallagher, sept. 2000)

Contenido

	A Didáctico	B Transitorio	C Conceptual	D Constructivista principiante	E Constructivista experto	F Indagación Constructivista
1 Estructura del contenido	Contenido factual, *factoides*	Contenido que tiende a ser descriptivo con conceptos y factoids con el mismo énfasis	Contenido que tiende a ser explicativo con contenido conceptual organizado alrededor de ideas claves	Maestro y alumnos negocian la comprensión de *ideas claves* con el contenido del maestro enfatizado	Maestro y alumnos negocian la comprensión de ideas claves basados en las ideas y contenido de los alumnos	Investigaciones dominan el contenido. Contenido conceptual y conexiones son parte del diseño, realización, análisis y reporte de la investigación
2 Ejemplos y conexiones	Sin ejemplos o interconexiones al: a. eventos del mundo real b. ideas relacionados c. ideas claves del tema	Ejemplos del mundo real con/o ideas relacionados separados de otros partes del contenido	Ejemplos y conexiones hechos por el maestro a: a. eventos del mundo real b. ideas relacionadas c. ideas claves del tema	El maestro lleva alumnos en uso de ejemplos y construyendo conexiones a: a. eventos del mundo real b. ideas relacionados c. ideas claves del concepto	Conexiones hechas por alumnos con consejo del maestro a: el mundo real b. ideas relacionados c. ideas claves del concepto	Conexiones construidas por alumnos relacionadas a la investigación, análisis de datos y construcción de conceptos
3 Limites, excepciones y interpretaciones múltiples	Simplificado a tal punto que límites o excepciones dentro del contenido no presentado. Muchas afirmaciones absolutas sin explicación	Existen algunos limites, excepciones e interpretaciones alternativas incluidas, pero no integrados con el contenido	Limites, excepciones e interpretaciones presentados como parte del contenido	El maestro lleva alumnos a identificar limites y excepciones que pueden generar modos alternativos de representar o interpretar observaciones y eventos	Maestro y alumnos identifican límites y excepciones que pueden generar modos alternativos de representar o interpretar observaciones y eventos	Maestro y alumnos identifican limites, excepciones e interpretaciones alternativas por medio de aplicar conocimientos a resolución de problemas
4 Procesos y historia de la ciencia	Ningúna mención explícita de cómo conocemos. Método científico presentado separado como procedimiento por memoria	Ninguna mención de cómo conocemos. Procesos de ciencia (observación, inferencia, experimentos, etc.) no integrados con contenido	"Como conocemos" incluido en contenido. Maestro integra procesos de ciencia con conceptos.	El maestro lleva alumnos a reconstruir evidencias usadas para formular ideas científicas y usar procesos científicos para formular y evaluar ideas	Alumnos, con consejo del maestro, reconstruyen como ha sido usado la evidencia para formular ideas científicas y a usar procesos científicos para formular y evaluar ideas.	Procesos de ciencia aplicados para diseñar proyectos de investigación, colección y análisis de datos, y construcción de conceptos

Acciones y Valoraciones del Maestro (STAM, 1995)

	A Didáctica	B Transitorio	C Conceptual	D Constructivista principiante	E Constructivista experto	F Indagación constructivista
5 Métodos	Predominan 1 o 2 métodos de enseñanza centrados en el maestro	3 o 4 métodos de enseñanza centrados en el maestro, incluyendo algunos "hands-on"	Repertorio amplio de métodos de enseñanza centrados en el maestro, incluyendo "hands-on"	Algunos métodos centrados en el alumno, como trabajo grupal, discusión, mapas conceptuales	Uso extensivo de métodos centrados en el alumno	Método de proyectos con M y A escogiendo métodos de investigación y análisis, guiados por problemas investigados
6 Labs, demos, "hands-on"	Demostraciones, labs, y actividades "hands-on" son escasos	Algunas demos,labs o actividades " hands-on" que son de receta o sin dirección (sin seguimiento)	Muchas demos, las o actividades "hands-on" enfocados conceptualmente. "Respuestas" conocidas generalmente de ante mano.	Investigaciones, demos y actividades H-A llevadas por el M y incorpora algunas ideas de A	Investigaciones, demos y actividades construidos por M y A y hechos con ideas de A	Demos y actividades H_O son parte de investigaciones largas. A tiene alto grado de generar preguntas y planear investigaciónes
7 Interaccion es de M-A	Poca interacción M y A de temas (chalk and talk)	M-A interacción de exactitud de ideas de A sobre hechos sin conexión	M-A interacción de exactitud de conocimiento de A sobre contenido conceptual	M-A interacción de clarificación y utilidad de ideas de A y comprensión es dirigido por el M	A y M tienen input a clarificación y utilidad de ideas y comprensión de A	M—A interacción enfocada en investigaciones con temas y metas determinados frecuentemente por A
8 Preguntas del M	Preguntas de M requieren memoria de hechos	Preguntas de M dirigidas a ideas científicas, no a conexiones ni aplicaciones. No construyen a partir de respuestas de A	Preguntas de M dirigidas a conocimiento de conceptos científicos y sus conexiones y aplicaciones. No construyen a partir de repuestas de A	Preguntas de M están orientadas a la meta y a veces se obtienen de respuestas de A. Uso para clarificar ideas de A.	Preguntas de M están orientadas a la meta y frecuentemente se obtienen de respuestas de A. Uso para clarificar ideas de A	Preguntas de M orientadas a la meta, se obtienen de respuestas de A y usados para guiar investigaciones
9 Tipos evaluaci ón	Pruebas y quizzes	Pruebas, quizzes y ocasionalmente chequeo de conocimiento de A	Pruebas, quizzes y frecuentemente chequeo de conocimiento de A	Formas múltiples. Algunos valoran conocimiento de A y algunos comprensión de A	Formas múltiples. Casi todos valoran comprensión de A	Formas múltiples saliendo de investigaciones y presentaciones.
10 Valoraci ón más allá de	Nada	Chequeo de conocimiento de A	Chequeo de conocimiento y planificación	Para guiar M ajustar actividades	Para guiar M y A ajustar y llevar a cabo actividades	Para guiar M y A ajustar investigaciones y análisis
11 Respuestas del M a ideas de A	M ignora ideas de A acerca de la materia.	M algunas veces acepta todas las ideas de A pero observa sus ideas no científicas como algo extraño.	M investiga ideas de A acerca de la materia y trata de cambiar ideas no científicas.	M ocasionalmente busca ideas de A y las considera para tomar decisiones. Las usan a veces para diseñar actividades	M busca activamente ideas de A. Valoración determina decisiones instruccionales.	Trata los A como aprendices auto-dirigidos y participa como co-investigador.

Acciones de los Alumnos: (STAM, 1995)

	A Didáctico	B Transitorio	C Conceptual	D Constructivista principiante	E Constructivista experto	F Indagación constructivista
12 escritura, representación de ideas	Predominan escritos y otras representaciones de ideas no usadas. Respuestas cortas	Escritos y otras representaciones de ideas usados ocasionalmente. Principalmente reconfiguraciones de la información dad.	Varias formas de escritos y otras representaciones de ideas usadas. Principalmente reconfiguraciones de la información dada.	Algunas veces A usa escritos y otras representaciones de ideas como parte del desarrollo de comprensión y construcción de sentido. Mucho es reconfiguaciones de la información dada.	A frecuentemente usa escritos y otras representaciones de ideas como parte del desarrollo de comprensión y construcción de sentido	A escoge el uso de variedad de formas de escritos y otras representaciones como parte del desarrollo de comprensión y construcción de sentido
13 Preguntas de A	Pocas preguntas de A	Predominan preguntas de A aclaran procedimientos. Algunas piden aclarar terminología o repetir información	Preguntas de A se enfocan en aclarar sentidos relacionados a conceptos específicos o procedimientos	Algunas preguntas de A se enfocan en aclarar sentidos relacionados a conceptos específicos. Algunas tratan de ideas claves, sus conexiones y aplicaciones. Pocas son procedimentales.	Preguntas de A tratan de ideas claves, sus conexiones y aplicaciones.	Preguntas de A tratan de ideas claves, sus conexiones y aplicaciones en el contexto de un marco investigativo de largo plazo
14 Interacciones A-A	A-A interacciones son raras	Algo de interacción A-A, principalmente de procedimiento	Algo de interacción A-A de procedimiento. Algunas de articular ideas científicas correctamente	Algo de interacción A-A dirigido hacia comprensión y aplicación de ideas científicas. Algunas de procedimiento	Interacción A-A dirigido hacia comprensión y aplicación de ideas científicas. A son independientes.	Interacción A-A es frecuente y dirigido hacia comprensión y planificación. A son muy independientes.
15 actividad iniciado por A	A raramente ofrece ejemplos o análisis por su propia voluntad	A ofrece pocos ejemplos pero con pocas conexiones de actividades en el aula	A ofrece algunas ejemplos relacionados con actividades de aula	A ofrece análisis y ejemplos. Algunos relacionados a actividades de aula, otros poco relacionados.	A ofrece análisis y ejemplos, la mayor parte relevante a actividades de aula.	A ofrece análisis y ejemplos, los cuales ayudan a determinar la dirección de la clase.
16 Comprensión de A de expectativas de M	A son pasivos o ignoran procedimientos del M	A muestran confusión por los procedimientos	A aceptan los procedimientos y su papel	A muestran algo de frustración con su papel. p.e. "¿Por qué el M me da nada solamente la respuesta?"	A negocian un poco con el M sobre los procedimientos y los papeles.	A ayudan definir su papel en la investigación

Recursos (STAM, 1995)

	A Didáctico	B Transitorio	C Conceptual	D Constructivista principiante	E Constructivista experto	F Indagación constructivista
17 Riqueza de recursos	Poco más que un texto o formato	Texto y pocos recursos, incluyendo algunos acetatos	Múltiples recursos, p.e. visual, videos, material de laboratorio, tecnología, gente	Múltiples recursos, p.e. visual, videos, material de laboratorio, tecnología, gente	Múltiples recursos, p.e. visual, videos, material de laboratorio, tecnología, gente	Múltiples recursos, p.e. visual, videos, material de laboratorio, tecnología, gente
18 Usos de recursos	A observan pero no usan activamente recursos. Recursos no siempre relacionados con contenido	Recursos no relacionado al contenido	Recursos relacionados al contenido e ilustran ideas.	Algunos recursos usados para ayudarles con la comprensión y aplicación de ideas	Muchos recursos usados para ayudarles con la comprensión y aplicación de ideas	Recursos integrados vienen de la investigación
19. Acceso a recursos	Acceso a recursos controlado por el M	Acceso a recursos controlado por el M	Acceso a recursos controlado por el M pero hay algo de discusión de acceso con los A	Acceso a recursos guiado por el M con algo de discusión de acceso con los A	Acceso a recursos basado en negociaciones de A y M	Acceso a recursos guiado por la pregunta de investigación

Ambiente (STAM ,1995)

	A Didáctico	B Transitorio	C Conceptual	D Constructivista principiante	E Constructivista experto	F Indagación constructivista
20 Toma de decisiones	Dominado por el M	Dominado por el M. Comparte escazas decisiones con A	Dominado por el M. Comparte pocas decisiones con A por el uso del tiempo	A y M toman algunas decisiones juntos por el uso del tiempo y actividades	A y M toman muchas decisiones juntos por el uso del tiempo y actividades	A y M toman decisiones juntos de la naturaleza y procedimientos de la investigación
21 Material didáctica a la vista	Pocos materiales didácticos a la vista. No siempre integrado al contenido	Algunos materiales didácticos a la vista. No siempre relacionados al contenido	Muchos materiales didácticos relacionados al contenido	Muchos materiales didácticos relacionados al contenido	Muchos materiales didácticos relacionados al contenido, algunos hechos por A	Muchos materiales didácticos derivados de la investigación
22Trabajos de A a la vista	Pocos ejemplos de trabajo de los A a la vista	Trabajos de los A a la vista típicamente iguales (p.e. de modelos idénticos, de hojas de trabajo)	Algo de variación en los trabajos de los A a la vista	Trabajos de los A incluyen algunas creaciones de los A (p.e. posters originales, cuentos, etc.)	Trabajos de los A incluyen muchas creaciones de los A (p.e. posters originales, cuentos)	Trabajos de los A incluyen creaciones de los A derivados de la investigación

App. X: Diagnostico (entrevista)

A. En general, de estrategias didácticas:

1. ¿Cómo seleccionas estrategias didácticas? ¿Cuáles son más usuales ? (unos ejemplos)
2. ¿Cómo seleccionas actividades de aprendizaje? Da algunos ejemplos más usuales.
3. ¿Qué te dice "trabajo colaborativo"? ¿Qué involucra?
4. ¿Trabajas en colaboración con otros profesores de la materia? ¿Cada cuándo? ¿Cómo? ¿Para qué?
5. ¿Trabajan tus alumnos en forma colaborativa, en grupos? ¿Cada cuánto? ¿Cómo?
6. ¿Cuánta libertad/autonomía tienen tus alumnos en la clase? Explica con ejemplos.
7. ¿Cómo mides el aprendizaje de tus alumnos? ¿Conocimientos? ¿Actitudes? ¿procedimientos? (unos ejemplos)
8. ¿Puedes observar la motivación y la iniciativa en tus alumnos? ¿Cómo?
9. ¿Tienes estrategias para trabajar con la diversidad que siempre existe entre tus alumnos? Explica.
10. ¿En qué tipo de áreas te sientes mejor preparado? ¿Menos preparado?
11. ¿Tienes apoyo por parte de la escuela? ¿En qué forma? ¿Cómo puedes describir el ambiente de la escuela para trabajar?
12. ¿Tienes trabajos administrativos a parte de tus horas de clases? ¿De qué se consiste?
13. ¿Te sientes motivado en tu trabajo? ¿Apreciado por la administración y los alumnos?
14. ¿Tienes un segundo trabajo?

B. Expectativos en relación con TACTICS:

15. Explica tu conocimiento/comprensión de TACTICS.
16. Si lo has usado, ¿cuándo?
¿cómo?
¿con cuáles grupos? ¿materias? ¿temas?
¿con cuáles resultados?
11. ¿Tienes confianza en tu habilidad para entrar en el proyecto? Explica por qué.
13. ¿Crees que el aprendizaje de los alumnos va a cambiar con TACTICS. ? ¿en qué aspectos? ¿Cómo podrías medirlo?
14. ¿Qué expectativas tienes del proyecto con TACTICS.?
15. ¿Qué problemas podrían ocurrir con el uso de TACTICS.?
16. ¿Cómo piensas que podría afectar tu propio enseñanza tu participación en el proyecto?
17. ¿Crees que el tiempo dedicado a TACTICS.quita tiempo relevante para la cobertura de tu materia?
18. ¿Crees que hay ventajas/desventajas en trabajos interdisciplinarios para el aprendizaje de la biología de parte de tus alumnos?

App. XI: Entrevista con profesores de ciencias

(basado en Hargreaves, A., 1984 y Feinman-Menser y Floden, 1986)

1. ¿Cuál es tu concepto de "enseñanza"? ¿Qué hace un "**buen**" maestro? ¿Cómo se puede juzgar?
2. ¿Cuál es tu concepto de "aprendizaje"? ¿Qué es un "**buen**" estudiante? ¿Cómo se puede juzgar?
3. ¿Cómo formaste estos conceptos de aprendizaje y enseñanza? ¿De algunos cursos? ¿Experiencia? ¿De un maestro tuyo?
4. ¿Cuál es tu estilo de enseñanza? ¿Siempre usas el mismo? ¿Cómo sabes cuándo debes cambiarlo? ¿Hay un estilo mejor que otros?
5. ¿Cómo te juzgas a ti mismo como maestro? ¿En base a qué?
6. ¿En cuáles áreas te gustaría mejorar?
7. ¿Cuáles son las satisfacciones (gratificaciones) de ser maestro?
8. ¿Cuáles son las limitantes? ¿Los problemas principales?
9. ¿Por qué empezaste a trabajar como maestro?
10. ¿Cuáles son tus metas y objetivos principales como maestro?
11. ¿Cuáles materiales o niveles prefieres enseñar? ¿Por qué?
12. ¿Qué es un buen ambiente de aprendizaje en el aula? ¿Lo puedes crear tu? ¿Cómo?
13. ¿Cómo podrías describir tu relación con tus alumnos?
14. ¿Cuál es tu opinión de esta escuela con respecto a los maestros, alumnos y administrativos?
15. ¿Qué interacción tienes con tus colegas en la escuela? ¿En otras escuelas?
16. ¿Qué control administrativo hay en la escuela sobre los maestros? ¿Cómo es tu relación con el director?
17. Qué posibilidades de participación o influencia tienes para tomar decisiones o cambios en la escuela?
18. ¿Cómo planificas tus clases? ¿Cuánto tiempo por hora de clase? ¿Por cuántos periodos de trabajo planificas: por semana, mes, semestre? ¿Qué es más importante para ti cuando planificas tus clases: contenido o actividades?
19. ¿Cuáles otras actividades o responsabilidades tienes en la escuela, aparte de tus clases?
20. ¿Qué imagen tienes de las siguientes relaciones en esta escuela:
    a. alumno-alumno?
    b. alumno-maestro?
    c. maestro-padre de familia?
21. En tu opinión ¿cuáles son las causas principales de la deserción que hay en la escuela?

App. XII: Cuestionario para la orientación profesional de los profesores

(basado en Jongmans, 1998)

Escoge el número que mejor corresponde a tus opiniones según la siguiente escala y escríbelo enfrente del número de cada frase.

Escala de contestar:

1	2	3	4	5	6	7
No estoy de acuerdo			Neutral		Estoy completamente de acuerdo	

1. La cooperación con otros maestros es necesaria para llevar a cabo los trabajos de enseñanza en una forma adecuada.
2. El desarrollo profesional continuo es importante para los profesores.
3. El desarrollo de los planes de acción de la escuela no debe ser solamente la responsabilidad de la administración.
4. El trabajo de un maestro debe incluir otras responsabilidades independientemente de la enseñanza.
5. La actualización en la literatura profesional es muy importante para los profesores.
6. Los profesores individuales no pueden ni deben decidir solos que métodos de enseñanza usarían en sus clases. Las decisiones se debe hacer al nivel de la escuela/institución.
7. Es muy importante para los profesores que discutan entre sus colegas su forma de enseñanza.
8. Al nivel general se deben hacer acuerdos acerca del ambiente escolar.
9. Los profesores individuales no deben decidir solos qué contenido de materia van a enseñar en sus clases. Las decisiones se deben hacer al nivel de la escuela/institución.
10. Los profesores deben incluir nuevas innovaciones educativas en sus actividades de enseñanza.
11. Las nuevas teorías educativas son importares, también para los maestros con mucha experiencia.
12. Es importante para los profesores comparar sus propias actividades de enseñanza con los métodos comprobados de ser efectivos.
13. Se deben ampliar los criterios de evaluación de los profesores, para incluir todos los aspectos de su trabajo, no solamente las calificaciones de sus alumnos al final del curso.

App.XIII:Cuestionario sobre la implementación de aprendizaje colaborativo

(basado en CLIQ, 1998)

Este cuestionario es para conocer más las razones que determinan si un maestro decide implementar o no la estrategia de aprendizaje colaborativo, para identificar los factores que influyan en las decisiones de un maestro. Esta información es completamente confidencial y nos ayudará en la elaboración de programas más eficaces para el desarrollo profesional de los maestros.

La definición que usamos de aprendizaje colaborativo es: una estrategia de enseñanza en la cual los alumnos trabajan juntos en forma activa, con propósitos específicos, con responsabilidades definidas, en grupos pequeños, para mejorar su propio aprendizaje y el de sus compañeros.

Existen dos partes del cuestionario. Favor de seleccionar la letra que corresponde a tu opinión para cada frase y escríbela enfrente del número.

Sección I: Opiniones profesionales acerca del aprendizaje colaborativo:

La escala de repuestas:

A. Estoy muy de acuerdo
B. Estoy de acuerdo
C. Indeciso
D. Estoy completamente en desacuerdo
E. No es relevante

1. Si uso aprendizaje colaborativo, los alumnos tienden a distraerse de la actividad.
2. Entiendo lo suficiente acerca del aprendizaje colaborativo para implementarlo con éxito.
3. Los gastos involucrados con la implementación del aprendizaje colaborativo son costosos.
4. La competición prepara mejor a los alumnos para el mundo real.
5. La capacitación que recibí sobre aprendizaje colaborativo me ha preparado para implementarlo conexito.
6. El aprendizaje colaborativo no promueve los alumnos más inteligentes.
7. Hoy en día hay demasiadas exigencias para hacer más cambios en educación.
8. El aprendizaje colaborativo se apega con mi filosofía de enseñanza.
9. Actualmente mis alumnos no tienen las destrezas necesarias para trabajo colaborativo efectivo en grupo.
10. Para que yo tenga éxito en el uso de aprendizaje colaborativo depende del apoyo de mis colegas.
11. Usando aprendizaje colaborativo se pueden crear demasiados problemas de disciplina entre mis alumnos.
12. Usando aprendizaje colaborativo aumenta mi estatus profesional.
13. Para que yo tenga éxito en el uso de aprendizaje colaborativo depende del apoyo de la administración de la escuela.
14. El aprendizaje colaborativo contradice las metas de los padres de familia.
15. El aprendizaje colaborativo es una estrategia valiosa de enseñanza.

16. La interacción entre pares ayuda a los alumnos obtener una comprensión más profunda de la materia.
17. Mi capacitación en aprendizaje colaborativo no ha sido suficientemente práctico para que yo pueda implementarlo con éxito.
18. El aprendizaje colaborativo es apropiado para el nivel de escuela que yo enseño.
19. Si uso aprendizaje colaborativo, muchos alumnos esperan que otros miembros del grupo realicen el trabajo.
20. Es imposible implementar aprendizaje colaborativo sin materiales especializados.
21. Me siento demasiado presionado por la administración para usar aprendizaje colaborativo
22. El aprendizaje colaborativo utiliza demasiado énfasis en el desarrollo de las destrezas sociales de los alumnos.
23. Creo que puedo implementar aprendizaje colaborativo con éxito.
24. Tengo muy poca experiencia docente para implementar el aprendizaje colaborativo con éxito.
25. Participando en aprendizaje colaborativo mejora las destrezas sociales de los alumnos.
26. Es imposible evaluar equitativamente los alumnos con aprendizaje colaborativo.
27. Hay demasiado poco tiempo para cubrir el currículo para preparar a los alumnos a trabajar efectivamente en grupos.
28. Hay demasiados alumnos en mi clase para implementar aprendizaje colaborativo efectivamente.
29. Usando aprendizaje colaborativo promueve amistad entre los alumnos.
30. Mis alumnos no quieren trabajar en forma colaborativa.
31. Participando en aprendizaje colaborativo interfiere en el progreso académico de los alumnos.
32. Implementando aprendizaje colaborativo requiere mucho esfuerzo.
33. El aprendizaje colaborativo no es apropiado para la materia que yo enseño.
34. El aprendizaje colaborativo promueve el aprendizaje de alumnos de bajo rendimiento.
35. Me siento presionado por otros maestros para usar aprendizaje colaborativo.
36. El aprendizaje colaborativo es una estrategia eficiente para usar en el aula.
37. El aprendizaje colaborativo me ayuda a cumplir con las metas de mi escuela.
38. La implementación de aprendizaje colaborativo necesita demasiado tiempo de clase.
39. Usando aprendizaje colaborativo promueve actitudes positivas de los alumnos acerca del aprendizaje.
40. Yo encuentro que aprendizaje colaborativo es demasiado difícil de implementar con éxito.
41. El aprendizaje colaborativo no funcionará con mis alumnos.
42. Prefiero usar las estrategias conocidas de la enseñanza en vez de nuevos métodos.
43. Si uso aprendizaje colaborativo, mi clase es demasiado ruidosa.
44. Creo que soy un maestro muy efectivo.
45. La implementación de aprendizaje colaborativo toma demasiado tiempo de preparación.
46. Yo siento un compromiso personal para usar aprendizaje colaborativo.
47. El aprendizaje colaborativo da demasiado responsabilidad a los alumnos.
48. las condiciones físicas de mi aula son obstáculos para el uso de aprendizaje colaborativo.

Seccion II: Practicas docentes del presente:

Favor de escoger la letra que mejor corresponde a tu opinión para cada frase y escríbela enfrente del número de la frase.

Escala de respuestas:

A. Siempre
B. Casi siempre
C. Algo
D. Un poco
E. Para nada
F. No es relevante

1. Evalúa hasta qué punto el aprendizaje colaborativo es parte de tu rutina diaria en el aula **en este momento**.
2. Evalúa hasta que punto piensas que vas a incorporar el aprendizaje colaborativo en tus clases en el futuro.

***** Si no utilizas aprendizaje colaborativo en el aula, no tienes que contestar las siguientes frases.

3. Evalúa hasta que punto organizas las actividades del aprendizaje colaborativo para asegurar que todos los miembros del grupo trabajan juntos en forma activa.
4. En una actividad típica de aprendizaje colaborativo, evalúa hasta que punto los miembros participan activamente.
5. En una actividad típica de aprendizaje colaborativo, evalúa hasta que punto tus alumnos terminan su parte del trabajo del grupo.
6. Evalúa hasta que punto implementas aprendizaje colaborativo para mejorar destrezas sociales.
7. Evalúa hasta que punto implementas aprendizaje colaborativo para motivar a los alumnos.
8. Evalúa hasta que punto implementas aprendizaje colaborativo para aumentar el auto-estima.

App. XIV: TACTICS Cuestionario de Opinión para Maestros

Aplicado el 29.05.02 en un taller de evaluación con los maestros y investigadores de TACTICS en México, en el DIE- CINVESTAV

Sobre tu participación:

1. ¿Has podido disponer del tiempo necesario para atender al proyecto?
2. ¿Ha sido fácil la relación con los alumnos? ¡Por qué?
3. ¿En qué forma has supervisado el trabajo de los alumnos?
4. ¿Qué has aprendido durante tu intervención en el proyecto?
5. Explica como ha influido el proyecto en tu práctica docente.
6. ¿Se te ha presentado algún problema al aplicar los cuestionarios? Si es así, explícalo.
7. Explica como ha sido la comunicación con los otros profesores del proyecto.
8. ¿Cuál ha sido tu motivación para seguir en el proyecto?
9. ¿Has desarrollado alguna habilidad en cómputo a través de tu participación en el proyecto?
10. Explica si has sentido a *e-groups* como un programa amigable para el maestro o no, en cualquiera de los casos explica ¿por qué?
11. Si participaste en la fase piloto del proyecto, compara los resultados con los de la fase que estamos concluyendo.

Sobre tus alumnos:

12. ¿Han tenido algún problema tus alumnos al trabajar en *e-groups*? Si ha sido así explica cuál.
13. Si usaron *net-meeting* explica cuál fue la experiencia de tus alumnos.
14. Si usaron *chat* explica cuál fue la experiencia de tus alumnos.
15. ¿Tus alumnos tuvieron problemas de comunicación relacionados con el idioma? Descríbelos.
16. ¿Tuvieron problemas con el equipo de cómputo? ¿cuáles?
17. ¿Se ha podido relacionar los contenidos de los temas del proyecto con los de las materias curriculares?
18. ¿Has encontrado diferencias en la forma en que trabajan tus alumnos antes y después de su intervención en TACTICS?
19. ¿Qué opinas del contenido de los trabajos finales de los alumnos? ¿A qué le atribuyes que hayan sido así?
20. ¿Cuál crees que haya sido la mayor motivación de tus alumnos para entrar al proyecto y en que aspectos éste no ha cumplido sus expectativas?
21. ¿Cómo evaluarías este año del proyecto?

App. XV: Guía para las Entrevistas después de Observaciones en Clase

1. **Planeación:**

¿Cómo habías planeado esta clase? ¿Que hiciste? ¿Con cuáles materiales planeaste: libro de texto/ notas anteriores?
¿Lo hiciste por escrito? ¿Hiciste notas para seguir?
¿Cuáles procedimientos consideraste?
¿Incluiste aplicaciones/ relevancia a la vida cotidiana de los alumnos?
¿Cómo contribuyó esta clase a tus objetivos de la unidad?

2. **Contexto/alumnos:**

¿ Cómo caracterizas este grupo en general?
¿los alumnos que participan más?
¿los alumnos que participan menos?
¿Tienes un reto en particular con ellos?
¿Cómo trabajan contigo?
¿Qué conocimientos/ habilidades/ actitudes tuvieron los alumnos antes de esta clase?
¿Cómo lo determinas?
¿Tienen compromiso con las actividades/ disposición para trabajar?
¿Cómo trabajan mejor?

3. **El desarrollo:**

¿Cómo viste el desarrollo de la clase? (según tu planeación)?
¿Cómo lo avías previsto? ¿Qué avías esperado conseguir?
¿Lo obtuviste? ¿porqué?
¿Tomaste decisiones sobre la marcha? ¿cuàles? ¿al base de que?
¿Durante el desarrollo de la clases pusiste en práctica consejos o sugerencias de otros profesores? ¿de tus clases de la maestría? ¿Cuàles?

4. **Evaluación:**

¿Cómo sabes si los alumnos aprendieron lo que quieres?
¿Cómo ves la respuesta afectiva de los alumnos?
¿Qué tipo de evaluación has dado/ vas a dar sobre el tema?
¿Resultados?

5. **Mejorías/ cambios:**

¿Qué cambiarias en tu clase si la volvieras a carla con el mismo (parecido) grupo?

App. XVI: Guía de la Entrevista con los directores de las preparatorias

1. Cuánto tiempo tiene como director de esta preparatoria? ¿Cuánto tiempo cómo maestro aquí?

2. ¿Cuál fue su proyecto educativo cuando entró como director?

3. ¿Cuáles son las responsabilidades de cada profesor?

4. ¿Qué reglas o controles hay en la escuela sobre el desempeño de cada profesor? (libertad de cátedra, asistencia, cobertura del programa, calidad de enseñanza, etc)

5. ¿Cuáles son las responsabilidades de cada alumno?

6. ¿Qué reglas o controles hay en la escuela sobre el trabajo de cada alumno? (asistencia, calificaciones, comportamiento, etc)

7. ¿Cómo puede describir el ambiente de la escuela con respecto al aprendizaje-enseñanza?
¿Hay colaboración entre la administración y los maestros? (ejemplos)
¿entre la administración y los alumnos? (ejemplos)

8. ¿Cómo me podría describir el maestro **ideal** de ciencias?

9. ¿Qué apoyo hay en la escuela para que un maestro pueda desarrollarse para llegar a ese nivel?

10. ¿Qué piensa del currículo de biología?

11. Para Ud, ¿cuál es la estructura **ideal** de una clase de ciencia?

12. ¿Cómo ve el nivel de aprendizaje y enseñanza de las ciencias en la escuela?

13. ¿Tiene algún proyecto para mejorarlo? ¿cuál?

Appendix C: Table for Analysis of Common Knowledge, Collaborative Work and Community of Practice

Levels	Categories	Codes
Common knowledge (CK)	Active participation	▪ Physical or temporal space to work together between peers ▪ Degrees of sharing work, interaction at each step of the work (co-construction) ▪ Basic vocabulary necessary to take part (essential understandings) ▪ Degree of direction (independent/ ritual) ▪ Ss "controlling" other Ss
	Questioning: Use	▪ look for information ▪ direct S thought and action (control), focus attention ▪ establish limits of shared attention, shared activity, common knowledge ▪ explicit recapitulation/ review ▪ S request clarification/ more information ▪ Close topics or not, de/contextualized comments)
	Style	▪ open/ closed (punctual) of content ▪ directed one student or generally ▪ implicit if answer is wrong (silence, other question) ▪ articulating own ideas or listening (T and Ss) ▪ explicit/ with gestures/ looks/ emphasis on words
	IRF (type of question-response T-Ss)	▪ formal, without exploration/ ignoring or following Ss' comments ▪ evaluating comprehension ▪ focus attention ▪ feedback, clarification
	Use of scaffolding	▪ invoke common/supposedly shared knowledge ▪ explicit summary/ continuity/reinforcement ▪ induce knowledge with tips/ words or phrases to complete (T control) ▪ use of S knowledge/experience to build on ▪ use past or extracurricular/daily experiences to build on/ T takes advantage of displaced references ▪ reference to use in future of knowledge ▪ planning of transfer
	Basic rules of discourse	▪ implicit or explicit ▪ As try to discover rules of game/ "correct" answer
	Teaching of content	▪ Ritual (practical aspect most NB/ what and how) or understanding of concepts, principles ▪ Designed or emergent ▪ Basic vocabulary

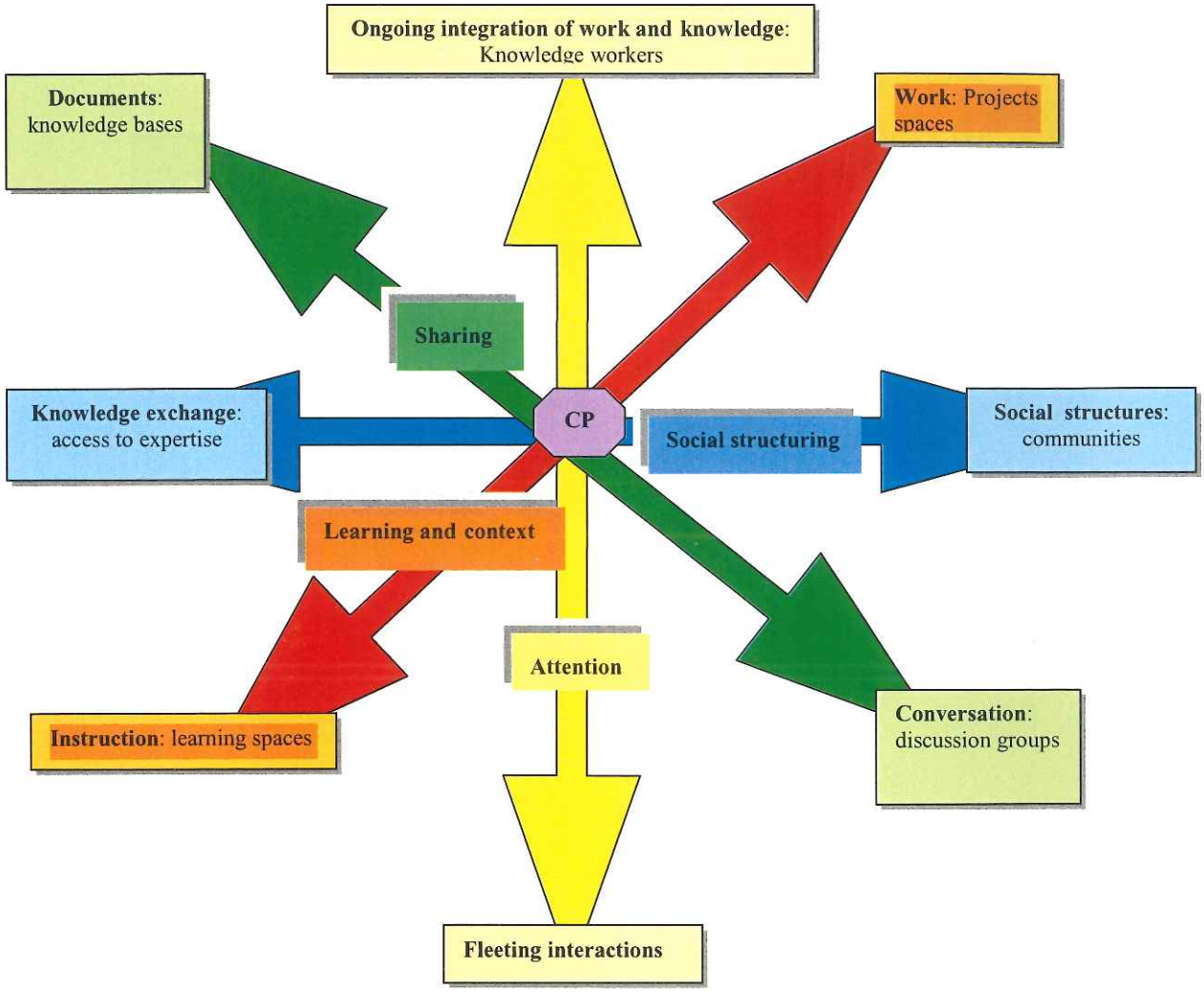
Levels	Categories	Codes
Collaborative Learning (CL)	Shared objective/goals	▪ objectives clear between T and Ss, i.e.S support in discipline ▪ shared information (past or daily), ideas
	Type of discussion	▪ social (social aspects of interaction, assigning tasks, organization, etc.) ▪ related to work (cognitive aspects, selecting, identifying, predicting, etc.) ▪ procedural (how to work, etc.) ▪ off task (all not included above)
	Role of teacher	▪ as expert, to give access to procedural aspects and knowledge ▪ to accompany Ss in exploration/ elaboration/ negotiation/ clarification/ evaluation (tutor/ facilitator) ▪ use of confrontation (in cases of misconception) ▪ to control activities ▪ disciplinary
	Responsibility	▪ to do work on time ▪ for own learning ▪ for others' learning
	Planning/ coordination	▪ control by T ▪ opportunities for Ss to participate in planning, to make changes
	Use of collaborative tools	▪ technical tools (computers, etc.) ▪ organization and coordination of resources
	Ecology of classroom (climate/ environment)	▪ space and their structures (artifacts, technology) ▪ development of activities to transform information into knowledge

Community of Practice (CP)	Share an interest	▪ understand an issue ▪ agree on common approaches
	Interact and build relationships	▪ help each other solve problems and answer questions ▪ network across teams ▪ types of participation (legitimate peripheral, marginal, authentic, border-crossings) ▪ mutual engagement (relations within community, in learning) ▪ mutual accountability/ responsibility ▪ emergent or designed strategies ▪ evidence of competence (experience demonstrated through practice, degree of active participation, degree of legitimacy to make changes/ negotiate, degree of membership) ▪ negotiation (degree of participation to use, control and modify meaning, meanings of success or failure)
	Share and develop knowledge	▪ share information and insight, best practices ▪ negotiate meanings ▪ build tools and a knowledge base ▪ share teaching and learning ▪ global or local learning practices ▪ shared repertoire (artifacts, history, concepts, gestures, style, discourse)
	Evidence of identity formation	▪ as a member of the class/ TACTICS/ school / UAEM ▪ modes of belonging: <u>engagement</u> (development of interpersonal relations, create meaningful activities) ▪ modes of belonging: <u>imagination</u> (create new images, reflect, build productive images of who we are, of the world, of the possible) ▪ modes of belonging: <u>alignment</u> (coordinate energies and personal activities, enable our Ss to act, effective participation in broader enterprises) ▪ identification: experiences and materials develop membership (social status) and communities (social structure) ▪ negotiation: degree of participation to use, control and modify meaning, define ownership of meaning (social status)

Appendix D: Dimensions of Community-based Knowledge

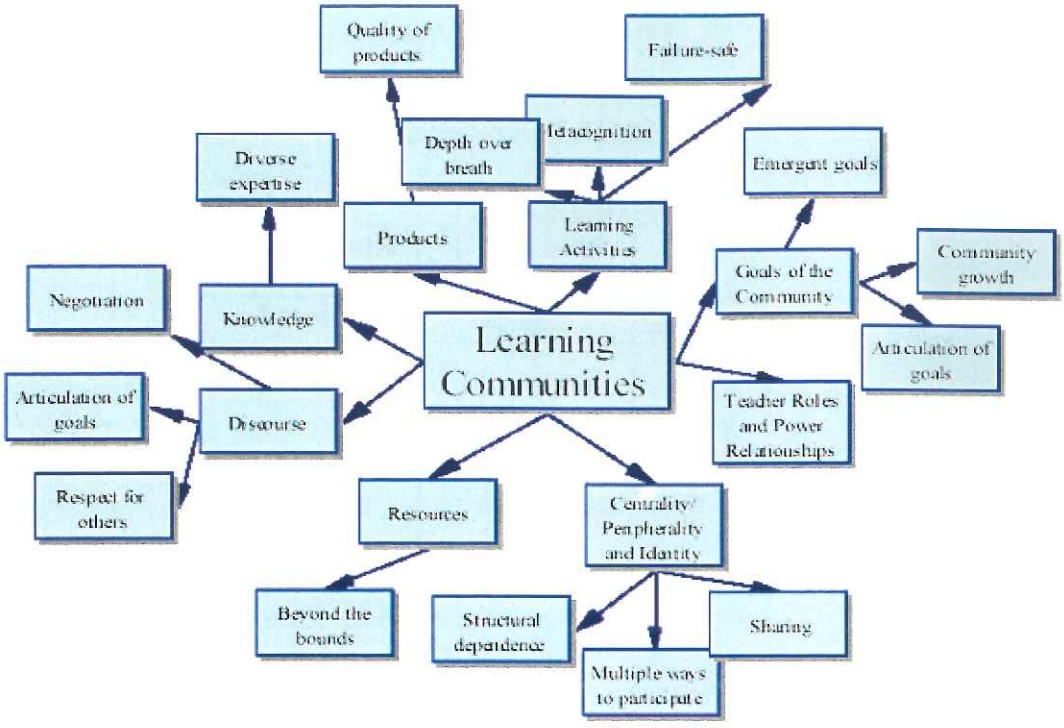
In this diagram, each axis represents a dimension of the social life of knowledge whose tensions between the 2 requirements at each pole need to be integrated. Where the four axes cross would be a functional community of practice (CP). (Wenger, 2001, pp. 43-44)

Figure 6:



Appendix E: Bierlaczyc and Collins' Map of a Learning Community (2004)

Figure 7:



Appendix F: Philosophy of Teaching: STAM Analysis of Maria

(Append. G, Salish I, 1997) Interview: Nov. 28 and Dec. 3, 20001

(numbers refer to the number of answers given codified with the coding maps and table in *Salish I, Instrument Package and User's Guide*, pp. 51-114)

	Level 3		**Teacher styles categories:**			
	Teacher centered		***Conceptual***	***Student centered***		
	Level 2:		**STAM**	**categories**		
Aspects of classroom	***Didactic Transitional***		***Conceptual***	***Early constructivist***	***Experienced constructivist***	***Constant inquiry***
Level 1 categories						
Teacher/Content			1			
Self as Teacher	9	3	3	4		
Teacher Actions	5	1	2	4		
Student Actions	5	2	1	4		
Environment	4			1		
Context	5			4		
Diversity	1		1			
Philosophy of Teaching	11	2	3	5		

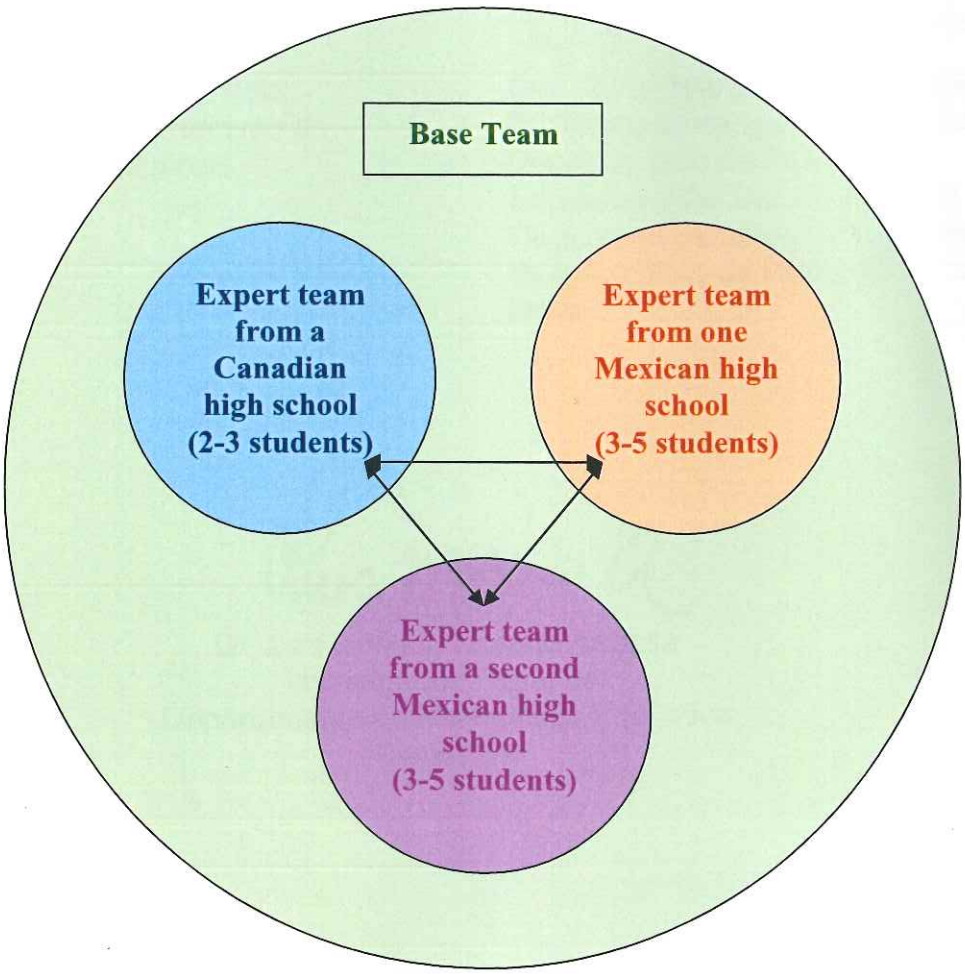
Appendix G: TACTICS Model

Topics of investigation:

In the table below are the topics used for the four years in the TACTICS project.

Topics	Subtopics		
1. Contamination	1 (a) Air	1 (b)Water	1 (c) Soil
2. Reproduction	2 (a) Assisted	2 (b) Cloning	2 (c) Prenatal diagnostic
3. Medicines	3 (a) Allopathic	3 (b) Homeopathic	3 (c) Traditional
4. Wastes	4 (a) Domestic	4 (b) Hospital	4 (c) Industrial
5. Energy	5 (a) Solar	5 (b) Eolic	5 (c) Biomass

Jigsaw model of interaction of the students (via Internet):
Each base team is given one of the above topics and each expert team, each from a different school, investigates one of the three sub-topics, then communicates their findings to the other 2 expert teams via Yahoo e-groups and MSN messenger. The final product is a summary of the three investigations. Each investigation includes scientific, social, legal and ethical aspects.



El jurado designado por el Departamento de Investigaciones Educativas del Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional, aprobó esta tesis el día 24 de febrero de 2005.

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