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Content

1. BASELINE DOCUMENT

1.1. Spanish National Education System

In the last 40 years, four general educational laws, almost one per decade, have been enacted in Spain. These general laws (LGE; LOECE; LOGSE and LOE) represent the progressive movement, from non-regulated and only available to minorities to compulsory for everyone until 16 years old, that Spanish education has undergone. In this chapter it is summarised this recent history of the Spanish educational system, drawing a picture of the general framework regulating it nowadays, in particular regarding the science subjects.

1.1.1. Legal framework

In 1970's the *Ley General de Educación y Financiamiento de la Reforma Educativa, LGE* (General Act on Education and Financing of Educational Reform) established compulsory education for all pupils between ages of 6 and 14 years old under the *general basic education* (EGB). This Act attempted to unify all the educative levels, overcoming the internal inconsistencies caused by the different partial reforms previously undertaken.

In 1980, under the influence of the 1978 Constitution, it was enacted the *Ley Orgánica por la que se regula el Estatuto de Centros Escolares, LOECE* (Act on the Regulation of the Statute of Educational Institutions) which regulated school statutes. This Act was the first mandatory attempt to regulate education principles, the organisation of educational institutions, and student's rights and duties according to the principles ratified in the Constitution.

The 1990 important changes were made on non-university education by the *Ley Orgánica de Ordenación General del Sistema Educativo, LOGSE* (Act on the General Organisation of the Education System). This Act was characterized by the following general objectives: the definition of basic compulsory education as envisaged by the Constitution, between the ages of 6 and 16, free of charge and comprising primary education and lower secondary education; the effective regulation of education at the pre-compulsory stage; a thorough reform of vocational training, by establishing a postsecondary level and the link between special subjects schooling (artistic and language education) and other types of education.

Recently, in 2006 the *LOE Ley Orgánica de Educación* attempted to simplify the complex legal situation, repealed the previous acts and became the basic regulation for the general organisation of the Spanish non-university education system.

The main change in this curriculum is the shift from a focus on the acquisition of contents (before organised as conceptual, procedural and attitudinal contents) towards a **competence-based framework,** as an adaptation of key competences proposed by the European Commission, which sets the importance on teaching for and assessing the "mobilisation and use" of these contents. This new curricula was launched without the support of a specific programme of teacher professional development.

1.1.2. Spanish educational system and curriculum

A diagram of the current Spanish Education system is presented in Figure 1.1. As seen in this figure, nowadays compulsory full time education covers education from 6 to 16 years old, including both education levels: Primary (6 to 12 years old) and Secondary (12 to 16 years old).

Regarding the ratio distribution per levels, it is established according the following limits: primary level, maximum 25 students per class; secondary level, 30 students per class.

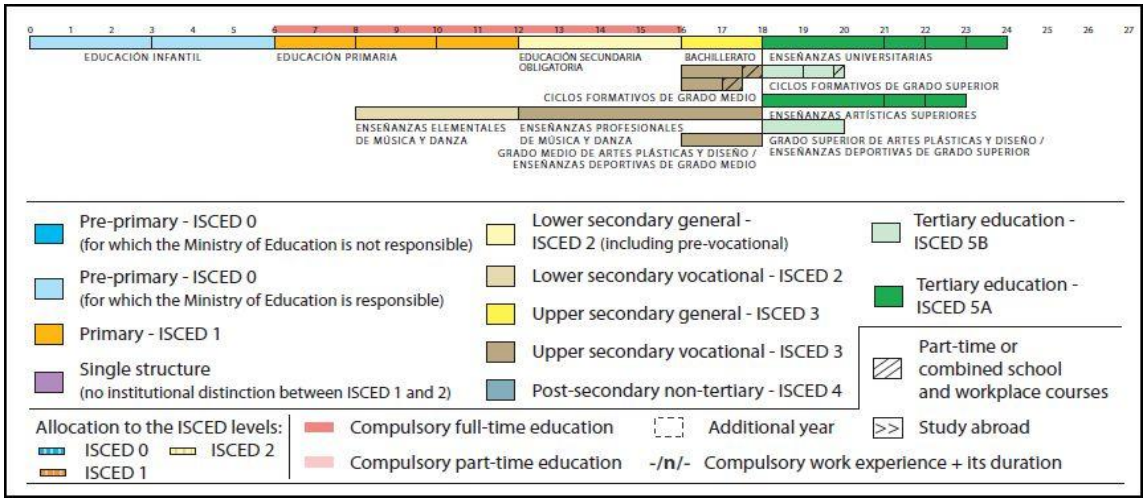

Figure 1.1 Spanish Education System. Source: Eurydice, European Commission, 2010.

The Ministry of Education's Action Plan 2010-2011, developed in collaboration with the Autonomous Communities, is organized around 8 basic competences, which are defined as the tools that future individuals should have to permanently adapt to the new changes. These competences are the necessary skills, abilities and knowledge, both specific and generic, to keep learning and finding successful ways to adapt to a world characterized by change, complexity and interdependence.

The Ministry of Education establishes the national core curriculum at both primary and lower secondary education and, on the basis of these national core curricula, each Autonomous Community establishes its own curriculum, as well as the methodological guidelines for teachers.

In Catalonia, the curriculum emphasizes and gives specific guidelines on contents' functionality as relating the contents to real events or everyday problems; giving importance to procedural aspects based on experimental work, field work and manipulation; and transpose knowledge and attitudes into daily actions, both individually and collectively.

Competences over educational matters are divided between the State and the Autonomous communities (see figure 1.2.)

DISTRIBUTION OF RESPONSIBILITIES IN EDUCATION (NON-UNIVERSITY EDUCATION)	
Central government	General organisation of the education system, minimum requirements for schools, minimum core curriculum, international cooperation in education, policies to encourage and coordinate research. It also organises the general planning of education and regulation of academic and professional qualifications, core curricula guaranteeing the right and duty to know the Spanish language (notwithstanding the Autonomous Communities' competence regarding the establishment of regulations to guarantee citizens' rights to use and know their own languages). High Inspectorate (whose duty is to monitor the observance of minimum requirements for education set by the State for the entirety of the national territory), state-wide general diagnostic evaluations, policies on financial aids for studies, ownership and administration of public schools abroad, establishment of the legal basis for foreign schools in Spain, education statistics for State purposes, etc.
Autonomous Communities	Administrative responsibility within their territories; schools creation, authorization and management; development of State regulations regarding syllabuses and regulation of levels, branches, grades and specialisations; guidance and support for pupils; staff management; educational inspection; supervision of textbooks and other materials; diagnostic assessment in schools within their territory; facilitating information exchange and the promotion of good educational or management practices; providing the necessary data to the State to elaborate national and international educational statistics; publishing data and indicators contributing to facilitate transparency, good educational management and educational research; negotiation and awarding of subsidies to private schools; administration of scholarships and aids; regulation of the relevant Autonomous Community's School Council composition and functions, etc.

Figure 1.2 Distribution of responsibilities in non-university education: State and Autonomous communities. Source: European Commission, 2010

Science education

One of the aims of secondary education mentioned in the Curriculum is that students should 'view scientific knowledge as an integrated knowledge which is structured into different disciplines'; they should also be able to understand and apply problem solving methods to various fields of knowledge and experience[1].

For that reason in Spain, as in most of European countries, the organization of science teaching both in primary and lower secondary education is integrated, although it is split into separate subjects by the end of lower secondary education.

In all the primary courses, the area of science knowledge is not considered a basic or instrumental area, such as languages or mathematics, which affects the time dedicated to the acquisition of scientific competence. During this stage, Science is integrated with other disciplines within a subject called "*Knowledge of the natural, social and cultural environment*".

Although the subject represents a 15% of the total teaching hours with 465 hours in the totality of the level, the part of science takes less than a 7% of the total (less than half of the 15% that represents the subject)[2].

In the lower secondary education, science is an integrated subject for the first three years "Natural science", despite the secondary school teacher specialisation on biology and geology or on physics and chemistry makes it common that different teachers teach different content within the same subject.

This subject takes up to 230 hours from the first to the third year, which represents the 18% of total teaching hours. For the last year of the secondary compulsory education, science education has become optional, including a separation of disciplines (Physics/Chemistry, Biology/Geology) representing 70

[1] December 29th, Royal Decree 1631/2006, establishing the national core curriculum for ISCED2 (BOE 5-1-2007), for full text see: http://www.boe.es/boe/dias/2007/01/05/pdfs/A00677-00773.pdf

[2] *ENCIENDE* Report, 2011, Page 25.

elective teaching hours each one. If we take into account all compulsory secondary (including the fourth year) students who do not choose to take elective science on the last year, their science background will only be a 14% of the total hours[3].

Science in post-compulsory education is present specifically in the two years of *Bachillerato*, the upper secondary education addressed to higher education studies. In this post-compulsory courses, science education is part of two of the four available branches, that of Science and Technology. Post-compulsory science subjects also included in some of the specific branches of the intermediate vocational training (*Ciclos formativos*), for instance in those related with health or chemical industry.

Mathematics education

The curriculum includes the aim of 'applying mathematics in real life contexts', with emphasis on using what is familiar to students as a reference to learning contexts. Activities such as reflection, establishing a working plan, adapting it, generating a hypothesis and verifying the validity of the solution are also included in the core part of the curriculum.

At primary level, 'problem-solving processes' are one of the central themes of mathematical activity and they should be the source and principal support for mathematical learning throughout primary education'[4]. The mathematics curriculum in compulsory secondary education also refers specifically to problem solving as a basic topic of the curriculum[5], and mathematical content is adjusted so that it engages students and helps prepare them for adult life.

Mathematics in primary education covers around 16 % of the national core curriculum, with a total of 535 hours[6]. Mathematics is also obligatory from the first to the fourth year of lower secondary education, with a total of 385 hours within the four years, which is about the 14% of the curriculum.

Mathematics in post-compulsory education is present specifically in the two years of *Bachillerato*, the upper secondary education addressed to higher education studies. In this post-compulsory courses, mathematics education is part of three of the four available branches, that of Science, Technology and Social Studies, although in this last one mathematics has a different approach, as it is related to economics and other social studies' subjects. Post-compulsory mathematical subjects are also included in some of the specific branches of the intermediate vocational training (*Ciclos formativos*), for instance in those related with economics or business.

1.1.3. The Catalan educational system: regional focus of Spanish TRACES project

The TRACES project in Spain will be restricted to the Autonomous Community of Catalonia (Catalunya). This decision takes into account the complexity of the partially decentralized educational system in Spain, where different regions have different curriculums and school organization under a general

[3] December 29th, Royal Decree 1631/2006, establishing the national core curriculum for ISCED2 (BOE 5-1-2007), for full text see http://www.boe.es/boe/dias/2007/01/05/pdfs/A00677-00773.pdf
[4] Royal Decree 1513/2006, on national core curriculum for Primary Education http://www.boe.es/boe/dias/2006/12/08/pdfs/A43053-43102.pdf
[5] Royal Decree 1631/2006, on national core curriculum for Lower Secondary Education, http://www.boe.es/boe/dias/2007/01/05/pdfs/A00677-00773.pdf
[6] Royal Decree 1513/2006, on national core curriculum for Primary Education http://www.boe.es/boe/dias/2006/12/08/pdfs/A43053-43102.pdf

educational law. This situation makes for other important international surveys and evaluations also to focus on the different regions of Spain differentially, as it is the case of the OCDE PISA studies (with independent results for Catalonia) or the TALIS survey (including data from 2 different autonomous communities).

Catalonia is an autonomous community and exercises its self-government[7] in the Spanish State. The Generalitat is the institutional system around which Catalonia's self-government is politically organized. The Generalitat has extensive competencies in education and other matters (such as health, citizen security and civil protection, culture, linguistic policy, industry, urban development, housing, regional politics, transport, environment, etc). This results in Catalonia having their own national curriculum below the umbrella of general Spanish educational laws.

Catalonia is the second most populated autonomous community in Spain, with a population of more than 7.535.000 inhabitants (according to the municipal registry of 2011). This represents approximately the 16% of the total Spanish population (47.151.000 people, according to INE data of 1st January 2011), with an immigration rate of 12.5% (according to municipal registry data of 2008)[8].

Schools in Catalonia

The Spanish education system is characterized by a large proportion of private school sector. Catalonia is not an exception. The educational scenario of Catalonia, according to statistical official data from the Generalitat de Catalunya (2010) is shown in Figure 1.3.

According to this information there are 2.271 public centres, considering primary and secondary levels of education (75% primary and 25% secondary) and 712 private centres with 50% of primary centres with most of private centres giving both primary and secondary education level.

	PUBLIC	PRIVATE	TOTAL
Childhood education	801	588	**1.389**
Childhood and primary education	1.710	121	**1.831**
Secondary education	560	114	**674**
Childhood and/or primary and secondary education	1	477	**478**
Special education	42	64	**106**
Initial professional qualification programs (PQPI)	124	77	**201**
TOTAL	3.238	**1.441**	4.679

Figure 1.3. Catalan schools according to level and sector.
Source: Generalitat de Catalunya, 2010

1.2. Spanish Students Education Results

Although no school leaving examinations exist in Spain, the selective external evaluation made in our school system is the university entrance examinations. However, other internal assessments to evaluate the achievement of the basic competences throughout the school years are made by different education administrations. The most important internal assessment in Spain is the General Diagnostic Evaluation, while the PISA study has become the main external evaluation of our educational system.

[7] In accordance with the Constitution of 1978 and the new Statute of Autonomy, approved in 2006
[8] Source: Official site of the Catalan Government, www.gencat.cat

The PISA study, released by the OECD in 1997 and implemented in 2000, aims to measure the educational performance of students from 15 years in areas considered key, such as reading literacy, mathematics and science. From the year 2000, both Spain and Catalonia have participated in the PISA studies made every three years.

The General Diagnostic Evaluations of the education system, by the Institute of Evaluation, are included in the National System of Education Indicators. According the General Diagnostic Report, these assessments are used as one of the basis for designing improvement measures. They include tests to evaluate pupils' reading, mathematics, science and social-related skills at the end of the 2nd cycle of primary education (grade 4) as well as at the end of the 2nd year of lower secondary education (grade 8). At present, there is a plan to extend these tests to the 6th and 10th grades as well. In addition to these sample-based national tests, each Autonomous Community carries out an annual diagnostic evaluation of all students in their territory in the same grades. In our case, the Catalan Department of Education carries out the Assessment of Primary Education every four years (see next sections)

1.2.1. External evaluation results: Pisa

Spanish Pisa results

Regarding PISA results, the Spanish average performance both in Science and in mathematics is lower than the EU average, although the spread of student achievement is not high. Scientific level of students in Spain is significantly less than the average of other countries, reaching 13 points below the OECD average (488 compared to 501 points, see Table 1.4). In the case of Mathematics' performance, it is also 13 points below the EU average (483 compared to 496 points).

OVERALL RESULTS PISA 2009		
	Scientific Literacy	*Mathematics Literacy*
Spain	*488*	*483*
OECD average	*501*	*496*

Table 1.4 Overall results of PISA 2009. Comparison Spain. Source: PISA 2009

The evaluations also show that our educational system has a low percentage of students achieving levels of excellence in general and in mathematics and science (the study makes up to 6 levels of competence, being the Level 2 the base level of competence).

The percentage of students in higher levels of scientific literacy is almost 5 points below the average of other participating countries. Only a 4% of students are at levels considered high, below the other countries (9% OECD average). On the other hand, there is a large group of students who are in the lowest levels, level 1 or below it. Specifically, a total of 18% of Spanish students are in this range, the same level as the OECD average (19%).

In the case of mathematics, Spain has better results, with an 8% of students at high levels of mathematics literacy, but still low when compared to the 13% of the OECD average. About a 24% of students are in the lowest levels of mathematic competence, similar to the 22% OECD average[9].

[9] PISA Report, 2009. See at http://www.oecd.org/dataoecd/10/61/48852548.pdf

Regarding gender, PISA 2009 results show a significant difference between boys and girls performance. In the case of Science, boys outperformed girls with a difference of 9 score points (OECD average zero score points), which is not as big as in Mathematics, where boys had an advantage of 19 score points from girls (OECD average 12 score points)[10].

Catalan Pisa results

According to PISA 2006 results[11], Catalonian educational results for secondary level is quite similar to the Spanish results, with a slightly higher average for both Sicence and Mathematics (Table 1.5).

	Science	Mathematics
Catalonia	491	488
Spain	488	480
UE-25 average	503	498

Table 1.5: Summary of PISA 2006 results in Catalonia, compared with Spain and the average of the European Union. Source: OCDE 2006

As shown in Figure 1.6., the percentage of students in Catalonia located in the lower levels of the scale of science performance (level 1 and below) is 18.6%, which is lower than the OECD, but still too high. Most students are concentrated in the intermediate levels (76.8% of students) and only 4.6% of the students are at upper levels (levels 5 and 6) of scientific competence.

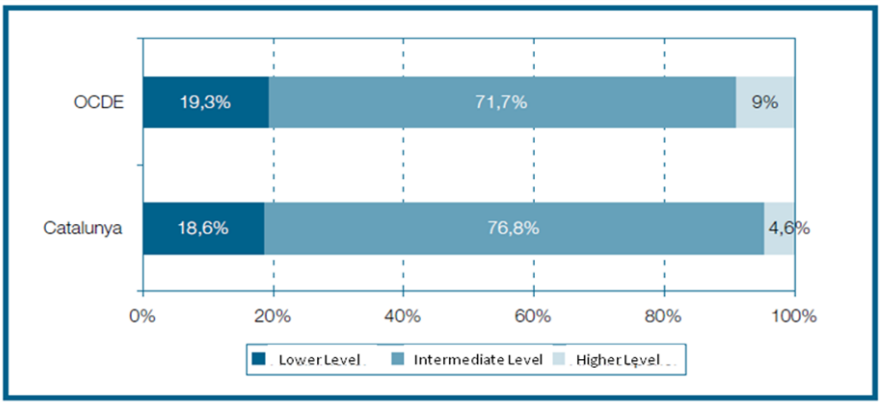

Figure 1.6. Percentage of students of Catalonia and the average of OECD located in lower, intermediate and upper levels of scientific competence. PISA 2006

In the case of mathematics, the percentage of students in the lower levels is even higher (21% of the students are at level 1 and below). Almost 71% of students are at the intermediate levels of performance and 8.1% at the higher levels.

[10] PISA Report, 2009. See at http://www.oecd.org/dataoecd/10/61/48852548.pdf

[11] Although the last PISA was in 2009, we use 2006 results because that year the study was centred in Science, and a deeper analysis was made in Science than it in Mathematics or Reading. We also use 2006 PISA mathematics results as it was the first year Catalonia participated in PISA and we do not have specific mathematics results for Catalonia before 2006.

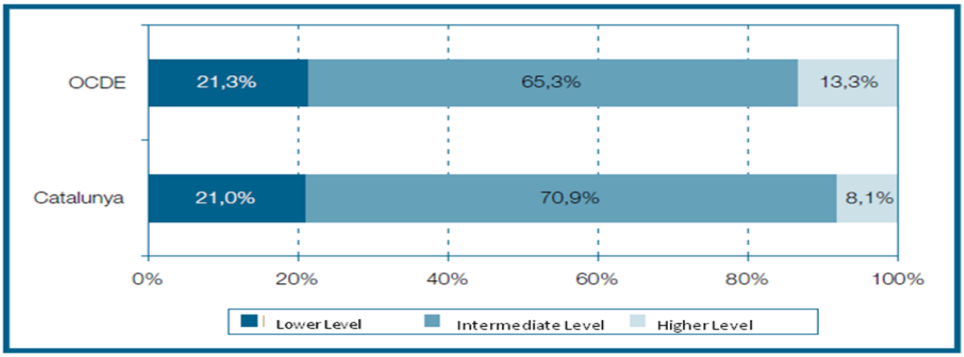

Figure 1.7. Percentage of students of Catalonia and the average of OECD located in lower, intermediate and upper levels of mathematics competence. PISA 2006

1.2.2. Internal evaluation results

Spanish internal evaluation results

As mentioned before, there are two General Diagnostic Assessments; one at the fourth year of Primary education and another at the 2nd year of lower secondary education (grade 8).

The results from the General Diagnostic Assessment 2009 in Primary Education, show that there is a strong correlation between achievement level in both science and mathematics and four out-of-school factors: parents' level of education and occupation; the number of books at home; and the availability of other resources at home such as a quiet place to study and an internet connection.

Regarding Science, results show that 17% of students are at the lower levels of the scientific competence, while only an 8% achieve level 5 of competence. Most of students (75%) are at the intermediate levels of scientific competence. The results are very similar to the PISA results for Science, noting that students are more familiar with the identification of scientific phenomena than with its explanation. However, the use of scientific evidence continues to be the less present acquisition among the students of this age.

Mathematics results are very similar: 16% of students at the lower levels and 8% at the highest levels of the competence. 76% of Students are at intermediate levels. Mathematical reproduction processes are easily overcome by fourth-grade students, while correlation and reflection are the most difficult processes in mathematics[12].

In the case of the General Diagnostic Assessment 2010 at the end of the 2nd year of lower secondary education the results obtained show the same tendency as the Primary level results, even more pronounced.

The distribution of students in the 5 levels of competence is exactly the same for Science and for Mathematics: only 8% of the students reach level 5 of both competences, while 18% are at level 1 and below. 74% of students are at intermediate levels.

Catalan internal evaluation results

[12] General Diagnostic Assessment 2009 in Primary Education, Ministry of Education http://www.educacion.gob.es/dctm/ievaluacion/evaluaciongeneraldiagnostico/pdf-completo-informe-egd-2009.pdf?documentId=0901e72b8015e34e

Since 1995 the Catalan Department of Education has been carrying out every four years the Assessment of Primary Education. This assessment is focused in five main areas: Spanish language, Catalan language, English language, mathematics and knowledge of the environment. The last one is the subject that includes science education in primary levels.

Science results in Catalonia

According to the Catalan Department of Education study, about a 70% of students would be among levels 3 and 4 of a 6 levels scale. The rest of students have the same distribution in the lower than in the higher levels (approximately 16% for both) (see figure 1.8)[13]. These results cannot be compared with any international study, but they would suggest that the major part of students is in a medium level for science education.

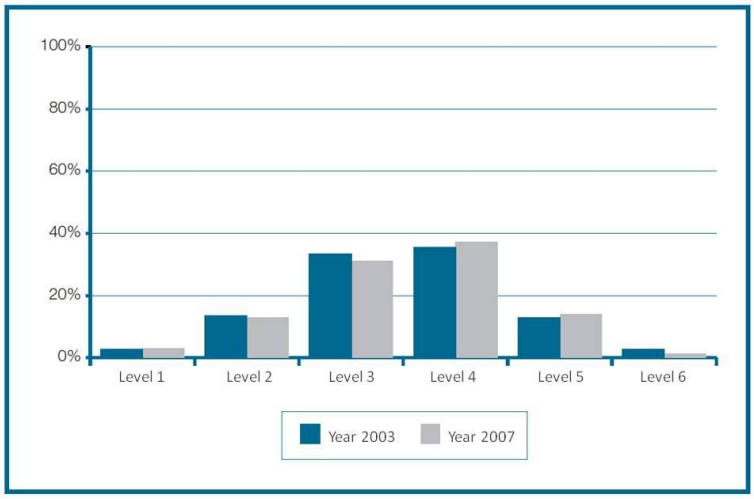

Figure 1.8: Percentage of primary students according to their achieving level on knowledge of the environment

Mathematics results in Catalonia

Mathematics results in the Assessment of Primary education in Catalonia show similar results. Most of students (67%) are at levels 3 and 4 the scale (33% and 34% respectively). Below these levels, there are 17% of students (levels 1 and 2) and above 16% (level 5) (see figure 1.9.).

Specially interesting is that more students are at the medium levels of the mathematics competence in 2007, while the percentage of students at upper and lower levels have decreased from 2003 to 2007. In the evaluation of 2007 level 6 is not even reached[14].

[13] Assessment of Primary Education 2007, Government of Catalonia http://www20.gencat.cat/docs/Educacio/Home/Consell%20superior%20d%27avalua/Pdf%20i%20altres/Static%20file/Informes%2016.pdf

[14] Assessment of Primary Education 2007, Government of Catalonia http://www20.gencat.cat/docs/Educacio/Home/Consell%20superior%20d%27avalua/Pdf%20i%20altres/Static%20file/Informes%2016.pdf

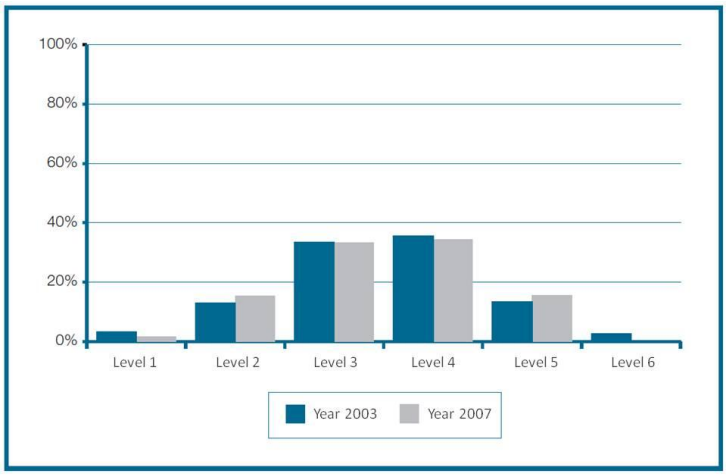

Figure 1.9: Percentage of primary students according to their achieving level on mathematics

General conclusions for Catalonian results

In general, both internal and external assessments show similar results regarding levels of competence for Science and Mathematics. Lower levels of competence are high, compared with the OCDE average, and most of the students are at intermediate levels. These results show an adjusted dispersion of performance, probably indicative of the trend towards equality of Catalan educational system. However, there is little excellence, and only a very low percentage of pupils reach the higher levels of each competence.

Regarding the different processes associated with scientific and mathematic competences, the trend is common in all the assessments. The use of scientific evidence is the most difficult process while the identification of scientific phenomena is easier for students. In the case of mathematics competence, students show a degree of increasing difficulty, as expected, in reproduction, correlation and reflection processes.[15]

1.2.3. Variables that may affect students' results

Titularity or school sector

In Catalonia there is a substantial private sector in education. According to the last official data (Catalonian Department of Education, 2010) 31% of the catalan schools are what is called "escola concertada", which is a type of semi-private schools which are privately run but receive most of their funds from public sources[16].

The difference in results between private and public schools (between centres) is big in Catalonia, when compared with the rest of Spain. However, this difference is rather small when compared with the EU-25 average (Figure 1.10).

[15] General Diagnostic Assessment 2010 in Secondary Education, Ministry of Education http://www.educacion.gob.es/dctm/ievaluacion/informe-egd-2010.pdf?documentId=0901e72b80d5ad3e

[16] These schools are called "*government-dependent private schools*", following OCDE definitions (TALIS project, OCDE 2009).

This is a significant result taking into account the big percentage of private schools (both government dependant and government independent). It shows that despite having a lot of private schools, the difference in results between them is not as big as in other European countries.

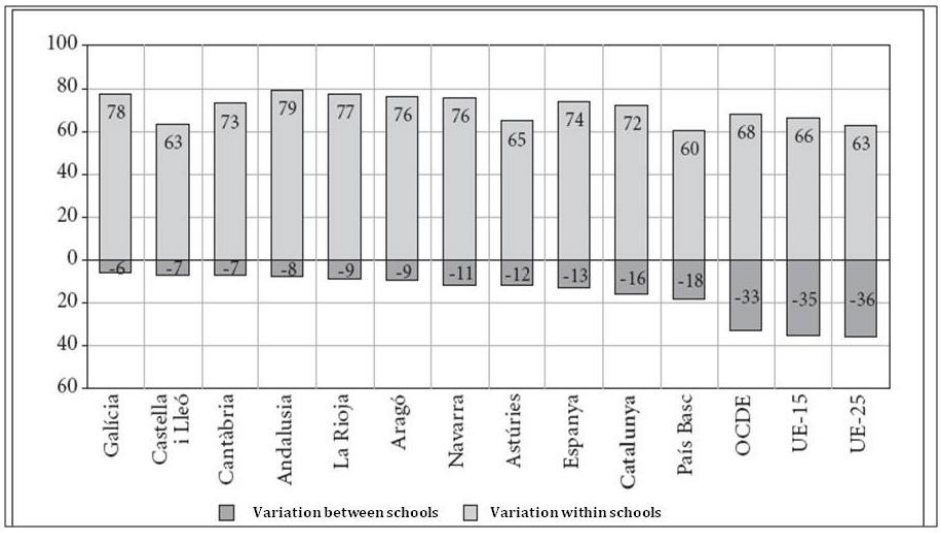

Figure 1.10: Difference between schools centre and within schools in different Spanish Autonomous Communities.

The differences in results of scientific competence between different types of schools is, however, significant in Catalonia (again when compared with the rest of Spain and in this case also when compared with the OCDE average). In general, one can see that those regions which have reduced the separation have better results than those where the difference in results between different types of schools is larger (see Figure 1.11)

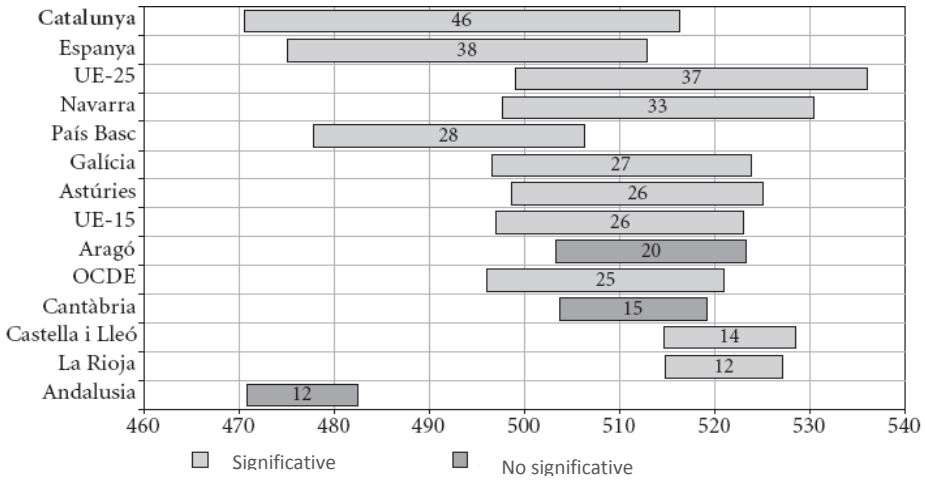

Figure 1.11: Difference between average results in scientific competence according to school type (public and private schools)

This difference between centres could be associated with the fact that students in private centres in Catalonia are also those with a better socio-economic background (which is not so much the case in other regions). However, the lower results of the public centres in Catalonia can not be associated with the socio-economic background of their students, because when correcting results by this variable, Catalonian public schools continue having the worst results than those of Spain (484 of scientific

competence). In this sense, it is complicated to establish the socio-economic background as accounting for the big differences observed.

Regarding teachers, there are strong differences between private and public schools in Catalonia. Teachers of public schools have better working conditions and more option for continuous professional development. Selection procedures are also very different between the two. All in all, sector of schools is a variable to take into account when analysing the Catalan educational context, as they constitute quite different working and educational environments. It is interesting to see if these different scenarios mean different connection with knowledge and usage of educational research results.

Immigration rate

We also consider important to choose schools in Catalonia according to different immigration rates. This is very much related to geographical distribution of the sample and school location (rural/small town, urban and sub-urban), despite not exactly the same indicator. In general, most of the immigrant population in Catalonia lives in the most populated areas. Resources and structure of these schools can also be different, in particular access to projects, innovation or continuous professional development. Figure 1.12 presents the profile of the population concentration in Catalonia. Nevertheless, it has to be noted that, to our knowledge, non official data is available regarding immigration rates by centre. In general, when studying this variable, experts in the field ask teachers or headmasters themselves about the immigration rate of their school and classroom.

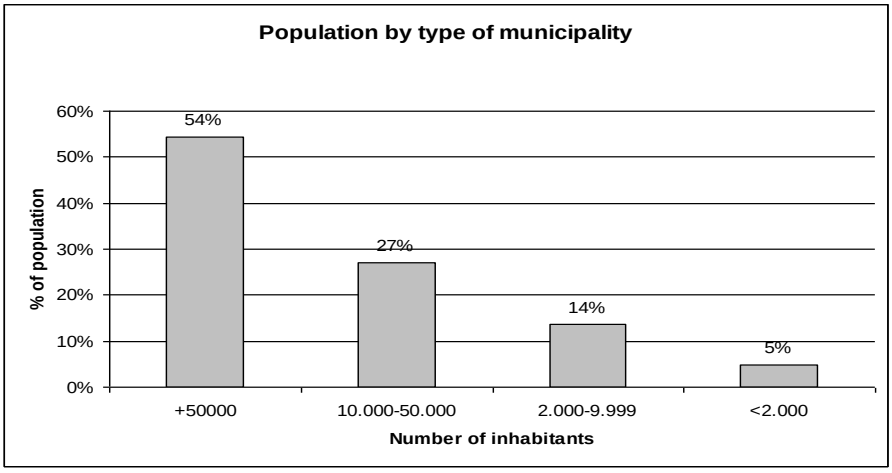

Figure 1.12: Concentration of Catalan population by type of municipality

It is also the case that there is an strong lack of correlation between the bad results of the Catalan public schools and the amount of immigrant (non-native) students, despite the fact that there is a very large proportion of immigrant students (the largest in Spain, see Figure 1.13)

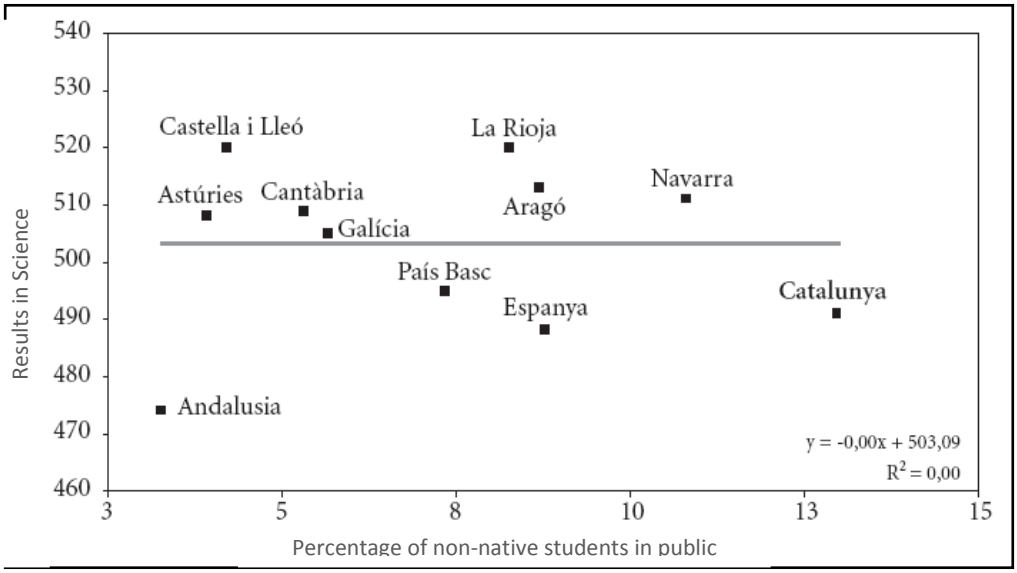

Figure 1.13: Students' results according to the percentage of non-native students.

However, immigration shows to have a stronger effect than that expected. Results of immigrant students are much poorer than those of national students (428 respect 499), explaining the great amount of students in Catalonia in levels 1 or less than 1 of scientific competence according to PISA (see Figure 1.14)

	SCIENCE			MATHEMATICS			READING		
	Native	Non native		Native	Non native		Native	Non native	
Aragó (6,2)	518	445	73	518	438	80	487	424	63
País Basc (4,4)	499	427	72	506	413	93	491	433	58
Catalunya (9,2)	499	428	71	494	428	66	484	412	72
La Rioja (7,0)	526	455	71	533	455	77	498	429	69
Cantàbria (5,2)	513	458	55	505	463	42	477	437	40
Espanya (7,2)	493	438	55	484	432	52	465	418	47
UE15 (8,0)	507	459	48	503	460	43	493	448	45
Navarra (8,7)	516	472	44	521	457	63	484	445	39
UE25 (5,8)	507	473	34	501	473	28	493	448	45

Figure 1.14: Students' results to PISA 2006 according to origin of students (native and non-native)

Separation according to levels

A very interesting characteristic of Catalan schools is that they separate students according to level in much larger proportions than in other regions in Spain (see figure 1.15). This is the case even though Spanish and Catalan system are officially inclusive. However, unofficial but recognised segregation takes place often.

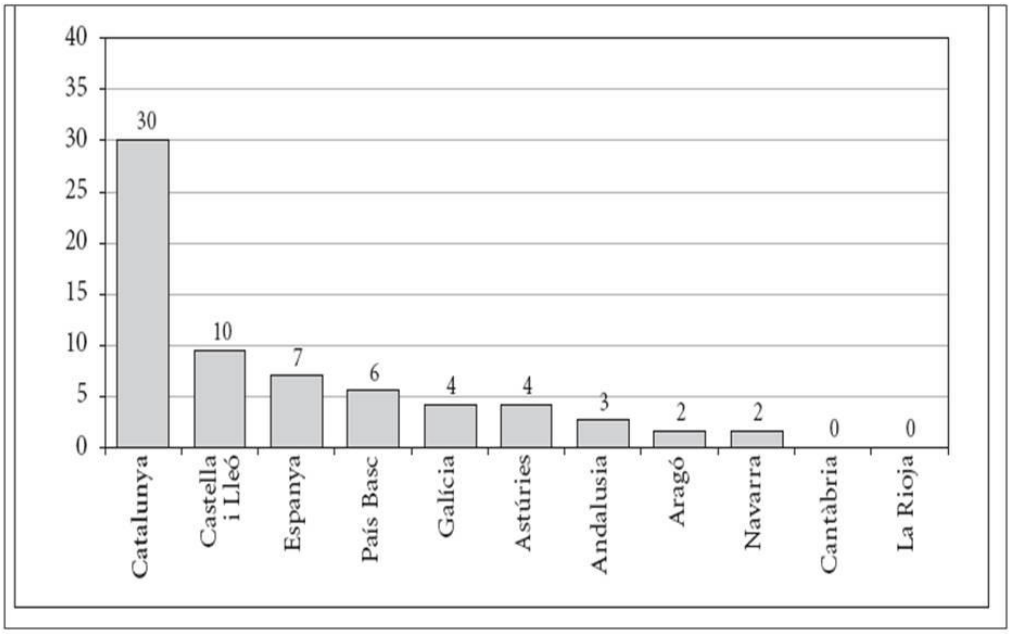

Figure 1.15: **Percentage of schools which separate students according to level in all subjects**

Level of school

Reality of primary and secondary school is also very different in Spain. Primary school teachers are most of them non-science specialists who teach all general subjects, with a particular emphasis on language and mathematics education. In contrast, secondary school teachers are mostly science or mathematics specialists, but they have a low knowledge on pedagogy and specific subject didactics. It is important, then, to take this variable into account when choosing the sample of the case study.

1.3. Teachers Education and Profession

1.3.1. Teachers' training

Teacher education, both initial and continuing, is one of the main national concerns when considering the improvement of school education and more specifically the improvement of students' competences in mathematics and science[17].

INITIAL TRAINING

In Spain the academic qualifications required to teach vary according to the levels of education where teachers work. The initial teacher education for both primary and secondary school teachers has changed in the last 2 years within the framework of the EEES and Bologna process for high education.

Primary School teachers

To become a primary school teacher, university qualifications are needed, either in the form of a Maestro certificate with the Primary Education specialisation (three years university degree), or the recent Bachelor degree in Primary Education, adapted to the EEES and lasting four years.

[17] Eurydice, 2011

Primary teachers are generalist teachers who teach all knowledge areas to a primary school student group. Science is very poorly represented in this initial university training of primary school teachers, as there is no science specialisation for generalist primary school teachers since the LOGSE educational law (1990). However, the new training opens the door to a greater emphasis on science or mathematics content for teachers, as it has been modified the rigid prior structure of specializations only for the areas of music education, foreign languages, physical education and special education. Nowadays, most universities include a small scientific itinerary or specialization within the four-year Bachelor degree.

About 70% of the contents are common for all specializations, and although universities have the opportunity to give more importance to scientific contents, the tradition gives greater weight to the previous specializations and the instrumental subjects such as languages and mathematics.

Regarding teachers educational profile and to better understand the actual teachers profile in Catalonia It has to be highlighted that, after 1990's reform some primary teachers were contracted also for compulsory secondary education.

Secondary School teachers

Secondary school teachers are specialists, either in mathematics or science subject, and they must hold a *Licenciado*, Engineer, Architect or equivalent Bachelor's degree (a four, five or six-year degree) and a post-graduate course.

Science teachers need a graduate in a natural science or related one, such as physics, chemistry, geology or biology. Mathematics teachers must hold a degree in mathematics or other related one, such as economics, architecture or engineer. This initial university graduate has none educational specialisation and it is the same one as those of future physicist, chemists or mathematician working in the industry, research field, etc. The pedagogical qualification needed to become a secondary school teacher is a post-graduate course.

For more than 20 years the post-graduate course consisted of a very short pedagogical training course named CAP (Certificate of Pedagogical Aptitude) after this initial scientific or mathematic training. Other attempts to improve secondary school teachers with better didactical and pedagogical training, such as the CQP (Course of Pedagogical Qualitifcation) were available but not compulsory, and thus, poorly chosen. Only recently (2009) and in accordance with the Bologna agreement, there was an abrupt change. The initial teacher training for secondary school teachers have achieved a master level with an extension of 60ECTS (1 year). This Master has separate specialisations in physics and chemistry teachers and biology and geology teachers, despite the integration of these subjects during the first three years of compulsory secondary schooling.

The CAP was for years criticized as inadequate training, considered in the international studies as a lack of a significant professionalizing training for secondary education teachers. The master course structure is similar to the previous CAP, but much broader in hours: general teacher education (psycological and sociopedagogical contents), teacher training in an area of knowledge (didactic contents of a specific subject and complementary training) and teaching practices in secondary schools.

According to the national study "Teaching and learning strategies in teaching science. Working Group Science and Education" (FECYT, forthcoming), in relation to science and mathematics teachers, elementary school teachers would have broad knowledge (at least, theoretically), but lack of scientific or mathematical training -didactics, while, on the contrary, high school teachers would have a high level of scientific knowledge, but also lack of didactic component.

TEACHERS PROFESSIONAL DEVELOPMENT

In-service training is a decentralised responsibility of the Autonomous communities despite some continuing professional development courses may be organised by the State.

All these activities may be grouped into three basic types: courses requiring attendance or on-line courses, seminars and team work. The following are some of the priority lines established by the LOE for in-service training programmes: to adapt knowledge and teaching methods to trends in education sciences and specific methodologies; coordination, guidance, tutoring, attention to diversity and organisation aimed at enhancing the quality of education and the functioning of educational institutions and specific training on the subject of equality or fostering use of information and communication technologies and foreign language learning.

Undertaking in-service training is voluntary but has a direct impact on teachers' professional careers, as it is regarded as merits in competitive examinations (merit for transfers, secondments, management of educational institutions) or as a necessary requirement to be eligible for a salary bonus.

According to TALIS (OECD, 2009) all Spanish teachers had reported having participated in some development while at the same time a 60% of them did still demand more professional development than they received, specially regarding areas such as: teaching special learning needs students, ICT teaching skills, student discipline and behaviour problems or teaching in multicultural settings.

1.3.2. The teaching profession

The general recognition of the crucial importance of teachers in the necessary task of improving education (as evidenced as a result of student performance in PISA) has become widespread since the publication of the influential report Teachers Matter. Attracting, Developing and Retaining Effective Teachers (OECD, 2005). This report provides an international comparison on key aspects of the teaching profession, including what their future career perspectives are.

In Spain there is no lack of attractiveness of the teaching profession (though socially recognition has been declining as in other countries) because there is more supply than demand for teachers. There are also no faculty retention problems because, as public officials, teachers are maintained in the profession throughout their working life. However, this does not guarantee an improvement in teacher quality, according to the results of the OECD (2005). The problems in our country are qualitative in nature and refer to three aspects: a demanding but inadequate selection of teachers, lack of incentives and flexibility in the teaching profession and limitations of the initial and continuing training the teachers.

Entering in the profession: selection processes

Regarding the selection of public teachers (which is the majority of teachers in the country) the admission criteria via public opposition, though highly competitive, shows not an strong enough emphasis on the knowledge and skills required for effective teaching.

In general the structure of public opposition has basically two tests (although the educational competencies are transferred to the autonomous communities and therefore may be differences in the selection of teaching systems between each other).

The opposition system of primary teachers has two separate parts. The first test integrates all content areas within the primary curriculum (as the area of mathematical knowledge language or knowledge of natural, social and cultural development in the case of science) with didactic and pedagogical contents (such as assessment or tutoring). It is not necessary the mastery of scientific/mathematic and didactic knowledge to overcome the opposition. The second test involves the presentation of a program and its oral presentation and defence in context, presenting a teaching unit for a particular course in a particular school. However, despite the demands of contextualization made, it is still a theoretical and simulative exercise away from real teaching practice.

In the case of secondary school teachers oppositions, they are very similar to those of primary education teachers, although the first test requires specific knowledge about an area or subject, which is generally very high level in the content discipline but not necessarily on the issues that teachers end up teaching (opponents of the specialty biology and Geology, for example, end up lecturing in chemistry or physics) neither, more importantly, in the domain of the scientific content to be taught (science education).

As can be seen, both for primary and secondary levels the selection processes of science teachers have serious problems. As indicated in the OECD report, these teachers selection procedures in the public system do not respond nor are adapted to the diverse local educational needs of the school in which the future teacher must exercise regarding neither the content to teach nor the educational reality to be handle. Therefore, the restrictive selection process doesn't guarantee the best teachers entering the profession, much less that the best teachers to the needs of the school A enter the school A. This situation is different in the case of semi-private or private school teachers, where the selection is made by the school itself (the governing body) and can, in theory, be done according to the needs, ideals and objectives of the school.

Introduction to the profession

Once obtained the position, teachers in public career systems like Spain generally lack an introduction to the profession according to their initial inexperience, not having initial induction periods in which new teachers have experienced mentors or tutors in the centers where they begin their careers. In induction systems, novel teachers still don't have the status of teacher and they are considered trainee teachers, similar to medical residents, and therefore does not have full teaching responsibility. This situation facilitates learning in practice and a gradual entry into the profession.

Lifelong within the profession

Another of the shortcomings of the teaching profession in Spain identified by several studies is the fact that public teachers lack incentives to stay in the profession and to continue evolving within it. For example, the entry into the profession is directly after the opposition, and as noted by the OECD, the procedures for handling an ineffective teaching are usually heavy and slow. In addition, seniority (measured in terms of three years and six years) is one of the criteria most used to grant higher wages.

Thinking that you have a lifelong profession for which capability has already been demonstrated (overcoming the opposition) and in which generally there is no incentive to pass other assessments / external regulations, has contributed to not considering lifelong learning as an urgent need and not valuing obtaining good results.

A third problem of teachers' professional profile in Spain is the rigidity of the public teaching system (civil service), which generally limits greatly the entry and hinder the exit in the same way. These schemes lack appeal for those who are not sure they want to dedicate a lifetime to the teaching

profession or for those who have already gained experience in other areas and want, in their working maturity, explore teaching. Thus, the teacher profile in Spain is highly homogeneous and rigid, and does not allow people with different backgrounds and suitable profiles for specific educational realities to access the profession.

Initiatives on teachers professional development

There are different initiatives, both at national and regional level, on teachers professional development. The IFIIE (Institute for Teacher Training and Educational Research and Innovation), the INTERCAMBIA portal ('To educate in feminine and masculine'), the Institute for Educational Technologies are a few examples of social networks that facilitate the exchange of experiences and resources between teachers.

In each Autonomous Community, the Education Department supports Centres for Continuing Teacher Development with programmes to develop teacher networks. In the case of Catalonia, the website developed by the Regional Education Department is called Xtec (Telematic Educational Web of Catalonia)[18]. The course on 'Strategies for Mathematics Problem-Solving' offered in Catalonia is aimed at generalist teachers at primary level in particular, and aims to provide them with different methodologies to work with problem-solving in their daily teaching practice.

The direct contact with applied research and additional resources provided by private companies or research institutions may be particularly beneficial for teacher professional development. Good examples of this are the strong training component in *El CSIC – Consejo Superior de Investigaciones Científicas – en la Escuela* (The High Council for Scientific Research in Schools)[19], or, at the regional level, the *Centre de Reçerca per a l'Educació Científica i Matemàtica* – CRECIM (the Science and Mathematics Education Research Centre)[20].

1.3.3. Distribution of responsibilities

Within schools, oganisational, pedagogical and managerial responsabilities are distributed among the different governing bodies of the insitution and may vary according to the different sectors of schools existing in the country: public, semi-private [21] or private.

For public schools these governing bodies are elected for a four-year term and they are, on the one hand, mixed-member bodies (the school council and the teachers' assembly) and, on the other hand, the management team comprised by the headmaster, the head of studies and a secretary or an administrator.

In semi-private centers, governing bodies must comprise at least the headmaster, the School Council and the Teachers' Assembly. Private schools enjoy autonomy to structure their organisation and as such may establish the governing and participatory bodies which they deem fit.

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[18] http://www.xtec.net/formacio/index.htm
[19] http://www.csic.es/web/guest/el-csic-en-la-escuela
[20] http://crecim.uab.cat/
[21] A definition, according to the Eurydice glossary, can be schools which are "*privately owned, co-educational and can be denominational or non-denominational. It is grant aided by the educational administration of the Autonomous Community concerned. Tuition fees are not payable, but families contribute to other expenses*".

Regarding headmasters, their selection in public schools is from official teachers of any of the types of provision offered by the school and must be carried out in accordance with the principles of equality, open publicity, merit and ability. In semi-private schools, the headmaster represents the owner of the centre and is appointed by consensus reached between the owner and the School Council.

Nevertheless, Spain is still one of the countries where the selection of headmasters is linked to their length of service as teachers and their responsabilites are only some more than which their colleagues have. In these sense, and taking into account the results of TALIS (OECD, 2009), Spanish headmasters present a very low profile regarding both *"Instructional and Administrative leadership"*. (See figure 1.16)

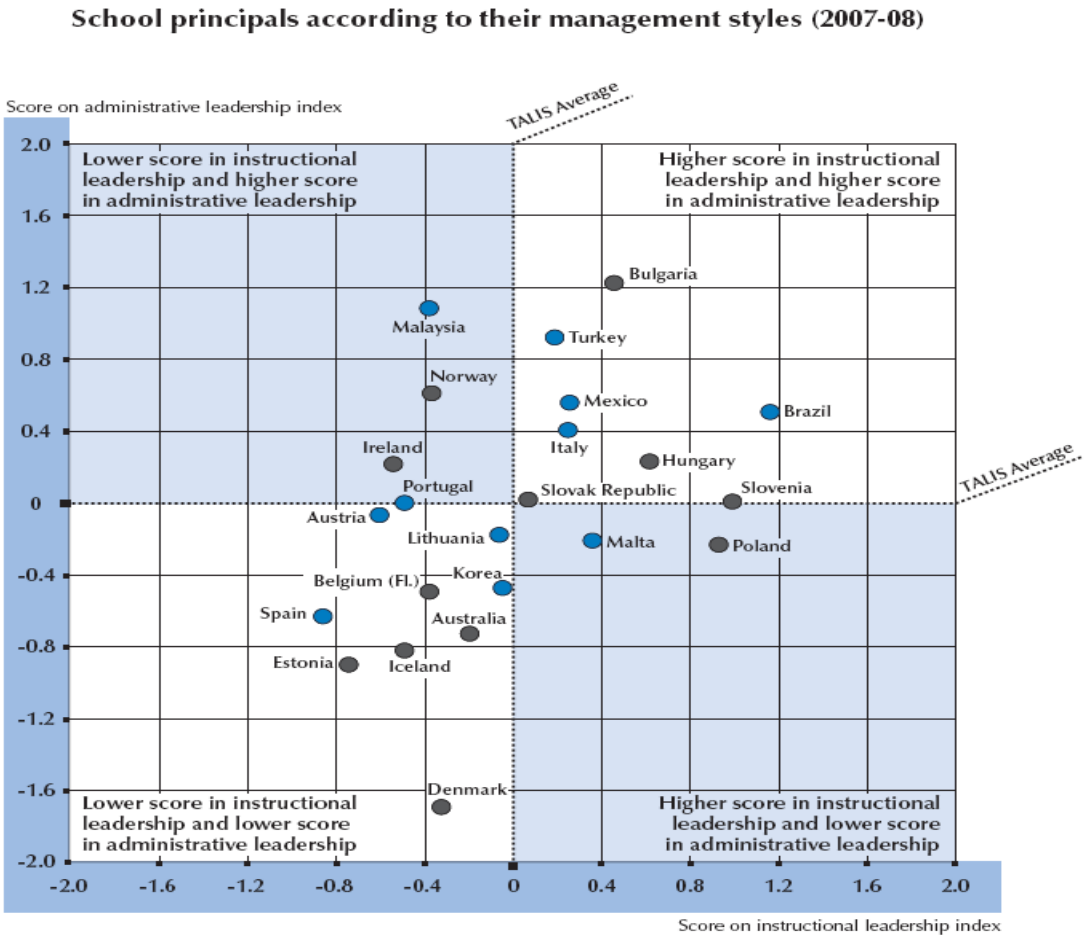

Figure 1.16. School principals according to their management styles. Source: OCDE, 2009

Instructional leadership takes into account the management styles including *management of school goals, structional management and direct supervision of instruction in the school* while Administrative leadership includes *accountable and bureaucratic management*. As figure 1.16 shows, Spanish headmaster are below the average in both cases being lower the instructional leadership profile but, furthermore, their involvement in "*Decision making"* is also lower than average what indicates the lack of responsabilites given to headmasters. This decision making refers to activites such as selecting and firing teachers, establishing teachers starting salaries and their increases, or choosing which textbooks are used.

Regarding this decision making areas and considering also the involvement of teachers it is interesting to highlight some of them taking into account where the decision-making is taken (European Comission, 2008). For example, regarding the content of the compulsory minimum curriculum, neither headmasters and school management body nor teachers are involved in this decisions as happens also with the content of examinations for certified qualifications. On the other hand, teachers are those who directly decide about some relevant topics such as: optional subjects to be teached, teaching methods, choice of school textbooks, basis on which pupils may be organised into groups for compulsory learning activities or criteria for the internal assessment and course repeat,

Finally, another point to be considered is the rol of the Head of Department (Secondary level) or the Cycle Coordinator (Primary level) that sometimes centralize the teachers decisions mentioned above.

Within this context, schools are prompted by the educational authorities to elaborate autonomy plans in order to become more autonomous institutions within the Plan for School Autonomy (Pla d'Autonomia de Centres[22]). From 2005, schools in Catalonia have been invited to elaborate their own educational plans with the intention to give autonomy to schools and more educational and organisational power to the school administration. This situation tries to solve the problem of Catalan and Spanish schools being one with very few self-control and with headmaster and other positions in the school administration as only administrative and bureaucratic ones (instead of control or decision making positions).

[22] **http://www10.gencat.cat/sac/AppJava/servei_fitxa.jsp?codi=9470**

2. NATIONAL CASE STUDIES REPORTS

2.1. Introduction of the Case Studies

Within this Spanish educational context, and considering the dimensions that the research team aimed to analyze, three case studies have been developed. These three case studies can be grouped into two different types: teacher education initiatives already happening and with an important role of the Administration (first case study, which is, in fact a comparative case study of two different initiatives) and professional development interventions in charge of the TRACES team (second and third case studies). In this sense, all the case studies report and are based on either on purpose or already happening field actions of **on-going** and **subject-based** continuous professional development (CPD), both within and outside the school setting, of primary school teachers. These field actions have been selected or designed due to the fact of their strong theoretical transformative potential, in order to explore the characteristics of CPD actions that are linked with educational research with the purpose to transform such actions in a research and evidence-based way. For the first type of case studies, TRACES' aim is to study specific training initiatives already existing by analyzing teachers' perspectives about these initiatives and their characteristics. In order to do so, two different existing training programmes, both out-of-school ones with an important innovation focus, have been explored. Both training programs are characterized by its focus on science education, a regular, self-organisedcontact with the research community,their official caracter (upport from the Educational Administration) and their long term approach.

Regarding the second type of case-study report, the analysis is focused on two interventions designed and implemented by the research team as school-based teacher education programs. Both initiatives are based on a model of teacher education where researchers and/or teacher educators give support to teachers in their own school, generally working at group level (cycle or whole school), to improve particular aspects of their practice. In the case of TRACES Spain this is done both for Mathematics (second case study) and Science Education (third case study), using two different models of research-based teacher CPD in which reflection and subject matter didactical knowledge have crucial importance. The second case study is based on the idea of model-lessons and video-based reflection on practice. Third case study is based on the idea of reflection on practice via participation on cycles of group design, implementation and reflection. Both field actions started during TRACES but are independant on the project funding, so they will continue after the project is ended

Dimensions of the meta-analysis

Without losing sight of the general TRACES question underlying the three case studies – How the research-to-practice gap in Science and Mathematics Education is dealt with in different continuous professional development initiatives which are aimed to transform practice and are compatible with the reality of teacher education in Catalonia?, specific questions were addressed when analyzing each case study. For this reason, dimensions of the meta-analysis have been defined in relation to what was expected to find in each case study.

The analyzed practices, then, are chosen to be interesting examples to explore mainly the TRACES meta-analysis dimension of the capacity of teacher education to transform practice, being these practices, which are long term initiatives with a high investment, an exception of what is usually done in teacher education in our country. Due to the diversity and systemic character at different levels of the initiatives explored, they also involve indirectly other TRACES meta-analysis dimensions depending on the field action characteristics and case-study focus. (see Table 2.1)

The analysis of these initiatives in relation to TRACES meta-analysis dimension of teacher education is done from a particular framework for teacher education present in all the case studies. This framework understands teacher education as a process of teachers' learning of didactical knowledge (PCK) in which the work of teachers among themselves and with researchers to improve practice is rooted on the idea of Communities of Practice. In this sense, the case studies specific research questions are define in relation with this particular theoretical framework, which will be introduced in each of the case studies.

CASE STUDIES TRACES-SPAIN										
CASE STUDIES		GENERAL RESEARCH QUESTION	SPECIFIC RESEARCH QUESTIONS	DIMENSIONS OF META-ANALYSIS						
				1	2	3	4	5	6	
CS1	**ICE** Official on-going, out of school and voluntary innovative teachers' group coordinated by expert in Science Education **CDEC** Official on-going, out of school and professional teacher education initiative for the training of teacher trainers	To what extent are these professional development groups an effective initiative to foster teachers' professional development taking into account the theoretical frameworks of professional development and professional learning communities?	How their ideas resonate, conflict with or add to the existing knowledge we have about effective professional development, in particular the well-known framework of Professional Learning Communities? What do teachers' participating in the teachers' group highlight regarding this professional development initiative?	■	■	■			■	
CS3	**MDL School** School-based teacher' education intervention based on model lessons of numerical sense and mental calculus strategies	To what extent this professional development initiative based on model lessons of number sense and mental calculus strategies fosters teachers' professional development taking into account the theoretical frameworks of *professional development and professional learning communities*?	What aspects of the professional development of MDL primary school teachers have evolved and how during a teacher education intervention based on joined common reflection of Mathematics' model lessons about of numerical sense and mental calculus strategies?			■	■	■		
			Which **aspects of the teacher education model** -based on common reflection of model lessons- have more incidence on the professional development of the participant teachers?	■					■	
CS4	**Amilcar School** Teachers' training intervention based on design, implementation and reflection of Science lessons	To what extent this professional development initiative based on design, implementation and reflection of Science lessons fosters teachers' professional development taking into account the theoretical frameworks of *professional development and professional learning communities*?	What aspects of the professional development of Amilcar primary school teachers have evolved and how during a teacher education intervention based on design, implementation and reflection of Science lessons?			■	■	■		
			Which **aspects of the teacher education model** -based on design, implementation and reflection of Science lessons - have more incidence on the professional development of the participant teachers?	■					■	

1. What role does teacher education play?
2. What role does an educational authority play in the change process?
3. What role does the school structure play in the change process?
4. What role does educational resource play?
5. What role does the social community play in the change process?
6. What role does research in science education play in the change process?

Table 2.1: TRACES meta-analysis dimensions

2.1.1. Justification of the case studies

Current Spanish curriculum is based on competences, guided by the framework for basic competences of the DeSeCo project (OCDE, 2007). Theoretically, this competence based framework is already being implemented at schools, thus demanding from teachers the capacity to teach their students not only particular contents but to develop their capacity to use these contents in practice, mobilizing them to solve problems. However, internal and external evaluation results evidence low students' achievement/ level of competence in both mathematics and science evaluations, without substantial improvement along time.

At the same time, research points out that many primary school practicing teachers have not learned some of the content, both didactical/pedagogical and subject matter content, they are now required to teach, or they have not learned it in ways that enable them to teach what is now required. In particular, curriculum reform processes have resulted in many teachers now having to teach a curriculum that is quite different from the one for which they were educated (Adler et al, 2005, p. 361). This is clearly the case within a competence based framework, which requires a very important mastery of subject matter knowledge and PCK to be able to be implemented and evaluated in an adequate way. In Spain, however, generalist primary school teachers have important lacks in their initial training both in subject matter and PCK training.[23] As a result, teachers need support in order to implement this new curriculum.

Along the lines of this situation, all TRACES national surveys bring to evidence teachers' general need for more specific training in order to be able to manage the contents in Science and Mathematics curricula and work within the competence-based didactical framework. The required knowledge is mostly research-based, thus giving importance to the participation of research in these training efforts. If the idea is, however, not only to master the mentioned contents but also to change actual practice, the required knowledge is also evidence-based, thus giving importance to reflection in each of the training efforts. Teachers often refer to their own professional experience as the main instrument that allows them to manage their work in the classroom, but only when this is done by seriously reflecting on practice from a research perspective it can have the desired impact on teachers' actions.

In that context, all the selected and/or designed field actions of our case studies are related to the professional development of science teachers in primary school levels.

Group 1

First case study offers a comparison between two continuous professional development (CPD) initiatives (ICE and CDEC teachers' groups) characterized by their potential in front of what is usually done with regard to teachers training programs, mostly proposed by the Administration when talking about public and semi-private schools. Both initiatives, did already exist when TRACES project was started and present some characteristics that make them interesting to be analyzed when looking for new ways to improve science education teachers practice. First group, ICE's one, is a teachers' group that meets monthly to exchange their experiences and to talk about new science education approaches. The second group, CDEC's group, is a group that started as training for teachers to become teachers' trainers and has continued its activity after this training was finished.

In contrast to what is usual in the teachers training programs that primary school level teachers receive, these initiatives are long-term ones, with about ten years of existence. Teachers participating in each

[23] For more information see baseline document

initiative take part of the initiative in a voluntary way and are opened to share with their colleagues their experiences in order to improve their own practice. Another similarity between both groups is the fact that they are constantly in contact with the science education research, being each group coordinated by a science education researcher and usually receiving advice, based on teachers' request, from well-known science education researchers. Finally, both initiatives are related to the Administration what has offered, in the case of the CDEC group, the opportunity of having some privileges that otherwise would not have been possible – like a time reduction in their teachers' tasks-.

Bearing all these particularities in mind, the authors considered that analyzing these atypical initiatives would be interesting in order to identify some key features that would be profitable for future CPD initiatives.

Group 2

Second type case studies are done in semi-private Schools. The decision of working with this kind of school is due to the fact that even though they are quite similar to public schools in terms of teachers' and students' profile, semi-private Schools' titularity implies a facility to arrange a specific whole school intervention. In this kind of school, the School Administration has the competence of deciding actions that involve the whole School faculty, such as choosing CPD initiatives for all teachers, while in public Schools these decisions are generally taken at the independent teacher level.

MDL and Amilcar case studies arise from this need of finding new ways and methods to overcome teachers' limitations in both subject matter and didactical/pedagogical knowledge through useful professional development programs that can help teachers to work from the competence-based framework.

To do so, the rationale behind the interventions that form the second group of case studies seeks to promote a real exchange between teachers and researchers in a peer-to-peer approach that fosters an authentic reflection on practice. These teacher development programs also want to facilitate the cooperation within the school creating a sustainable teachers' learning community working for the science and mathematics teaching and learning improvement. When doing so, it is important to take into account real School situations and constraints, teachers' perspectives about their own difficulties and several other factors –internal and external- that may affect teachers' practices.

2.1.2. General theoretical framework

Continuous Professional Development is the common topic behind the three Spanish case studies. For this reason, a general theoretical framework will be supporting the analysis of all the initiatives when responding to the general research question of each case study. This theoretical framework is developed in this section and will be referred to in each case study when presenting the results.

Teachers' Professional Development

Research in education and, by extension in the Science Education field, has experienced during the last decades, as stated by Huberman and colleagues, an *explosion of interest* towards teachers and teaching (Huberman et al. 1997). According to the authors, this increasing interest is mainly due to the growing recognition that teachers', their knowledge, beliefs, values and competence, have a crucial impact on school effectiveness. According to Adler *et al.* (2005), "quality instruction depends on teachers, and so their preparation and continuing professional development is crucial" (p. 360). This recognition has its roots in the theoretical frameworks of teacher thinking (Calderhead 1987; Clark and Peterson 1986;

Marcelo 1987), within which research results have shown that the level of professional development of teachers, in other words, what teachers know, can and want to do, has a strong influence on their teaching, and thus on what their students learn.

The idea that teachers' development is a crucial factor for the success of education has been informing educational policy since the 90's and is still today a central argument in most policy recommendations. Reports such as *What matters most: teaching for America's Future (NCTAF 1996) stating that "what teachers know and can do is the most important influence on what students learn*" (p.6) or the also well-known OECD report *Teachers' Matter: Attracting, Developing and Retaining Effective Teachers Education and Training Policy* (OECD 2005), confirming that of those variables which are potentially open to policy influence, factors related to teacher quality are the most important influences on student learning and should be addressed accordingly, bear witness to the relevance given today to teachers' development.

Closely related to the interest in teachers and teacher professional development is an interest in educational change and a subsequent reform movement worldwide. Whatever the extend of change, either a broad educational reform or a small curricular innovation, teachers are the ones who have to bring it to practice and need to be professionally developed to do so. In this sense, teachers are the most influential factor in educational change (Duffee and Aikenhead 1992) and educational change becomes actually a matter of teachers' development (Fullan and Hargreaves 1992).

Nevertheless, despite the extensive call for instructional reform in the science classroom of the last two decades, change has not been extensive (Davis 2003), and the numerous initiatives carried out in this field have produced mixed results and have raised several questions about the relationships between knowledge and action, teachers, the learning community and schools, and further work is therefore needed (Escudero, 2009). This situation would suggest that if reforms are not having the expected results, this implies that the traditional teacher education or continuous professional development initiatives are also not having the expected impact. Or, in other words, they are not adequately supporting the process of professional development that teachers need in the reform scenarios which, as science education researchers have acknowledged, pose great, in fact sometimes unexpectedly great challenges to teachers (Black and Atkin 1996; Darling-Hammond 1997; Furió et al. 2001; Jimenez-Aleixandre and Sanmartí 1995; Pintó 2005).

Trying to find the roots of this failure, some authors have pointed to the characteristics of the traditional teacher education initiatives. Little (1993) expresses the shortcomings of traditional teacher education within reform scenarios as a problem of fit between *"the ambitious visions of teaching and schooling embedded in present reform"* and the *"prevailing configurations of teachers' professional development [initiatives]"* (p.129). The author argues that the dominant model of teachers' professional development is a *training* model focused primarily on *"expanding the individual repertoire of well-defined and skilful classroom practice"* (p.129), which cannot meet complex demands in complex contexts of teaching and innnovation. Other authors have also criticised that, despite the global recognition of the importance of teacher continuous professional development, the characteristics of the initiatives available to teachers are inadequate for the requirements of reform. They have been described as fragmented, intellectually superficial, and, more importantly, as neglecting what it is known about how teachers learn (Ball and Cohen 1999; Borko 2004; Putnam and Borko 1997).

The traditional teacher training paradigm

The type of training offered to practising teachers has taken different forms over the years: examples include continuous training understood as any kind of training, whether individual or group; the notion of refresher programmes, offered at specific points and focusing on specific topics; the kind of professional development in which emphasis is placed on the idea of "evolution and continuity, going beyond the traditional juxtaposition between initial training and the consolidation of skills" (Marcelo, 1994; p. 315), among other models. What is generally referred to as traditional professional development is the professional development initiatives designed within the so-called *"training paradigm".* The rationale behind this paradigm has been described as that of establishing a bidirectional and univocal relationship between initiatives of in-service teacher training (or traditional teacher education) and the professional growth of teachers. Within this paradigm, it is considered that the traditional short-term and standardized sessions typical of staff development courses, workshops and seminars are the main source (or even the only source) of teacher development. Or in other words, that teachers mainly (even only) learn and develop along the official provision of in-service courses. It does not mean that teacher training activities are not useful. Under the right conditions, training-based staff development approaches have shown to have good results regarding discrete knowledge, skills and techniques (Villegas-Reimers 2003) and as such, are included in recent reviews as one of the possible designs of professional development activities (Guskey 2000; Loucks-Horsley, Love et al. 2003). The problem is that, unfortunately, quite often this approach has become the dominant or even the only one available for supporting the professional growth of teachers, much beyond the domains in which it can be effective.

As some authors have pointed out, traditionally professional development has been conceptualized as basically a dissemination activity: "*locate new knowledge relevant to teaching, package it in an attractive manner, and get it into the hands of teachers*" (p.194, Wilson and Berne 1999). For Ingvarson (1998) this traditional system of professional development is not only a model of in-service training, but something much deeper: a system within a particular reform agenda characterised by employers having control, governments establishing the goals, the leading actors being universities or consultants and the models of professional development used being usually short-term courses or workshops, which of course are not necessarily related to practical issues (Villegas-Reimers 2003).

For Guskey (2002) and others, the majority of these programs did not take into account two crucial factors: what motivates teachers to engage in professional development and the process by which teachers change. According to the author, "*many conventional forms of professional development are seen as too top-down and too isolated from school and classroom realities to have much impact on practice*" (p.3, Guskey 2000). In this sense, McLaughlin (1991) refers to professional development activities offered within the "training paradigm" as "*activities planned and developed far from the school site, with insufficient relevance to [...] classroom practices and inadequate follow-up to permit integration of new ideas and methods into professional activities*" (p.62). Compared with the complexity, subtlety and uncertainties of the classroom, in particular when change is pursued, much in-service training has been described as a low intensity enterprise that requires little involvement (little intellectual struggle, emotional engagement and participation) from teachers (Little 1993).

This fact is even worse when professional development is organised for helping teachers to cope with the new demands bottom-up education reform is posing to them. For the author, these sorts of activities are not able to "*deepen the discussion, open up the debates, and enrich the array of possibilities for action*" (p.148) that are necessary for teachers if they are expected to move beyond a

mechanical use of the curriculum. Huberman (1995) found that, according to teachers, the most robust opportunities for teachers' professional engagement are found in ambitious innovations, in particular when they are undertaken with colleagues. As mentioned before, other authors have emphasised the idea that traditional professional development does not take into account what we know about how people (how teachers) learn (Gil 1993; Porlán and Rivero 1998; Ball and Cohen 1999; Putnam and Borko 2000; Borko 2004). These traditional training initiatives have been discussed as having more a "transmission-oriented" than a constructivist or socio-constructivist approach. According to teachers' themselves, the professional development activities that help them best to develop professionally are *"observing other colleagues; collective enquiry into school improvement; taking part in coaching or mentoring; high quality training on specific skill areas, with excellent teaching materials and direct support to apply learning in classrooms"* (White paper on teaching and learning 2000, cited in Bolam, McMahon et al. 2005). These initiatives are collaborative, school-based and classroom-oriented professional development.

In Catalonia and Spain, as in most of the countries, most teachers' continuous professional development initiatives are closer to the traditional approach above described. Despite satisfactory in quantitative terms (number of courses offered, number of teachers taking teacher training courses, etc) and the large amount of money spent on it, the expected results are not always achieved, especially when we talk about education change in particular in science.

New paradigms for teacher continuous professional development

Considering what the new paradigm on teachers' professional development upholds, teachers' professional improvement is not restricted to happen in particular moments due to particular training activities, but along the complete professional life of teachers, in an ongoing manner, across a great variety of experiences. In this sense, within the new notion of professional development, one should refer to professional development experiences, initiatives, scenarios, contexts or settings rather than to particular training activities. Besides, different notions of teachers as reflective practitioners, as mentors, as coachers, as curriculum makers, as action researchers, etc. emerge as part of the professional development field. Some authors have made the point of considering part of professional development not only different formal but also informal experiences, such as teachers' collegial exchanges (Fullan 2001), bearing in mind that not any form of peer work or any use of teacher reflection should be seen as a potential professional development scenario and that the idea to be kept in mind is that of systematic intervention (Villegas-Reimers 2003).

In this new paradigm, the concept of professional development is considered from a contextual and organizational perspective and is geared toward change in both the individual teacher and the school (Marcelo, 1994). According to Guskey (2000), this new kind of professional development is seen as an *intentional*, *ongoing* and *systemic* process. Professional development should be designed and managed as a conscious effort to bring about positive change and improvement. Professional development is not, then, "*a set of random, unrelated activities that have no clear direction or intent*" (p.17) but a deliberate process, guided by a clear vision of purposes. In this sense, Guskey highlights the importance of planned goals for professional development: "*these goals form the criteria by which content and materials are selected, processes and procedures developed, and assessment and evaluations prepared*" (p.17). What is expected to be learnt would be made public, and thus, able to be revised and discussed.

Additionally, this process has to be an ongoing one. On the one hand, teachers need to keep abreast of novelty, that is, the new educational ideas, theories and research results. On the other, perhaps more

important even, teachers *"must constantly analyze the effectiveness of what they do, reflect on their current practices, make adaptations when things are not going well, and continually explore new alternatives and opportunities for improvement"* (p.19).

Finally, authentic professional development also calls for a systemic approach that takes into account all levels of the organization. This systemic approach is clearly associated with the extended role of the teacher in bottom-up reform approaches, is what most dramatically has affected the new views of professional development. In the new view of professional development, promoting it involves enhancing teaching effectiveness but also the transition to roles of higher status and responsibility within the teaching profession (Villegas-Reimers 2003): teachers as curriculum designers, practitioner researchers, inquirers of practice, etc. roles demanded by bottom-up reform, which need particular professional development initiatives to support them. According to Little (1993) and McLaughlin (1994), in these new reform scenarios the professionally developed teacher is the one who have not only grow professionally regarding classroom-related knowledge, skills and judgement, but also regarding the contribution to a professional community: learning how to cooperate and work, reflect, learn and decide with colleagues. Leithwood (1992) adds to this the importance of learning and developing to exercise leadership, which has been discussed as crucial and necessary to be constructed in these scenarios (Little 2003).

To sum up, then, when designing a professional development initiative, some features have to be born in mind: the use of external expertise, such as science education research experts, linked to school-based activity; observation; feedback (usually based on observation); an emphasis on peer support rather than leadership by supervisors; scope for teacher participants to identify their own CPD focus; processes to encourage, extend and structure professional dialogue; and processes for sustaining the CPD over time to enable teachers to embed the practices in their own classroom settings.

Even though the literature on professional development is filled with descriptions and discussions of failures, according to Guskey (2000) we can also find some strong evidence showing that some professional development efforts are highly successful. Main issues in common to all the reviews of effective professional development are resumed in Table 2.2 (Couso, 2009).

Characteristics of Effective Professional Development

It is planned as a **long-term process** and it is sustained to become **ongoing**, possibly job-embedded.
It has a **systemic view**: addresses both the teacher and the institution; takes into account the broader social and political context; it is linked with educational reform.
It is focused on reflection and **inquiry** for solving problems of teaching and learning, classroom practice and students' results in an evidence-based manner.
It is a **collaborative** process in which teachers and other necessary actors form a community.
It is focused on the **subject**, on both content and pedagogical content knowledge.
It takes into account what is known about **teachers' learning**

Table 2.2: Characteristics of Effective Professional Development according to the literature reviews of (Loucks-Horsley and Matsumoto 1999; Wilson and Berne 1999; Guskey 2000; Putnam and Borko 2000; Supovitz and Turner 2000; Loucks-Horsley, Love et al. 2003; Villegas-Reimers 2003).
Table extracted from (Couso 2009)

Despite the fact that the ultimate goal of any teachers' development initiative should be the improvement of students' achievement, as some authors have pointed out, research on or evaluation of professional development usually does not assess students' learning (Loucks-Horsley and Matsumoto 1999; Cochran-Smith 2000; Guskey 2000; Loucks-Horsley, Love et al. 2003) and the effectiveness of the initiative is measured taking into account teachers' outcomes. This is in agreement with what has already been commented about the broad consensus, not only in educational research but also in educational policy, that "teacher quality" is seen as the single most important school variable influencing student achievement. The problem is then not if evaluate via students or teachers' results, but how to define teacher quality in a measurable and comparable way. This teachers' quality, according to some research results, can be measured by readily measurable teacher characteristics such as qualifications, teaching experience, and indicators of academic ability or subject-matter knowledge. However, it could also be measured using more hardly measurable variables which have vital impact for students' learning, such as the ability to convey ideas in clear and convincing ways, to create effective learning environments for different types of students, to foster productive teacher-student relationships, to be enthusiastic and creative, to use a variety of teaching and learning methods and to work effectively with colleagues and parents, among others (Darling-Hammond 1999; Oecd 2005). Despite the difficulties to measure these variables, they are clearly aspects that teachers can learn in suitable learning environments, the literature having found that there are contexts of teacher work and collaboration in which they could develop more easily than in others. It is the exploration of those contexts, then, that can help to address the issue of evaluation of teacher professional development initiatives.

Professional Learning Communities

The importance of collaborative experiences

Within the new paradigms emerged as counterpoint to the traditional teachers' training programs, diverse alternatives to give answer to teachers professional development needs have been proposed by the research community. In this context, collaborative experiences such as professional networks, partnerships and communities have been largely discussed and there are a lot of arguments in favour: they are related with powerful educational ideas such as bottom-up reform, can influence in teacher learning and professional development and take into account teachers' experiences and views beyond the tradition of relegating them as mere executors of others' innovative ideas.

Reasons behind this paradigm shift are diverse, the most important ones related with what we know about how people learnt. Influenced by the works of Vygotsky, a growing recognition of the role of the social and cultural aspects in learning has permeated the way science learning in the classroom is seen (Driver et al. 1994; Solomon 1987; Tobin 1990). Based on the research findings supported since the 80's, science education literature has been referring more and more to the idea of learning mediated by the culture and the social environment in which the learners, students but also teachers, interact (Bell and Gilbert 1996; Engeström 1994). This so-called *socio-cultural* view of learning stresses the importance of interaction and discourse in learning in school but also in teachers' work. We learn from others, with others, in our mutual interaction. This fact gives collegiality and cooperation among teachers a crucial importance regarding teachers' learning, far beyond the traditional calls for collegiality for organizational purposes. In this regard, Escudero (2009) highlights three contributions of social and cultural theory on knowledge and learning that are relevant to the initial and continuous training of teachers: 1): the notion of knowledge and learning as active and contextualized phenomena and processes; 2) the idea of knowledge as a social and cultural reality; and 3) the distributed nature of knowledge, i.e. its acquisition by means of relationships between people and the different sources of information. This author also considers that the learning experience is more profound when knowledge is related to the context of participants in a training programme, when it is linked to real-life activities and when it is used in a reflexive and practical way: "Hence the justification for — and power of — training models based on practice, on case studies, on project work or on learning through problem solving, especially if these activities are able to foster reciprocal relationships between theory and practice, between knowledge and action" (Escudero, 2009; p. 13)

Linked with this socio-cultural paradigm we found the situated cognition theories supporting that "learning is a process of enculturation or individual participation in socially organized practices, through which specialized local knowledge, rituals, practices and vocabulary are developed" (Hennessy 1993). Learning happens in the situations or in the social activities in which we are involved, and in this sense, it happens through experience (Barab and Duffy 2000; Engeström 2001). This implies that learning is understood as doing, becoming, belonging and experiencing. In the case of teachers, it happens while teaching, but also while discussing with colleagues, while mentoring, while participating in action research or while actively working for a shared objective with others, such as teachers, teacher educators or science education researchers. Krainer (1999) claims that professional development is the result of greater awareness among teachers of the factors that affect educational phenomena, and that such awareness can lead to a gradual and progressive improvement in teachers' understanding of their own professional practice. Llinares and Krainer (2006) propose that one way of achieving this awareness is through reflection on — and analysis of — teaching in classroom situations, as well as through the interaction between teachers who are motivated by their joint reflections on different aspects of teaching practice.

Acquiring knowledge, that is learning, is then viewed as social participation, a matter of being an active participant in the practice of a particular social community (Wenger 1998). Elaborating on this, Westheimer (1998) highlighted five features of community that are the basis for any theory of community: shared beliefs and understandings; interaction and participation; interdependence; concern for individual and minority views and meaningful relationships. This give rise to new ideas of community as a paradigm for understanding learning and social participation.

Considering these ideas for teachers' learning and, more particularly, professional development, some authors point out that the features of the development of accomplished teacher- "a member of a professional community who is ready, willing, and able to teach and to learn from his or her teaching experiences" (Shulman and Shulman 2004, p. 259) are: Vision, Motivation, Understanding, Practice, Reflection, and Community. Teacher development can be then analysed at an individual level according to the first five characteristics but this individual development always occurs within a *community* that can enhance, actively inhibit or be neutral regarding the individual development of teachers.

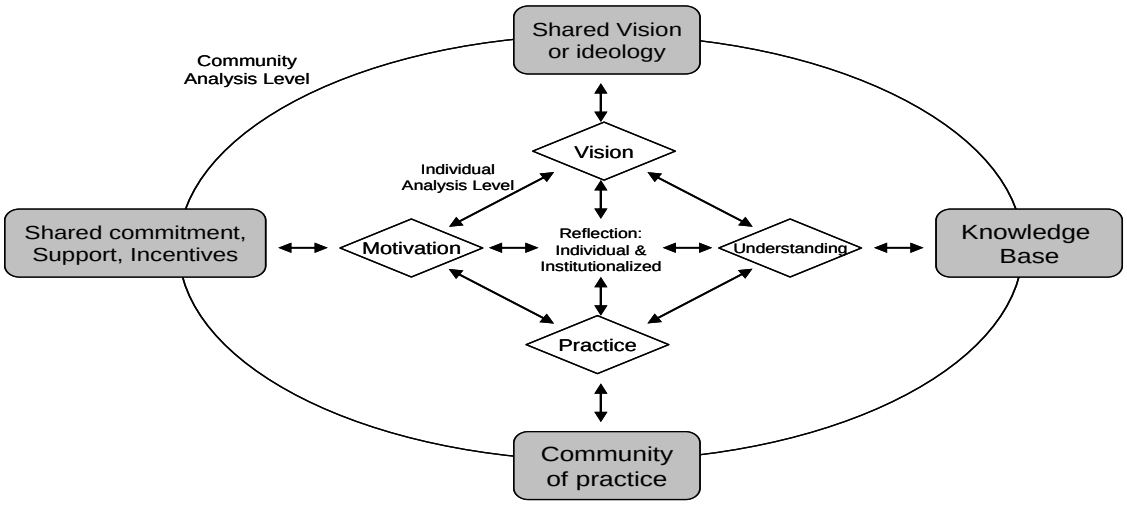

Figure 2.1: Learning communities at the individual and institutional levels
(Shulman & Shulman, 2004; p. 266)

The formation of *communities* is considered in the literature as a "strategy of curricular reform, not only because they promote innovation within schools but also because they are regarded as favouring the learning, autonomy and empowerment of those who participate in them, and this has an effect on their professional development" (Couso & Pintó, 2009; p. 6). According to these researchers, professional development includes work outside the classroom whereby, in a social professional environment, teachers reflect upon, evaluate, make decisions about and innovate in relation to their teaching practice. In this sense, the community is not a mechanism to produce change and learning, but the scenario or context where change and learning happens, which could be a particularly rich or particularly impoverishing scenario. It is for this reason that fostering teachers' communities appears to hold considerable promise for promoting teachers' professional development, allowing teachers to construct new roles in education and supporting them to change their classroom practice. However, this only will be possible in particular types of communities of practice.

In this sense, literature has been analyzing how these teacher communities should be in order to foster teacher professional development. According to Fullan (1992) this could be done by fostering interactive professionalism. This means the support of teachers as continuous learners in a community of interactive professionals. The author describes this sort of settings as "*teachers and others working in*

small groups interacting frequently in the course of planning, testing new ideas, attempting to solve different problems, assessing effectiveness, and so on" (p.120-121). Other authors have added to this description the importance of communities as empowering scenarios, when teachers participate *"in a professional community that discusses new teacher materials and strategies and that supports the risk taking and struggle entailed in transforming practice"* (Mclaughlin 1993), p.15). In the literature, these ideas has been developed and referred to within different frameworks: communities of practice (Barab et al. 2002; Little 2002; Palincsar et al. 1998; Putnam and Borko 2000b; Wenger 1998); discourse communities (Engeström 1994; Putnam and Borko 2000b); on-line communities and networks (Barab et al. 2001; Lieberman and Grolnick 1996; Lieberman and Wood (2003); teacher communities (Grossman et al. 2001; Thomas et al. 1998) and professional learning communities (Hargreaves 2007; Stoll et al. 2006; Stoll and Louis 2007), among others.

Seeing the diversity of notions and proposals, it is not surprising that some authors have *"urge caution about the profligate uses of the term community"* (p.6), which seems at risk of losing its meaning (Grossman, Wineburg et al. 2000). In this sense, some proposals have been more elaborated at operational and practical levels, particularly the notion of *professional learning communities (PLC)* which are nowadays the most well-known and used community scenario for teachers' and schools' development. Kemmis (1987) points out that training initiatives centred on schools adopt a dialectical perspective which acknowledges that "schools cannot change without the commitment of teachers, and teachers cannot change without the commitment of the institutions in which they work; schools and systems are, likewise, interdependent and interact with one another in the process of reform; and education can only be reformed by transforming the practices which constitute it" (cited by Marcelo, 1994; p. 354). Despite for most of the literature these PLC refer mostly to school-based and school-wide communities, we do not adopt here this view because it narrows the field of action precisely when the idea is to open professional development to all scenarios where teachers develop professionally. We prefer to use, then, an extended notion of community which, however, struggles to maintain the idea of aiming for a systemic approach, at the possible systemic level that could be achieved in each educational scenario.

What is a Professional Learning Community (PLC)?

In the literature about PLC it is clearly stated that at the heart of the notion of professional learning community it is the notion of *community* in itself (Grossman,Wineburg et al. 2000; Couso 2002b), focusing not just on individual teachers' professional learning but of professional learning within a community context (a community of learners, and the notion of collective learning).

Based then on the idea of community developed by Westheimer but including the important "*learning of professional knowledge*" focus, different definitions and proposals of PLC's have emerged, always suggesting "*a group of people sharing and critically interrogating their practice in an ongoing, reflective, collaborative, inclusive, learning-oriented, growth-promoting way, and operating as a collective enterprise"* (Stoll and Louis 2007). PLCs are associated with settings where teachers collaborate among themselves and with others to reinvent practice and share professional growth (Mclaughlin and Talbert 2001). In this sense, some key characteristics of the PLC scenarios are proposed: shared values and vision; collective responsibility; reflective professional inquiry; collaboration ; and central focus on group, as well as individual, learning (Bolam, McMahon et al. 2005). Or, as summarized by Escudero (2009) learning communities in schools are constituted and developed across three dimensions:"Coordinating and establishing social and intellectual collaborative relationships between teachers; Deliberating over and constructing a shared pedagogical culture with respect to values,

principles, concepts and practices related to the curriculum, teaching, evaluation, organization and the functioning of schools; Formulating and carrying out research on practice (analysis, reflection, observation, evaluation, pedagogical critique), the aims being to generate knowledge about practice and to access and reconstruct external knowledge for practice" (Escudero, 2009; p. 19). These characteristics emphasize that PLCs are not just communities, but communities of and for professional learning, where a key goal is continuous learning rather than implementing a specific change initiative. The importance of learning here is crucial, not only as something that results from community work but which is the intentional and explicit objective of community work. Summarizing the literature, Hord (1997, p.1) blends process and anticipated outcomes in defining a 'professional community of learners' (Astuto, Clark, Read, McGree & Fernandez, 1993) as one in which their participants: "*seek and share learning, and act on their learning. The goal of their actions is to enhance their effectiveness as professionals for the students' benefit; thus, this arrangement may also be termed communities of continuous inquiry and improvement."* In this sense, evidence of change in teacher talk and exchange about professional issues is a key indicator of a learning community. Other characteristics are also identified when talking about PLCs such as mutual trust, respect and support among staff members, and inclusive membership looking beyond the community for sources of learning and ideas (Bolam et al., 2005; Stoll et al., 2006).

What is not a Professional Learning Community (PLC)?

Despite the importance of exchange and collaboration in the PLC framework, collaboration among teachers it is not *per se* an indicator of PLC. We could find well established teachers' groups in which there is no reflection about the teaching profession, where learning of teachers and improvement of students' results is not explicitly stated as their goal and/or where collaboration is only at the level of sharing anecdotes, resources or advice, for example. In spite of the other benefits associated with these sorts of arrangements, taking into account the definitions stated above these wouldn't be considered PLCs. In this sense, the literature distinguishes softer approaches of community, where there is only sharing of materials or shared visions but not the goal of change of teaching (Visscher and Witziers 2004), from the idea of PLCs. The importance of this focus on learning and development is not minor: a research addressed to explore the link between PLCs and students' outcomes concluded that shared goals, joint decision-making, shared responsibilities, consultation and advice were important but insufficient to improve educational practice and, consequently, student achievement (Visscher & Witziers, 2004). Rather, effects resulted when participants translate their vision and cooperation into a system of rules and goals regarding teaching and instructions, making their professional activities evolve by analyzing data on student performance from this established framework. It is in this sense that not all communities or teacher gatherings could be considered professional learning communities (Grossman et al. 2000). Bryk and colleagues' Bryk, Camburn, and Louis (1999) findings lead them to suggest that ''*if professional community in fact fosters instructional change, it does so by creating an environment that supports learning through innovation and experimentation*'' (p. 771). For Escudero (2009), those activities which are considered to be potentially beneficial, such as working with colleagues to reach a deeper understanding of teaching and learning processes, will not, according to prove to be beneficial unless detailed attention is paid to content, conceptual reference points, processes and outcomes of teachers' learning.

This sort of environment would require of reflective dialogue, inquiry of practice and the recognition of the inner value of professional development, in addition to sharing of teaching and learning materials and shared vision. Llinares and Krainer (2006) consider that reflection "is a key element in the development of processes required for on-going learning since it is assumed that reflection is a means by which teachers continue learning about teaching and about themselves as teachers" (p. 442). While

considering reflection as a strategy for professional development, Marcelo (1994) also points out that "the aim of every strategy which seeks to promote reflection is to develop teachers' metacognitive skills, skills which enable them to be aware of, analyse, evaluate and question not only their own teaching practice but also its ethical and value basis" (p. 334). A professional community of learners, then, has particular goals, values and belief systems, but also discourse structures, for instance as a community of research, inquiry or reflective practices. For doing so, the community relies on the development of a *discourse genre* in which constructive discussion, questioning, querying, and criticism are the mode rather than the exception. What is pursued is a culture where a questioning, evidence-informed, reflective and self-evaluative attitude and action of all participating agents is promoted.

How effective are Professional Learning Communities (PLCs)?

As mentioned above, a key purpose of PLCs is to enhance teacher effectiveness as professionals, for students' ultimate benefit. Behind this idea is the general assumption that "*high quality professional development will produce superior teaching in classrooms, which will, in turn, translate into higher levels of student achievement*" (Supovitz and Turner 2000), p. 965). Initiatives within the PCL framework have shown to make a significant difference in terms of teachers self-efficacy beliefs (a construct which the literature relates with student achievement) (Cowley and Meehan 2001; Lakshmanan et al. 2011) and, more importantly, also in terms of directly measured student achievement (Bolam et al. 2005; Louis and Marks 1998; Mclaughlin and Talbert 2006; Stoll et al. 2006).

Until recently there has been limited research evidence about effects of work-based learning and other forms of professional development on student learning (Analytical Services, 2000) with exception of those with very specific aims (Joyce, Calhoun & Hopkins, 1999). The literature has presented some indications, however, of a link between PLCs and enhanced student outcomes. A 'learning-enriched' teachers' workplace appears to be linked to better student academic progress (Rosenholtz, 1989), higher levels of achievement in schools with positive professional communities Louis and Marks (1998) and positive impact on students included enhanced motivation and improvements in performance (Cordingley, Bell, Rundell & Evans, 2003). These cases were reported in situations in which teachers were focused on "authentic pedagogy" (higher quality thinking, substantive conversations, deep knowledge and connection with the world beyond the classroom) and where teachers experienced above average transformational leadership. Wiley (2001).

In the same direction, some authors support the idea that professional community is an important contributor to instructional improvement and school reform Little (2001), confirming that schools with a genuine sense of community shown an increased sense of work efficacy that led to increased classroom motivation and work satisfaction, and greater collective responsibility for student learning Louis, Kruse and colleagues (1995) and that teachers having developed a PLC, enhanced not only their knowledge base, but also had a significant impact on their classroom work Andrews and Lewis (2007) and their own behavior: greater confidence; enhanced beliefs among teachers of their power to make a difference to pupils' learning; development of enthusiasm for collaborative working, despite initial anxiety about classroom observation; and, greater commitment to changing practice and willingness to try new things. (Cordingley, Bell, Rundell & Evans, 2003)

Other authors, however, discuss that the effects of professional community in changing classroom practice may be less than those suggested in the literature and provide a different view of these scenarios regarding their usefulness (Seashore, Anderson et al. 2003). For the mentioned authors, professional communities are not seen always useful to promote teachers' change (which is strongly dependant on individual teacher knowledge base, epistemology, beliefs, motivation, disposition, etc.).

For example, for McLaughlin and Talbert (2006) school-based PLC have impact on *school culture, instructional quality and student outcomes when they are centred on students, use data effectively, distribute expertise, and enjoy district-level leadership and investment, the latter systemic variables generally out of the control of science education research.* In addition, we cannot simply equate changing or learning with improvement and assume benevolence or efficiency of any community of practice. Wenger (1998) and Bryk, Camburn, and Louis (1999) repeatedly urge caution in this direction, warning about the fact that the path between professional community and instructional improvement is not necessarily direct. They note how PLCs might be orienting its professional interaction towards conserving and legitimating unsuitable existing practices rather than changing them.

How can be organized an effective Professional Learning Community (PLC)?

In agreement with the ideas mentioned above, to create and develop a PLC some features have to be borne in mind. PLC activities have to be developed by focusing on learning processes; making the best of human and social resources; interacting with and drawing on external agents; and managing structural resources, among others (Stoll, 2006).

a) Focusing on learning processes

As already mentioned, main PLC purpose is the increase of student learning via a focus on teachers' development and professional growth directed towards improving practice. This teachers' learning is not only the learning of formal knowledge for teaching, that is knowledge externally generated (the knowledge base of the teaching profession), but also other sorts of knowledge such as knowledge in practice and about practice (Putnam and Borko 2000). In this sense, PLCs rest on well-established assumptions about how teachers learn and change their practice related with the acquisition of practical knowledge (Van Driel et al. 2001) and with the idea of teachers' reflection in and on practice(Schön 1983). In other words, within the PLC paradigm teaching is considered a non-routine, complex and life-long learning activity for which much more than formal knowledge is needed because "*there is a great deal of untapped knowledge already existing in schools and teachers; […] the challenges teachers face are partly localized and will need to be addressed ''on the ground'', and […] teachers improve by engaging with their peers in analysis, evaluation and experimentation*" ((Toole & Louis, 2002, p. 248).

This last point is a quite crucial one regarding the association of PLC with communities of professional reflection and communities of inquiry, both powerful notions related with the ideas of teachers' learning via reflecting and constructing knowledge from evidences of actual practice. This is not a minor challenge for teachers, neither at local and observational level (for instance using one self's classroom and students' data) nor at a more global and analytical one (for instance using the more available than ever student results from external tests and evaluation initiatives). Despite it seems that within this period of increased school accountability data analysis and use is now an important part of teachers' jobs, Dudley (1999) highlighted difficulties faced by teachers trying to use data to improve their teaching. However, research suggests that using evidence can be a means of promoting both professional development and school improvement (Earl & Katz, 2002; Sebba, 1997; Thomas, Smees & Elliot, 2000). Some authors refer to the idea of "inquiry as stance" as the standpoint of teaching, highlighting the importance of this idea of teaching as the profession of gathering data about student's results from teaching practice to improve it (Little 1993). Callejo, Valls and Llinares (2007) consider that video recordings of class episodes are a good way of enabling reflection on different aspects of class management, on the learning and teaching process, on the role of the teacher, and on the difficulties and potential of pupils, such that the general ideas of teachers can be nourished and supported by empirical evidence. In some schools functioning as learning communities, it gradually begins to mature

into an accepted, iterative process of data collection, analysis, reflection and change (McLaughlin & Talbert, 2001).

b) making the best of human and social resources;

At the heart of the change process, is the individual (Hall & Hord, 2001): "Although everyone wants to talk about such broad concepts as policy, systems, and organizational factors, successful change starts and ends at the individual level. An entire organization does not change until each member has changed" (p. 7). Being this true, PLCs are distinguished by their emphasis on group or collective learning. King and Newmann (2001, p. 89) highlight the link between the individual and the collective: despite high quality instruction depends upon the competence and attitudes of each individual teacher, teachers' individual knowledge, skills and dispositions must be put to use in an organized, collective enterprise. That is, in PLC social resources and the interaction between them must be cultivated, and collegiality, as already mentioned, is crucial not only for organizational purposes, but due to its potential regarding teachers' development.

But how can group or collective learning take place in a school or within a group of teachers, in a way that the best is made of all the human resources involved? Authentic collaboration between participants, whatever their role, position, experience and so on (Couso 2008b) appears then to be a key link. This requires authentic dialogue to take place (Senge, 1990). However, genuine dialogue is difficult to achieve in educational settings, where there is a tendency of domination of certain voices (Oswick, Anthony, Keenov, Mangham & Grant, 2000) and where there is not a unified commitment from members (loyalty to and identification with the group and the collective enterprise). As a consequence, leadership and hierarchy structures play a very important role regarding the use of all resources in a PLC. Leadership and hierarchy structures are crucial both as the existing power relationships that a new community culture will have to deal with, and as the new structures which will be established when a PLC evolves in time. Leadership is therefore an important aspect that can enhance or inhibit adequate practices and culture within a PLCs. Interestingly, true leadership is not only neither directly related with the role of the school administration staff (for instance the headteacher or principal in the school), but mostly with how leadership is distributed among PLC participants.

Role of leadership in PLC

In this context, some authors have discussed what the role of the leaders should be in a PLC. Schein (1985, p. 2) argues that: *"...there is a possibility ... that the only thing of real importance that leaders do is to create and manage culture and that the unique talent of leaders is their ability to work with culture".* This culture is one of reflection and inquiry, as has been mentioned above, but also of trust: the single strongest facilitator of professional community commonly agreed among scholars in the field (Stoll and Louis 2007). This implies the importance of a leadership that helps teachers to feel confident and in a safe environment to expose them when demanding activities are requested. Otherwise involved teachers feel they are in risk: they think they are going to be evaluated in terms of having or not enough knowledge and mastery of profession, showing too much of themselves when sharing views and beliefs and that they will lose their autonomy. This situation tends to isolate teachers, a situation common and even chosen by teachers who understand this isolation as synonym of professionalism, capability and autonomy Perrenoud (1995).

Regarding this leadership, it is increasingly recognized that it cannot be the domain of one individual or a small 'senior' group because of the complex nature of work, and accomplishing workplace responsibility depends on reciprocal actions of a number of people (Gronn, 2003). Indeed, joint action,

characteristic of PLCs, has been described as distributed leadership (Gibb, 1958; Gronn, 2000; (Mulford & Silins, 2003).Spillane, 2006)(Spillane et al. 2001), a concept grounded in activity theory that focuses not on actions of the individual positional teacher leader but on the leadership practices that take form in the interaction of either formal or informal teacher leaders with others within particular situations. This does not mean, however, that there is a flat structure or not structure at all within the PLC. On the contrary, such a challenging scenario needs different roles with different responsibilities, being the role of coordinator a particularly important one. What it implies is that this coordinator should be a positive leader that supports the development of trust and promotes distributed leadership among participants.

c) Interacting with and drawing on external agents

The idea that learning in a PLC is not only the learning of formal knowledge and the importance of distributed leadership does not imply that a group of teachers analyzing their practice on their own without any external facilitation and support is the idea image of a PLC. On the contrary, a PLC as the one describe along the above paragraphs is such a challenging scenario for teachers that external and expert help is not only desirable, but necessary. There are two important reasons behind this, who point towards two different sorts of external agents. The first is that any teacher development initiative that it is closed to external inputs suffers the risk of getting stuck. Smylie (1995) suggests that individuals and groups need access to multiple sources of learning and that creativity and innovation may be constrained if teachers only have access to others with similar ideas and experience. PLCs are not an exception and they cannot 'go alone' without connections with outside agencies. Indeed, some time ago Fullan (1993) argued that that organizations that act self-sufficient *''are going nowhere''*. To promote, sustain and extend teachers within PLCs, they need external support, networking and access to other partnerships, such as other teacher groups. A second reason is related with the fact that even though PLC are the context where teacher learning takes place, for adequate educational change any teacher learning is not equally valid. If the community is to be intellectually vigorous, members need a solid basis of expert knowledge and skills. Research in Education and Science Education has provided a corpus of knowledge and ideas which should not be ignored by teachers when they are pursuing the achievement of better students' results. In addition, education researchers with expertise in teacher education and the idea of communities of practice can play an interesting role as facilitators of PLC, as it is very difficult that such an scenario is adequately lead by those who does not already know what a PLC is and who will learn that by participating in one. Besides, PLC are not fixed structures that can be easily replicated. Rhythms and expectations need to be adapted to the context, as not all communities pose the same challenges. Different features need to be taken into account, such as the group size (small groups seem to be more effective), educational level (in primary this kind of community works seems to be easier), location of the group (and its influence to the links that could be made with external agents) and other factors such as the history and tradition of the teachers group itself. This makes the contribution of experts in the field a welcomed one.

Role of Educational / Science Education researchers

In this sense, Educational and Science Education researchers can be particularly good external/internal agents who can bring research-based inputs and help guiding the activities of the PLC, for instance as coordinators. Researchers can be facilitators, guiders or participants of the community, depending on teachers' expertise, educational system, scope of change to be achieved, tradition in collaboration and other factors. There is a need, then, of fitness to purpose and context in the organization of a participatory approach such as a PLC.

d) managing structural resources

There are different resources which are necessary regarding the creation and sustainability of PLC. One of the most important is time: time is critical for any non-superficial learning (Stoll, Fink & Earl, 2003), in particular when what is learnt is participation in a new culture. In this sense, all issues mentioned such as learning of expert knowledge, learning how to reflect and inquiry in and about practice, development of leadership capacities, development of trust, etc. take time. This time helps the community to mature, evolving from a phase of "pseudo-community" characterize by two aspects. First, that teachers seem to have learnt the new ideas but are only starting to grasp them or have adopt them at the level of the rhetoric, instead of transforming practice and showing ownership regarding the new practices (Ogborn 2002). Second, that conflict does not arise either because there is the perception of "convergence" or because there is not enough trust and self-confidence to really expose personal views (Grossman et al. 2000). At the stage at which didactical and professional conflict can arise and properly dealt with properly within the community, it can be said that the PLC is becoming mature. For these reasons, the research suggests that when a PLC is being developed, it needs to be organized to allow time for staff to meet and talk regularly, a structure where it is easier to have professional discussions and also appropriate spaces to do so (Louis et al., 1995).

The above mentioned situation, however, is hardly the case in most schools or teacher professional development initiatives, and when this is the case, it is generally associated to special projects or initiatives where achieved changes do not persist over tie neither become spread (Ingvarson et al. 2005; Lerman and Zehetmeier 2008). In this sense, the sustainability of the PLC is not generally guaranteed due to the fact that it needs a deep change of the participating people and existing structures. Sustaining change requires sustaining deep learning; involving a broad range of people in ''chains of influence''; spreading improvements beyond individual schools; using existing resources rather than extra ones that vanished when funding finishes; nourishing and taking care of people; sharing responsibility; activist engagement to secure outside support; and developing capacity that enables *''people to adapt to, prosper and learn from each other in their increasingly complex environment''* (Hargreaves, 2004). Ideally, by promoting change of the teaching and school culture, PLC should "survive" the initial project phase (the phase when the community is created and university experts, researchers and/or teacher educators facilitate and support the process) to continue on its own with minimal external input, after funding is over and in more real conditions. However, this is very difficult to be achieved and it is common that researchers establish conditions that are favorable to the innovation's success (because change has to be shown) but that generally depend heavily upon the extra support from researchers.

e) External factors

At an external level, PLC efforts can be influenced by different external factors, which are those factors affecting teachers and schools in general. At the local community level, PLCs can be affected in terms of local community preferences and demands, but also by its socioeconomic profile and the challenges that this could mean, etc. At the broader community level, PLC can be affected by the social perception about teachers' tasks and schooling in general, affecting teachers' motivation and their belief that what they are doing is worthwhile, but also by policy decisions.

2.2. Case study report 1: ICE and CDEC teachers' group. A comparative case study

The first case study report "ICE and CDEC teachers' group" is actually a comparative case study report on two different field actions of a long-term, out-of school, voluntary teacher professional development initiative which were already taking place when TRACES project was initiated. Both actions have been monitored and studied by researchers within the TRACES Spanish research team in order to analyze their potential as initiatives to bridge the research to practice GAP in primary and pre-primary school science education, assessing the existing resemblances and differences between the initiatives. The following report presents both initiative and discusses their advantages and limitations from a particular theoretical framework related with the literature of professional development (communities of practice) and bottom-up and systemic reform. Findings show how this sort of out of school teacher education initiatives, despite quite successful in terms of development of participants and sustainability, have limitations regarding influence at school and educational system level. However, many important lessons can be learnt from its analysis, pointing towards particular actions which could lead to more fruitful interventions.

2.2.1. The Local Context of the Field Actions

1.A ICE TEACHERS' GROUP

a. Table showing the descriptive characteristics of the training programme

Type	*Science education teachers' group for in service primary teachers (voluntary)*
Size	*19 teachers*
Level	*Pre-Primary and Primary levels*
Profile	*On service teachers from different contexts (schools) and backgrounds*
Origin	*Teachers' initiative*
Responsibility	*Teachers and University (science education research)*
Relation with educational authorities	*The initiative takes place within an official body but with total autonomy (lack of educational authorities' influence)*
Level of investment	*Medium investment (voluntary monthly meeting)*
Time scale	*Long term*

b. Qualitative description of the unit of intervention

First case study refers to a voluntary innovative teachers' group sharing teaching and learning materials in the context of the ICE[24] (Education Science Institute), an official center dependent on the Generalitat *de Cataunya*[25] and on the *Universitat Autònoma de Barcelona*[26] that is devoted to initial and mostly in-

[24] Institut de *Ciències de l'Educació, in Catalan*. Herinafter, ICE.

[25] The Generalitat is the institutional body around which Catalonia's self-government is politically organized (including education competences). For more information see baseline document and "*The Catalan educational system: regional focus of Spanish TRACES project*" in Delivarable 2.2-Spain suvey report (**http://www.traces-project.eu/**)

service teachers' training. Being this an already existing interesting *action* regarding the analysis of the gap between Science Education research and actual teaching practice, this Case Study reports the analysis of this initiative.

This teachers' group[27] was born during the scholar year 2002-2003 and since its creation its activity has not been stopped. The group was created by the initiative of the participating teachers, from pre-primary and primary levels, together with the support of the ICE and a science education researcher from the UAB (who is part of the Barcelona TRACES team) that was proposed as group coordinator. Being in contact with ICE teacher training activities during some years, teachers that started this group willed to create a space to share their experiences within the group and to be able to keep in contact with some experts (at a science education research level, but also in some other areas such as pure science or general pedagogy) beyond the more traditional training programs to which they or their school were attending to.

Teachers' profile

As already mentioned, teachers participating in ICE's group are on service pre-primary and primary teachers from different schools of the metropolitan area of Barcelona (within a twenty kilometers radius from the city). The group is quite heterogeneous, not only regarding their schools but also regarding their personal and professional profile. We find both women and men and their professional experiences ranges from less than five years to more than 30 years of teaching experience in public schools. Main characteristics of teachers participating in the group are summarized below.

Level in which they are teaching	Pre-Primary	2
	Primary	12
	Pre-Primary and Primary	4
	Teachers' training	1
Initial teachers' training	With science specialization	8
Years of experience as a teacher	<5 years	3
	5<x<10 years	2
	10<x<20 years	3
	20<x<30 years	5
	> 30 years	6
Gender	Male	3
	Female	16
Years in the group	< 2 years	7
	2<x<5 years	4
	5<x<10 years	8
School Administration	Teachers holding positions	5

Nearly half of the teachers participate in the group since it was founded. They arrived to the group mainly through their participation on ICE's voluntary training programs or through the recommendation of researchers who were supporting their schools at the time[28]. Nowadays the group keeps more or less constant in terms of the participating teachers, but there are some new members. In this case, new

[26] *Universitat Autònoma de Barcelona* (UAB) is the University to which the Spanish TRACES team is related to.

[27] From now we will refer to it as ICE's group

[28] There is a modality of teacher education and school support which consist of a particular programme in which expert teachers considered teacher trainers or science education researchers work with an school as external advisors in order to improve some particular aspect of the school.

teachers are contacted by the teachers of the group or by the coordinator when they think that his or her philosophy could fit to the one from the rest of the group.

Some of the participating teachers belong to their school administration body, mainly as head of studies or chief of department. Additionally, most of them (about fourteen) come from schools with a kind of science department or with special programs for science education (science projects, laboratories …), which is a situation not usual in the Catalan school at pre-primary or primary levels, where Science is taught as an integrated subject together with social sciences and were a scientific specialization of teachers does not exist from the 90's. From these cases, only four schools started this science project thanks to the own initiative of the teacher or teachers participating in ICE's group, whereas the others were actively promoting science teaching before their participation in the ICE group, being this the main reason to be interested in such a group.

Coordinator profile

Current ICE's group coordinator is a highly experienced science education researcher with more than twenty years of experience as primary and secondary school teacher. She is a geology graduate and holds a degree in primary school teachers' education. At present she is staff of the Mathematics and Science Education Department of the UAB, where she is teaching science and geology education at pre-service level for future primary and secondary school teachers, both at graduate and master level. She usually collaborates with the ICE and the Generalitat de Catalunya Education Department as teacher trainer for in-service teacher education. As a researcher in Science Education, she is part of the Barcelona TRACES team.

She has been coordinating the group since the second year of its creation[29] (2004) and their main tasks have not change since then. She is in charge of the organization of the meetings, starting from the initial agreements that are defined at the beginning of each academic year by the group, taking also care of promoting team building by proposing some social activities such as visits to particular schools or museums... The dynamization of the meetings is also in her charge, meaning that she sees to collect teachers' interests and find which experts could give answer to these interests, inviting them to participate in the group meetings. Being an active member of the science education research community, she counts with a network of experts and access to high level research resources that is very valuable for the group.

When teachers present their own experiences, the coordinator gives them feedback, as the rest of the participants in the group, but also helps the group to summarize and to identify main topics to be developed, helping to link them to the science education research results.

Finally, the coordinator is also who usually brings to the group project proposals coming from the Administration or from some formal or non formal educational organization such as science museums in which the group can decide to participate or not.

Dynamics of the group and theoretical underpinning behind the initiative

According to the documentation shared by the group coordinator (see Appendix 1) the objectives of the group were: to share practical experiences and training to enrich the group participants; to be continuously updated regarding innovations and science education tendencies for pre-primary and primary levels; to know, create, try and analyze innovative experiences; to define criteria to bring

[29] During the first year the group was coordinated by another science education researcher

science closer in a useful way to pre-primary and primary teachers; to uncover incoherence and myths in order to reflect and to consider questions regarding ways of teaching and finally, to find ways to spread the group experiences, reflections and ideas in an easy way for all pre-primary and primary teachers in order to influence beyond the group participants in the improvement of science education.

With these aims in mind, and according to the information gathered from participating teachers and the coordinator, ICE's group meets once per month in the facilities of the ICE, in Barcelona, in their own free time out of their normal teaching hours. These meetings are coordinated by the science researcher who dynamizes the sessions and brings to the group any necessary inputs either requested or not by teachers themselves. The main activity of the group is the sharing of science curriculum materials designed and usually already implemented in the classroom by the teachers of the group themselves. Other activities which also take place are the participation of external experts, generally from science education research field or from other areas (specific science discipline or pedagogy); the organization of teacher education activities outside the group (such as workshops or specific trainings offered to external teachers); or visits to diverse museums or schools that could be interesting for the teachers in the group.

Regarding the collegial exchange, when teachers present their own proposals or designed teaching and learning materials, they received feedback from the group in an informal way, not having agreed a systematic way of presenting the activities or of analyzing them. The rest of the group can offer its opinion regarding different topics: feasibility in their schools, changes to be made (based on their own experience), etc… From this discussion and thanks to the coordinator role some topics to be discussed are highlighted, which could give rise to an specific session to talk about them. Only occasionally the group has proposed a material or activity to be tested by each teacher in the group, allowing a general reflection and discussion of a common experience.

The participation of the science education research community is mainly proposed by the coordinator who, answering to the interests of the group or taking into account the topics that could have emerged during previous group sessions and that would need to be more developed and reflected, proposes to invite some experts to the group meetings. During the first years of the group activity, the research contribution was quite generic and well-known science education researchers made some sessions talking about central science education topics such as modeling, formative assessment or practical work. These first sessions helped the group to construct their own philosophy regarding how to teach science. This philosophy is mainly characterized, according to the coordinator, by the use of models or modeling, meaning that science is taught around some central scientific ideas. This approach has lead to other approaches such as the introduction of practical work (experimentation) for the construction of models and the contextualization of science teaching.

In the last years, the group takes advantage of any relevant event to choose a common theme that would be developed by the group during the entire school year in order to go more in depth with a discipline or subject. This has been the case of the work around *chemistry* during the year 2010-2011, because of the International Year of the Chemistry (2011) or the curriculum design regarding *physics* that they are just initiating while this case study is being written, in the context of the centenary of the Titanic's sinking in 2012. Also in these cases, the coordinator proposes experts that would accompany the group during the entire school year, participating in some of their meetings and offering inputs that teachers can use in their own lessons.

There are other activities also carried out by the group such as visits to museums or schools, proposed by teachers themselves or the coordinator. In the case of the visits to schools, the visited schools are usually those of the participating teachers, especially if they have any special feature regarding the teaching of science which could inspire other members of the group. Examples are timetable flexibility, scientific laboratory installations, science corners, etc… This kind of activities, however, are more organized as social events proposed for team building than actually working sessions.

ICE's group has had the opportunity to participate in some occasional and specific initiatives in the field of teachers' training. Specifically, there have been two cases: the first one was initiated by a science museum that wanted to propose a conference in their own facilities for pre-primary and primary teachers regarding practical work. Teachers from the ICE's group were responsible for designing these activities and carrying them out during the conference day. This was a one-time event and there has been no follow up for the participating teachers. Regarding the second initiative, it was planned to be carried out during the year 2011-2012 and it consisted on a training program for pre-primary and primary teachers organized by the ICE and designed by the teachers participating in the ICE's group. Finally it will not take place because there were not enough teachers that had signed up for the course. It has to be highlighted that this course was planned under the ICE's request, because as a center responsible for teachers' training programs it promotes that innovative teachers' groups such as this one have more impact on other teachers not being involved in the group.

Finally, and at a more individual level, some teachers in the group have published articles in teachers' journals presenting their own activities or discussing some topics which have been designed or discussed within the group. Nevertheless, and even though the opportunities for publishing seem more easy when being part of the group due to the received support both in terms of confidence and theoretical basis, this is not a general trend in the group and these publications are not made under the umbrella of the ICE's group.

Due to the fact that ICE's group meetings take place only once per month and that teachers work in different schools, a digital platform (Moodle based) was created in order to centralize the group activity. This platform allows increasing the group activity by an asynchronous work by means of resources such as forums, documents exchange and others. Until now, all the group activity has been registered in the platform, uploading the meeting minutes and the related documents (teachers' or experts' presentations, participants' publications, science education research news or articles or links to interesting web pages). Even though this platform is not the central tool for the group activity and not all their potentialities are being used, it helps to centralize and register the work being carried out by the group.

1.B CDEC TEACHERS' GROUP

a. Table showing the descriptive characteristics of the training programme

Type	*Training for teachers' trainers*
Size	*16 (average)*
Level	*Pre-Primary and Primary levels*
Profile	*On service teachers from different contexts (schools) and backgrounds*
Origin	*Administration's initiative*
Responsibility	*Administration-Universities*
Relation with	*The initiative takes place in an official body*

educational authorities	
Level of investment	*High investment (part time during three years)*
Time scale	*Long term*

b. Qualitative description of the unit of intervention

Second case study refers to training program aimed to train on service pre-primary and primary school teachers to become trainers (formative influence) of other pre-primary and primary school level teachers. This program was initiated by the Department of Education (main authority in education in Catalonia, belonging to the Generalitat de Cataunya[30]) who requested its design to the General Centre of Resources for the teaching of Science (CDEC for its Catalan initials), which is an educational service belonging to de Department itself and that makes available to science teachers, for both primary and secondary school levels, innovative teaching resources and organize an important part of the continuous teacher education in Catalonia for science education. As for the previous training initiative, this case study reports the analysis of an already existing interesting *action* regarding the analysis of the gap between Science Education research and actual teaching practice.

This teachers' training program was born in 2005, firstly with the general aim of improving pre-primary and primary school teachers' science education knowledge. However, once the design of the program was initiated another Administration initiative supposed a slight modification of the design. The initiative in question, called Science Classroom, consisted in the provision of ICT equipments for a science laboratory to all the schools in the region, starting with a pilot group of 100 schools.

According to the documents elaborated when designing the program , main objective of the analyzed initiative was to cover the deficiencies detected in pre-primary and primary school level teachers' initial and continuous training. Regarding initial training, these deficiencies were related to the duration of this initial training and the disappearance of a specialization in science. On the other hand, when talking about the continuous training the program wanted to address four problems: the decrease of science education training demand on schools and teachers' side; the lack of formative influence in science education for pre-primary and primary school levels; the difficulties to cover the Catalan region in terms of training programs; and the difficulties to find experimental schools willing to carry out innovation in science education.

The teachers program, then, was addressed to train future teachers' trainers[31] with a twofold objective: to help teachers in schools to learn how to use these ICT resources and to introduce in schools new science education approaches based on science education research results. This objective was ambitious not only at content level but at a geographical level, because one of the main purposes of the program was to cover as much as possible of the Catalan territory. Even though the training program was planned for more scholar years, it took place during the years 2005-2006, 2006-2007, 2007-2008 and 2008-2009 due to the fact that the project Science Classroom was gave up for economical reasons, without reaching all the planned schools. Nevertheless the group has continued its activity as a professional development initiative for teachers in the group as we will see later on.

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[30] Institutional system around which Catalonia's self-government is politically organized (including education competences). For more information see "*The Catalan educational system: regional focus of Spanish TRACES project*" in Delivarable 2.2-Spain survey report (**http://www.traces-project.eu/**)

[31] From now we will refer to it as CDEC's group

The training program had two phases. First phase was addressed to train CDEC's group teachers on both ICT's and science education research. This phase did not finished in the first scholar year but continued during all the years that the training program was active and beyond. Second phase consisted on training teachers in schools with the ICT resources by means of a short training program (20h). During the first scholar year, the responsible of the program realized that the transfer to the schools was not enough and that more training was needed so it was designed a third phase of support for the schools (18h during three scholar years). Figure 2.2 represents these phases and who was responsible or receiver of each of them.

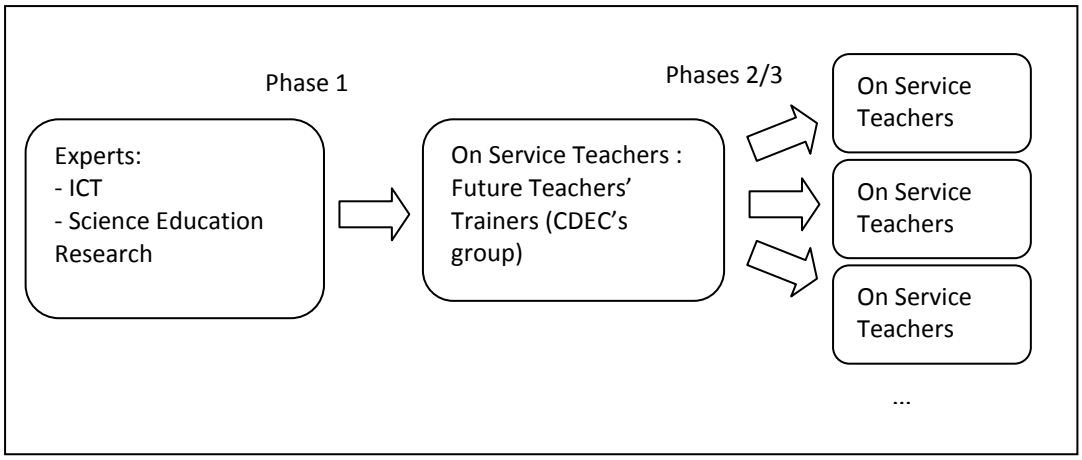


Figure 2.2: Training phases and responsibilities of each phase

The design of the program was entrust to a science education researcher from the *Universitat Autònoma de Barcelona* that was closely in contact with teachers on service thanks to her active participation in the CDEC activities. Three main requirements were requested to the Administration in order to carry out this initiative: to count on teachers on active service, being in charge of science education in their schools and with an existing recognition regarding their innovative proposals in terms of science education; to allow teachers to attend to the training program for almost two scholar years; and to guarantee a part time reduction of their working day to be devoted to the training program. All requirements were accepted by the Administration and, in its first year, fourteen teachers were attending to the training program. Table 2.3 shows the evolution of teachers participating in the training program until it was ended. Some teachers continued after the first year, others left and new ones joined to the group while it program was supported by the Administration.

Scholar Year	Nº of teachers
05-06	14
06-07	21
07-08	19
08-09(*)	9

(*) In scholar years 09-10, 10-11 and 11-12 CDEC's group continued their activity but not as teachers' trainers

Table 2.3. Number of teachers participating in CDEC's group by year.

Apart from these teachers, some others were also participating in the group but without the part time release and with less responsibility on any teachers' training. This was the case of teachers that, even

though they were not included in the Administration program to become teachers' trainers, were so interested in the CDEC's group that managed to participate in the group in their free time just to keep updated.

Once the program devoted to train schools in ICIT's and science educations was finished and Administration resources were withdrawn, the group continued its activity diminishing its role as teachers' trainers. This situations was due to the fact that the reduction of the part time was relegate to an Administration's permission that allowed teachers to have only a free evening from their school tasks to continue participating in the group, what made difficult to reach the same number of schools than before. Finally, also this permission was cancelled and nowadays teachers from the CDEC's group continue to meet in their free time to get advantage of the already existing group dynamics.

Teachers' profile

As already mentioned, teachers' profile was defined from the beginning of the program design, being one of the requirements to launch the initiative. On the one hand, they had to be on service teachers teaching in pre-primary and primary school levels. Additionally, they should be in charge of the science education in their schools even though it was only at their classroom level. They had to be also considered innovative teachers, meaning that their classroom proposals should offer new approaches in science education and that their interest for being updated as science education teachers should be proven. Finally, the coordinator's purpose of covering all the Catalan territory required the participation of teachers from all the regions in Catalonia. With these requirements, the group became a heterogeneous one, with teachers with different backgrounds (not all of them had a science specialization in their initial training), type of school, gender or years of experience.

Most of teachers (about 17) participate in the official program during three years or more. The rest of teachers in the group was leaving or joining the group while the initiative was active, participating during one or two years. Two teachers were selected among the participating teachers to practice as group coordinators, helping the existing coordinator in their tasks. In this case, they were released of their teaching task and were hired as CDEC staff. It has to be highlighted that all teachers participate in the program in a voluntary way.

Coordinator profile

CDEC's group coordinator is an experienced science education researcher with more than forty years of experience as pre-primary and primary school teacher, being focused as a researcher on teachers' training, both initial and in-service, thanks to her posts in the university and the CDEC. She is a chemistry graduate and holds a master on science education research. At the present she is already retired, but continues to be in contact with teachers and research with several collaborations with the university and the CDEC.

She was responsible of the definition of the training program proposal (contents and calendars) and she was the person of reference for this initiative being in charge of the activities' organization, the coordination of the training programs in schools and the evaluation of the initiative itself, together with the two teachers that were released to help with the group coordination. At the beginning of the initiative she was in charge of the teachers' selection, according to what was defined in the program design and has always been the contact person between the initiative and the Administration, reporting all the initiative's outcomes and statistics and requesting Administration support when necessary. She was also responsible of the contact between teachers and the science education research community.

Dynamics of the group and theoretical underpinning behind the initiative

The design of the program was highly defined by the coordinator and an extensive document was presented to the Administration before the initiative was accepted. Additionally, other documents as the one mentioned had been produced while the initiative was being developed reporting both the activity of the group and the theoretical framework behind it. Based on these documents and the rest of information shared by the coordinator, the theoretical basis of the initiative can be identified. With the ultimate aim of improving science education to assure the achievement not only of scientific competences but of other key competences since early stages in education (pre-primary and primary schools) and based on a socio-constructivist education approach, the training program was designed as a participatory training. This participatory approach meant the need of counting on heterogeneity of teachers' profiles to have diverse points of view based on their own experience and capabilities to represent the different regions of the Catalan territory. It also meant to take into account the already existing experiences avoiding starting from scratch, the importance of working in group and of the permeability between this group and the research community.

The main objectives of the program was to train teachers to became teachers' trainers in order to: take advantage of the ICT resources available at schools, give answer to the increasing demand for a new science model training, design and reflect regarding learning and teaching materials, assess the experimental work carried out in the context of the Science Classroom project; and to elaborate and to test didactical proposals to use ICT in science education.

The design of the program defined two levels of impact in order to achieve the expected outcomes. First one referred to the training program for the future teachers' trainers and second one referred to the group's and individual's reflection and work to develop the school training programs for each Catalan region. To do so an external team called external adviser team and composed of Science Education University Departments' representatives, well known science education researchers and Administration representatives of ICT's programs and curriculum development was engaged in the program being in charge of CDEC's group training. Teachers in the group were supposed to devote 60% of their time to be trained by this external team and 40% of their time to their tasks as teachers' trainers.

Reflective practice

According to this time distribution, the training received by teachers was diverse and focused in two main topics: science education and ICTs. The approach that characterized this training was the *reflective practice* based on socio-constructivist methodologies and understood as the reflection about the own practice by means of the self-assessment and the active participation of the entire social group in which learning takes place. Main purpose of this reflective practice, according to the way it was used in this training program, is to turn the reflection in and about the own practice into a conscious habit that is integrated in the day by day teachers' activity. The starting point of this reflection is the real teachers' practice and what are pursued are its analysis and the construction, together with the rest of the teachers in the group, of improvement proposals.

All this process is made in groups, being the training made among equals and a crucial aspect is the contribution of theory by means of experts. To do so, it is necessary to create an atmosphere of trust among the participants, who have to share experience, being observed by themselves, etc… Finally, the communication between the participants and also between the participants and the coordinator has to be fluent and permanent, making necessary to open new ways of communication such as virtual spaces of communication.

Bering all this in mind, main objectives of this training were:
- To form a teachers' team able to reflect collectively regarding their own learning process with the aim of exchange strategies, resources and experiences
- To facilitate a techno-scientific and didactical updating of the participating group
- To improve the competence (knowledge and using) of training virtual spaces as tools to allow communication among all the team
- To collectively reflect about problems merged during the training trying to find shared solutions
- To develop personal and social skills such as autonomy, creativity, empathy, assertiveness…
- To show and to share own feelings and emotions
- To design a regulating and dialogist assessment of the teaching task
- To know how to work in group, cooperatively
- To reflect about the task of being teachers' trainers
- To exchange experiences regarding the use of ICTs in science classroom

According to the need of a theoretical support for this professional development, training was in charge of experts in both science education and ICT resources and the dynamic that characterized these sessions was the reflection about research proposals after an adaptation made by teachers to each teaching level or to a specific content: experts introduced a new point of view or methodology, teachers made an adaptation to their own school or the schools were the training would take place and came back to the group with some data to be discussed by the group, the coordinator and the experts. Due to the high formative value given to these sessions by the participating teachers, these dynamics have continued within the group even after the program was finished and is the central purpose of nowadays' group activity.

Regarding their role as teachers' trainers, main tasks were:
- To design different kind of training
- To select the contents to be worked
- To plan teaching sessions using the CDEC resources (materials and spaces)
- To prepare and test the teaching and learning materials
- To exchange strategies, resources and classroom experiences to use in the diverse teaching activities
- To carry out the school teaching sessions among the Catalan territory

The sessions carried out in schools were separated in two kinds of activities: a short training program (20h) that took place the first year that each school was engaged on the training program thanks to the participation on Science Classroom project and a phase of support during three scholar years (18h /year). In a first phase of the program, only some teachers of each school were trained and they were responsible to transfer the knowledge to the rest of the teachers in the school but this approach was changed after some pilot training, being the training sessions followed by all the teaching staff in each school. It has to be highlighted that, after the phase of accompaniment, some centers (about 75% of the participating ones) asked for more training and that other schools that had not received the resources related to the Science Classroom project asked also for a special training. Both demands were also covered by CDEC's group while the part time was available.

From the beginning all these tasks, both design-reflection and training sessions, were carried out in pairs (design and reflection were also done at group level). According to what teachers from CDEC's group have stated, each training program started with a meeting with the school administration in order to assure both the engagement of the school administration and of the whole teaching staff.

Additionally to these already established tasks, the group activity has been quite focused on making public their work by means of publications or seminars in which the program was explained. It was a key purpose of the coordinator to make the group's work available as much as possible and the good results of the program made the group to be requested by some teachers' organization at a national (Spain) level to explain their experience.

Finally, when the program related to the Science Classroom was finished, CDEC's group continued its activity but mainly as a continuous training for the participating teachers thanks to their usual contact with research. Each year, the group defines their objectives in term of contents to be worked (for example, in 2011 there was a focus on Chemistry and in 2012 this focus has been on Physics) and a program is designed to cover these objectives and the ones related to the expected outcomes such as publications or trainings that could be developed after the work made by the group. These activities are made in close relation with researchers on science education as can be shown by initiatives like the book released in 2011 "Chemistry in pre-primary and primary school. A new glance"[32], written by teachers together with a well-known researcher on science education specialized in Chemistry.

2.2.2. Case study report

a. Central problem of the Case Study

Presentation of the problem

Trying to sustain science education improvement over time and spread it throughout the whole systems seems to need new approaches of teachers' learning and development (Stoll et al. 2006). Additionally, the failure of traditional educational reforms, usually from a top-down approach and using traditional forms of teachers' development also requires new approaches to science education research that help to bridge the research to practice gap (Couso 2008a)

In this context, and based on the TRACES approach, this case studies try to analyze how a specific professional development program – 1) a voluntary teachers' work group for curriculum innovation in science education, originated by teachers themselves out of their schools and with regular contact with research and 2) a high investment teachers' work group for curriculum innovation in science education, with an important Administration's involvement and support and practicing as teachers' trainers - can foster and to what extent the introduction of science education research results to the science teaching practice through innovative proposals. In this sense, the specific characteristics of the groups are studied in order to identify barriers and facilitators to bridge the gap between science education research and practice and the transferability of the groups' dynamics to other teacher groups and into a school organization.

b. Research questions in this comparative case study

This comparative case study is part of the TRACES research project, and as such, it tries to answer TRACES research question which is common to all Spanish TRACES team case study reports. This question is related to the main goal of TRACES project, the exploration of the existing gap between current science teaching practice and the research in science education. In this sense, for this case study

[32] Izquierdo, M. et al. (2011) *Química a Infantil i Primària. Una nova mirada,* Ed. Graó.

where the particular initiative of the ICE teachers' group is analysed, the TRACES research questions we try to answer is:

> *To what extent are these professional development groups* an effective initiative to foster teachers' professional development taking into account the theoretical frameworks of professional development and professional learning communities?*
>
> > **In particular: A) a collaborative and voluntary teachers' group focused on curriculum innovation in science teaching such as the ICE teachers' group ; and B) a high investment teachers' work group for curriculum innovation in science education, with an important Administration's involvement and support and bringing innovation to classroom by their role as formative influence such as the CDEC teachers' group.*

In addition to this general TRACES question, there are other specific research questions we want to answer during our analysis of both teachers' group activity and which are related to the particular characteristics of these teacher development initiative. These are:

> *How their ideas resonate, conflict with or add to the existing knowledge we have about effective professional development, in particular the well-known framework of Professional Learning Communities?*

and

> *What do teachers' participating in the ICE and CDEC teacher's group highlight regarding these professional development initiatives?*

In this sense, this case study will be devoted to analyze to what extent are these professional development groups effective initiatives to foster teachers' professional development taking into account the theoretical frameworks of professional development and professional learning communities above mentioned, and assessing the significant resemblances and differences between both initiatives.

2.2.3. Research methodology

A. ICE Case Study

i. Data gathering strategy

Being this case study a research study related to an existing and on-going initiative, the design of the methodology was constrained by the characteristics of the analyzed group. In a first phase, and in order to understand the group approach and to identify the key contact people, an informal interview with the researcher who coordinates the group was carried out, collecting basic information such as the group composition, the nature of the meetings and main activities implemented by the group participants.

During this interview the coordinator and the researcher agreed which of the teachers members of the group would be adequate to be contacted for an extended interviewed, according to their specific profile and other factors such as the years being part of the group and the degree of representation of the group profile. Four people were selected (two of them belonging to the same school): a teacher with more than twenty years of experience as a primary school teacher that started to participate with the

group one year after its creation and had always been in the same school since her incorporation to the group; two teachers with also more than twenty years of experience that belonged to the initial group but who had taught in diverse schools during this period and now are teaching in the same school; and finally, a teacher with 12 years of experience as a primary school teacher that was introduced to the group four years ago and has just changed of school in the last academic year. Table 2.4 offers a summary of the profiles of the selected teachers.

	Teacher nº1	Teacher nº2/3	Teacher nº4
Years of experience as primary teacher	+20	+20	+10
Years in the ICE's group	8	9	4
Different schools experience while participating in the group	No	Yes	Yes

Table 2.4. Summary of selected teachers for ICE group

In order to design the interview, more information from the group was requested to the coordinator who facilitated documentation, in particular a summary of the minutes that are taken during each group meetings. Appendix 1 shows this summary in which the objectives of the group defined when it was created and all the group activities are collected and commented by the coordinator.

With all the information gathered the interview was designed, dividing the questions into four groups: General Information, Innovative group, Knowledge transfer and Influence on colleagues.

Questions regarding *general information* were designed in order to collect information about teachers' profile and their relation with the innovative group (years of experience in the group, how did they arrive to it, etc).

The main section of the interview was devoted to *the teachers' group* itself, and its questions were addressed to characterize the group objectives, dynamics and activity from the point of view of the participating teaches.

Finally, the last two sections, *knowledge transfer* and *influence on colleagues* were addressed to identify how the work carried out within the group could be or is transferred beyond the group itself and how the teachers participating in the group are influencing other colleagues, from the group or out of it.

All the interviews were made separately (except for the two teachers working in the same school) and took place in teachers' schools. They were audio recorded[33] and analyzed using the qualitative analysis program AtlasTi, which allowed identifying the more relevant snippets and labeling them accordingly to our theoretical framework.

Once this first analysis was completed, it was detected a lack of certain global information and also it was required to check if the views of the selected interviewed teachers were representative of the other participants. In this sense, and for completing the first results and conclusions, a written questionnaire asking for general information was administered to all the teachers participating (Appendix 3) in the group and a second interview was carried out with the coordinator to validate some of the glimpsed results (see Appendix 4). The interview questions can be consulted in Appendix 2.

[33] Interview recordings are available at: (pending to be uploaded)

ii. Data analysis strategy

The analysis was made at two levels. The first one was a more descriptive level, which helped to characterize the group and the profile of the interviewed teachers and was used mostly in the field action section already presented. The second level one was more interpretative and addressed to answer the above mentioned research questions by characterizing teachers ideas from the viewpoint of our theoretical framework. The rest of gathered information (coordinator interview and questionnaire results) was used to contrast first analysis results.

The procedure for referencing the data was as follows: each interview was labelled by teacher number (see Table 2.4) and when presenting the results, each quotation will we noted by this code and the Atlas Ti's quote number of the audio recording. Additionally, and in order to differentiate from the CDEC group quotations, quotations from ICE's teachers will be identified with an A at the beginning. (A_teacher #_quote #)

B. CDEC Case Study

i. Data gathering strategy

Being also this case study a research study related to an on-going initiative, the design of the methodology was again constrained by the characteristics of the analyzed group. In a first phase, and in order to understand the group approach and to identify the key contact people, an interview with the coordinator the group was carried out, collecting basic information such as the program origins, the group composition, the nature of the meetings and main activities implemented by the group participants. The interview was audio recorded[34] and some documents related to the design and assessment of the initiative were shared by the coordinator.

During this interview the coordinator and the researcher agreed the people to be contacted and interviewed in order to accomplish the research, according to the interest of their specific profile and other factors such as the years being part of the group, the degree of representation of the group profile and some specific roles carried out by them within the group. Three people were selected: all of them were teachers with more than twenty years of experience as a primary school teachers; only two of them started to participate with the group when it was created and the third one was integrated to the group during the last year of the official program and only one of them has worked in the same school during all this period. Those teachers with more experience in the group have been in charge of the co-coordination in some of the group stages: one of them was the co-coordinator of the group while the program was devoted to the schools training and the other one has started his role as co-coordinator during the scholar year 2011-2012. Table 2.5 summarizes teachers' main characteristics. Finally, it has to be highlighted that all of them continue to participate in the group now that the program is devoted to their own training and the Administration support in terms of part time reduction does not exist anymore.

	Teacher nº1	Teacher nº2	Teacher nº3
Years of experience as primary teacher	+20	+20	+10
Years in the CDEC's group	6	6	2

[34] Interview recordings are available at: (pending to be uploaded)

Co-coordinator of the CDEC's group	Yes	Yes	No
Different schools experience while participating in the group	Yes	No	Yes

Table 2.5. Summary of selected teachers for CDEC group

With all the information gathered the teachers' interview was designed, dividing the questions into four groups: General Information, Innovative group, Knowledge transfer and Influence on colleagues (see Appendix 5). Questions regarding *general information* were designed in order to collect information about teachers' profile and their relation with the innovative group (years of experience in the group, how did they arrive to it…).

The main section of the interview was devoted to *the teachers' group* itself, and its questions were addressed to characterize the group objectives, dynamics and activities. Finally, the last two sections, *knowledge transfer* and *influence on colleagues* were addressed to identify how the work carried out within the group could be or is transferred beyond the group itself and how the teachers participating in the group are influencing other colleagues, from the group or out of it.

All the interviews were made separately and took place in teachers' schools. They were audio recorded[35] and analyzed using the program AtlasTi, which allowed identifying the more relevant snippet and labeling them.

ii. Data analysis strategy

The analysis was made at two levels: the first one, which helped to characterize the group and the profile of the interviewed teachers, was a more descriptive level. The second one was more addressed to answer the research question, by considering TRACES dimensions. Both analysis were complemented with the information gathered in the official documents shared by the coordinator.

The procedure for referencing the data was as follows: each interview was labelled by teacher number (see Table2.5) and when presenting the results, each quotation will we noted by this code and Atlas.ti quote number of the audio recording. Additionally, and in order to differentiate from the ICE group quotations, quotations from CDEC's teachers will be identified with a B at the beginning. (B_teacher #_ quote #))

2.2.4. Results

1. What do teachers highlight regarding the professional development initiatives?

To find out which factors of each initiative could be key aspects for a successful teachers' professional development and to what extent is this success related to the influence of science education research in the groups, it is necessary to better characterize this initiative identifying what makes it special and should be considered for similar initiatives and what could be improved. Main aspects identified according to the point of view of teachers and coordinators participating in the studied groups are listed and developed below.

[35] Interview recordings are available at: (pending to be uploaded)

a) Relationship with Science Education Research

In both cases, ICE's and CDEC's group, one of the characteristics being reported by teachers as an advantage is the contact with research, showing teachers' recognition of this as an important aspect for changing and improving practice. Teachers referred to the importance of this contact with research extensively as one of the important aspects that their participation in the teachers' group brings to them.

> "*It has been a way to be approach to (science education) research. In my first years as professional I had only contact with the school and some trainings, and suddenly (after being part of the ICE's group) I have discovered a new world (…) University world is now closer than ever" (A-1-Q.2.30)*

> *"(We ask for research support because) we clearly see that to have an expert's view works very well" (A-1-Q 2.44)*

> *"A very important think of the training that we have received is to be in contact with (…) main well-known Science Education researchers" (B-3-Q3.11)*

According to teachers this is particularly important as research uses to be hardly accessible by teachers when traditionally developing their teaching work.

> *"There are things that could be interesting for teachers and do not arrive to them. And we participate in a group (…) where this things arrive" (A-4-Q4.19)*

> *"Some research resources are underused. I mean, someone makes an interesting research (…) but it rests in the academic world" (A-4-Q.4.16)*

> *"There are difficulties to be in contact with people from (science education) research. For me ICE's group is an opportunity to know what is being done at University. (…)In general, there is a lack of this contact with research" (A-1-Q 2.85/2.86)*

> *"A teacher that has not received the training I have received (in contact with research) would not understand science as I do. (…) A usual training has its limits" (B-2-Q2.39)*

> *"Is not the same to read a book than to be in contact with the one who has written it" (B-2-Q2.45)*

In the case of the CDEC group, this contact was even more important thanks to the fact that they had time specifically devoted to visit the Universities were researchers work, in order to overcome distance and time limitations and to be sure that each of the important figures of science education research community was participating in the training program.

> *"We could go to Girona with that researcher, we go then to the UAB …" (B-3-Q 3.12)*

This contact with research, however, is seen as useful *per se* but because in the group is done in a demand-driven way generally according to the teachers' needs. As teachers state, research information can arrive to teachers or schools without having been requested or without having into account real

teachers' needs, what makes this information underused. This is the case, for instance, of science education research and innovation journals which arrive to schools, but are not really used.

> "*I think that … is better if it's from your needs. It has sense."* (A-2/3-Q 3.53)

> *"You take more profit if you have the need (of the research point of view)" (*A-2/3-Q.3.54*)*

> *"In the training sessions we received people (refers to well-known science education researchers) that is people in which we were interested to be trained by"* (B-2-Q2.5)

> *"We were free to ask for a specific researcher (to work on specific topics they were interested in)"* (B-2-Q2.29)

Despite recognizing the importance of this contact with Science Education research, teachers also report an excessive theorizing of research ideas, which seem far from what teachers think, is real practice. In addition quite often this research is also communicated in a rather theoretical and transmissive form, instead of being shared with teachers with the purpose to use it for changing practice.

> *"(Contact with science education research) must be in a more recreational way, more as a workshop. I think that it reaches more when they (researchers) explain and you have to do. Otherwise, you have only theory and you have to act. And there is always a lack of acting"* (A-2/3-Q.3.52)

In the case of the CDEC's group, this distance between research and practice is also attributed to the lack of time to put in practice what research proposes. In their case, the fact of having specific time devoted to adapt science education research results to their own school or to the schools were they were training other teachers, allowed them to deeply incorporate science education innovations.

> *"Is not the same to read as a teacher a research book (…) I needed time to put it on practice, and you cannot always do it at school. Without having received this training (referring to the CDEC's group initiative) I wouldn't be able to test what I have tested in my own school"* (B-2-Q2:45)

Nevertheless, not only time is stated as the key feature to allow this application. Also the reflection related to this transfer is important, we will see in further sections.

Crucial to this well-considered contribution of Science Education research by the teachers group is the role of the coordinator, a Science Education researcher herself, who makes possible to translate the group needs into a feasible research request and facilitates the adequate contact with selected members of the research community.

> *"The coordinator (…) brings some experts (…) I am at that point that I really like to have someone that masters a topic, an expert"* (A-3-Q3.10)

> *"I think that one aspect that has to be highlighted is all the program proposed by (mentions the coordinator's name (…) how she proposed the training program"*
> (B-3-Q3.6)

Regarding what researchers contribute to the activity of the group, ICE's group teachers highlight that researchers in Science Education as those providing deep reflections and knowledge about specific topics in the field, seeing science education researchers as knowledge providers.

> *"One of the key points (of the ICE's group) is the connection with the world of people who is reflecting on education."* (A-1-Q2.32)

> *"It is necessary to have (a science education research) expert because is a person, more expert, who has more knowledge about this topic"* (A-2/3-Q3.43)

However, ICE teachers did not point out specific contributions from the science education research communities. In contrast to CDEC teachers, who seemed to have gone more in depth in the research contributions, we could say that ICE's group has inherit a kind of general approach to science education.

> *"The main idea (from the work with ICE's group) has been how to work when teaching science (…) Not so important what to work on but how to do it"* (A-1-Q2.40)

In addition to this general approach, CDEC teachers also mention specific topics related to science teaching and learning such as the *didactic triangle, inquiry* processes, working by *models* and the *learning cycle;* and highlight the fact that the training that they received was already based on these important ideas, what helped them to better incorporate them.

> *"(The basic ideas worked during the training were) the triangle of to think, to do and to communicate; the fact of working with (scientific) models is a very important topic and the matter of questions (…) We also worked about the learning cycle, among others."* (B-2-Q2.44)

> *"Because even thought we could already identify some things from a socio-constructivist point of view, to see it within a teachers' training model… I think it was very important (…. We usually make students to do it, but on the other hand teachers are not requested to do it (when receiving training)" (B-3-3.14)*

This knowledge provider is not the only role that ICE teachers attribute to the Science Education researchers. For teachers it is also important the direct contact with researchers that allows them to share and discuss with them their own practice, as a way of externally guiding it. In addition, and more importantly, ICE teachers give experts also the role of external evaluators of their practice, in the sense of those who can validate it.

> *"Then you ask to the expert: (for example) When I do something on chemistry, I don't know if this is adequate or not? And they always help us"* (A-2/3-Q.3.12)

For the CDEC's group teachers, this role is not as important due to the fact that their training put more emphasis on the development of new science learning and teaching materials. Even though some degree of reflection about what was already done by teachers was included in the training sessions, main work was based on the development and testing of new materials by the whole group.

"For example, when talking about models, she (the science education researcher) gave us the theory, then we received it, we adapted to each level (…) and then we contrast it again with her (the science education researcher)" (B-2-Q2.28)

In both cases, this research role seems to be related with teachers' increase of their self-efficacy conception and, more importantly, their courage to test new approaches or innovations compared with teachers not in contact with research.

"It (research on science education) opens windows and helps you to understand things regarding science that you didn't… that you did differently" (A-2/3-Q 3.32)

"(Research) gives you a framework that makes you feel sure" (A-1-Q. 2.42)

"We were able to introduce innovation in science education (…)" (B-3-3.29)

In the case of ICE's group, this security rests mainly in the recognition of learning by teachers, particularly learning of crucial Science Education ideas that can guide their practice. In the teachers' viewpoint, research in science education gives them a framework based on research results that help teachers understand and recognize good aspects of their practice, to work in a specific way and to reflect in order to improve.

"The expert tells you this is this; this goes there (…). We do things that we know that work, but we do not know why they work (…) we do not know how to label them" (A-2/3-Q.3.46)

"Sometimes you share experiences but a common framework is missed, there is a lack of reference (…) Being in groups like this (like ICE's group) you got trained" (A-1-Q.2.89)

"This reflection framework (…) I wouldn't have this framework if any expert had come to the group to talk about (a specific topic)" (A-1-Q.2.76)

"As an expert they help you to see this and this… to think about things that you wouldn't have seen… to improve" (A-2/3-Q3.45)

"We work on groups (…) We had a grid (…) In that grid we all write what we see (referring to the practice they were analyzing) (…) A lot of things of the "good practices" from the sessions (with science education researchers) that we had received" (B-3-3.29)

For CDEC teachers, once this security on their own work was achieved, the fact that their training was addressed to their development as teachers' trainers is in fact the key factor of this self-efficacy increase. Actually, we could confirm that their self-efficacy was higher than the one of ICE teachers, being CDEC teachers confident enough to develop a training program for each of the schools they collaborated with.

"I remember the sentence: "I am not a formative influence… I am just a teacher". But then, after some time: "well, ok, I am also formative influence"" (B-3-Q3.23)

The recognition of the role of research in their learning seems to be much related with the topic addressed in the teachers' group (Science) and the initial teacher education in the Spanish context. For the ICE teachers, research seems to fill the gap that teachers feel regarding their scientific initial training, giving to them resources to overcome this lack of knowledge.

> *"Our initial training in science, mathematics… was not good (…) So, for me, it (ideas coming from research community) gives me this confidence thinking that they are people that really know about it (…) it offers me a knowledge basis"* (A-2/3-Q3.39)

For ICE teachers, the success of their experience is, on the one hand, that they feel free to use the research inputs whenever they want, so they do not feel them as an imposition but, on the contrary, as something that helps and works in practice.

> "*When it is imposed, nothing works"* (A-2/3-Q3.50)

> *"Every time that you try to apply something of this external view, you see that it works"* (A-1-Q2.45)

On the other hand, teachers on both groups highlight that the constructed framework is used to share with the rest of the group the activities and projects carried out and to reflect about them.

> *"You have to adopt these ideas (…) you have to be able to analyze each step (…) You see what happens, you take data…"* (A-1-Q. 2.74/75)

Being this contact with research one of the main positives aspects of these initiatives, teachers suggest some changes in the schools structures and management that would facilitate the contact with research in the same way that is done within the group.

> *"It would be necessary that contact with research was mandatory, being part of teachers tasks such as being in the party committee"* (A-3-Q 4.24)

> *"It is necessary a regular contact of schools with research ,in order to overcome teachers' reticences (…) And all this should be fostered by the Administration*" (A-3-Q4.57/4.59)

> *"Teachers should have to be conscious that they need to be updated, to innovate (…) school administration influences a lot on it (comments an example of a school where its school administration fosters this kind of contact with research in their training programs proposals)"* (B-3-3.39)

b) Link to practice

Another key factor reported by teachers is the fact that what is discussed by the group comes usually from teachers experience and is easily applicable to real school practice.
In this sense, there is a clear reference to the need of an adaptation of what research in science education proposes to the actual classroom and schools context, recognizing the imoportance of transformation and owerneship of the innovations they are introduced.

"You bring the ideas to the classroom and you see the difficulties when you bring in to the students (…) There are changes (from what has been introduced by research experts). You have to make it yours" (A-1-Q 2.74)

"*Starting from what we have received from University people, we reelaborated (…) and we adapted to the schools"* (B-3-Q3.31)

In the case of ICE's group, this recognition of the importance of a link with practice makes that for teachers practical knowledge is of the same or even more importance than formal knowledge or science education research results. This results in some of the teachers considering their more experienced and knowledgeable colleagues as experts at a science research level, but who even deserve more credibility than science education researchers because they are more linked to the real classroom practice.

"What is good regarding ICE's group is that their components are people who are daily working with children in the classroom what, by antithesis, is the bad part of some researches that are done by people who has a lot of knowledge about whatever, but is not in the real context of classrooms. (ICE's) group has (…) people with a lot of knowledge, I mean, even at a theoretical level, but you trust them because they are talking from the same reality that you live every day. (…) Is a matter of credibility" (A-4-Q 4.75/4.79)

For its part, teachers in CDEC's groups find that the way the training program was designed, with the support of an Administration institution that is usually in contact with schools and is in charge of their continuous development programs, helped to assure a real link with the actual school practices.

"Is an institution (CDEC) that knows what wants to do and is specialized on that (to work directly with schools)" (B-2-2.82)

c) Teachers' reflection

Mentioned when talking about the difficulties that teachers have to gain access to science education research information, the lack of teachers' reflection in their day by day is reported as one of the main reasons why participating in a teachers' group as those analyzed makes the difference.

"The rush of the day by day makes you go headlong (…) (whereas)The work I do in the group has allowed me to reflect about what happens in the classroom" (A-1-Q2.22 / 2.49)

"The day by day traps you a lot.(…) If you do not force yourself (to go to ICE's meeting) (…) you would go home (and wouldn't reflect)" (A-1-Q2.78)

For teachers in CDEC's group, the fact that they got a time reduction in their tasks as primary level teachers, make this reflection even more important regarding the expected outcomes of their training participation.

"We had more time to think, to reflect, to assimilate what we received, and I think that (…)we did had that time that teachers do not usually have " (B-2-Q2.41)

In general, some causes of a common lack of reflection are reported by teachers in the group who consider that reflection should be an important task for teachers, included in their day by day teaching work. These barriers are also reported when talking about the difficulties to transfer the groups reflections to their own school, in both cases, or to the schools were CDEC teachers were collaborating with.

"*I have not too much time to reflect with my school colleagues (…) It is unfair how timetable and time for preparing classes is considered… there is not time for it. The system is designed to open the book*" (A-1-Q 2.60/ 2. 64)

"*I think that teachers should be freer when preparing materials. (…) If I have to prepare my classes but I want to get trained on this, I have to eat hours from my personal life (…) So, if we want to work on this… people who want to work on this should have one afternoon to meet and talk about it. These two hours that you are in the school but you are working to go on(…) And Administration should facilitate and consider this (…) but also to ask for accountability, for results " (*A-2/3-Q 3.72/73/74)

"Teachers should be used to share their things, to open their classrooms" (A-2/3-Q3.36)

"(It would be necessary) That really, within teachers' usual tasks, includes listening to this people (research experts)" (A-4-Q 4.22)

"*When trying to transfer it to the schools, we had to propose different timetables"* (B-2-2.51)

However, in the case of CDEC teachers, the fact that schools were they were collaborating as formative influence were interested in receiving the training helped them to obtain some degree of commitment by the management board. This commitment was translated into structural modifications that helped to carry out the needed reflection.

"You expect that teachers in the school to reflect (about the training) (…) but teachers in the school have not the same capacity to reflect if they have time than if they don't have it" (B-2-Q2.84)

"We tried to pass on to the schools (the need of timetable modification) (…) Some schools made it possible but other did not" (B-2-Q2.53)

But, which kind of reflection are teachers in the group talking about? In the case of ICE teachers, they mention that presenting their own proposals makes them to better prepare what they want to explain from a more didactical point of view considering, for example, the science education research experts' inputs shared in previous group meetings. This reflection is sometimes enriched by their colleagues' feedback, gaining a lot of knowledge by a low investment.

"I like to explain … When I have done things that I have thought about, to put in a form to be explained to other adults enriches me (…) It forces me to reflect, to synthesize (…). You are modeling and when you explain to others with a didactical view it enriches even more, it acquires significance. (…) And when you present, what the others contribute to your presentation, finishes enriching you" (A-1-Q 2.67/2.68)

"When someone presents something that has done, you can ask: and how have you done it? (…) Or someone tells you: look, if you do that in this way you could work this or that." (A-2/3-Q 3.14)

"(From these reflections) You can often take profit for your classroom" (A-4-Q. 4.8)

"Is that feeling of what demands you little and gives you a lot" (A-1-Q. 2.21)

As we can see, this reflection is not done together with science education researchers but at a colleagues' level. On the contrary, for CDEC's group teachers this reflection, both with colleagues and with the researchers, seems to be more important and a key feature of the group's activity. As seen before, it was usual to have a specific topic to work on together with the science education researchers (see section a), B-2-Q2.28) and the reflection with their colleagues was done in a more systematic way based on the *reflective practice* approach that guided their training program.

"*What was very, very important was the reflective practice"* (B-3-Q3.13)

"We tried to make some kind of exchange (with science education researchers and with colleagues). We designed materials, we tried to test with our own students. There was also a lot of exchange (between teachers). For example: something done about live being in lower primary was then exchange with upper primary (…) there was a return to the group (…) specially about the things that we had develop to be tested" (B-2-2.30)

d) Teachers' profiles

Beyond the dynamics of the group, the profile of teachers in each group has to be considered to better understand the group itself. However, it is clear that both groups have a big difference and is the fact that, in the case of the CDEC's group, they were selected by the coordinator according to their already innovative profile.

For ICE's group the fact that almost half of teachers participating received an initial training with some specialization in science has undoubtedly influenced the group's dynamics.

"In schools you can find that there is no one with science education (…) (On the contrary) In the ICE's group you find people who are in this world of science and there is an interest (on science) that facilitates things to arise" (A-4-Q 4.29/4.32)

Nevertheless, even for those teachers who have not a specialization in science it exists a special interest on science and, for them, working with the group helps to fill the knowledge gap existing due to an insufficient initial training on science. In fact, the lack of teachers' scientific knowledge in general is reported as an important problem for science education in school.

"*I like the field (science education) and I feel that I need to learn more about it*" (A-1-Q2.1)

"Sometimes we lack some training (on science content)" (A-2/3-Q. 3.57)

"There are people (teachers) that have finished their studies little time ago, but as they have not received scientific training (…) it is not enough" (A-4-Q 4.51)

In the case of CDEC teachers, this lack of training seems to be overcome, probably due to their consolidated profile as innovative teachers and usually influenced by previous experience with the science education research community.

"*As we had done a long-term training, the school philosophy was already really to teach science by models, etc… (…))* (A-1-Q1.7)

"*I did not have scientific content knowledge (…) but thanks to other colleagues that helped us to participate in (mentions an innovative project on science education)"* (B-3-Q3.7)

On the other hand, being the case that some of the participating teachers in ICE's group are part of their schools' administration team facilitates their influence on school's colleagues (even though, as we will see later on, this influence is not as important as one would expect).

"My role as head of studies facilitates it (to influence and help school colleagues)" (A-1-Q 2.71)

This is not the case of CDEC teachers because due to their time reduction they had to decrease their own school participation, being in most cases obligated to leave their roles in the school administration. This situation did not affect their school influence, due to the fact that most of teachers came from an already innovative school as seen before.

Another important point highlighted by ICE's teachers is the heterogeneity of the group, with teachers from different contexts and levels (from pre-primary to upper primary) allowing the participants to see an adaptation of ideas among each level and to create a network with teachers from other schools. This

idea reinforce again the importance that ICE teachers give to the influence of their colleagues, sometimes higher than the one coming from science education researchers.

> "*One of the things from the richness of the group is to see how the same approach can be applied from pre-primary to upper primary"* (A-1-Q2.46)

> *"An important point is to see that there exist other ways of doing things… that work. You are not closed to your school, to the specific reality of your school and the one of your teaching staff …"* (A-4-Q 4.25)

Finally, one of the main characteristics of the participating teachers in both groups is their interest for the didactics and science education research with a specific and common approach, especially in the case of the CDEC group where teachers were specifically chosen by their already teaching style. This fact is both positive (as we have seen when analyzing the group as a professional development initiative) and negative.

> *"What makes the group special is that there are people (some of the participating teachers) that have a lot of knowledge (on science education research)"* (A-1-Q2.79)

> *"A lot of people (from the group) had already participated in (mentions some innovative projects boosted by the science education research community)"* (A-4-Q4.37)

> "*People that was participating in the CDEC's group (when she arrived) had already collaborated with (mentions a well-known science education researcher)"* (B-1-Q1.6)

> *"I guess that they proposed me to participate in the group because… well, those who were already teaching science by means of different (meaning innovative) materials, I suppose that it is extended and I was found by (people in the group"* (B-2-Q2.8)

Together with other characteristics already mentioned we could say that this feature makes teachers' profiles quite specific what supposes a kind of stagnation for the group.

> *"It would be good if new people enter in the group (…) but it is not easy because you need to know the people that would get into the group (…) they have to follow this line, that have this way of understanding"* (A-2/3-Q3.47/3.49)

Related to this stagnation of the group is the fact that, as mentioned when introducing the group profile, most of teachers comes from schools in which it already exists a special approach regarding science education. Additionally, we have seen that first incorporations to the group were generated by an existing contact with research, what suggests that teachers or their schools already present an innovative approach before being involved on the groups. Moreover, considering that new incorporations come mainly from school colleagues, we could be facing a kind of inbred group in which, besides the knowledge growth within the group itself, the influence beyond the group could be limited to a very specific schools' and teachers' profile.

e) Influence of the group beyond the group itself

In these case, the fact that one of the groups (CDEC's one) had the purpose of training teachers to be able to train other teachers, makes that the influence of each group beyond it is quite different.

On the one hand, teachers from ICE's group feel that they could spread to other teachers the knowledge they have acquired, not at a training level because there is a lack of time for it, but influencing a little bit their teaching approaches.

"I think that as a group we think that… each of us is a kind of disseminator in our schools (…) Is not a trainer function but when you are in a school it is easy to be like wildfire (that is spread)" (A-1-Q. 2.35/2.36)

"The group goes always towards outside" (A-2/3-Q 3.24)

Nevertheless, influence of ICE's group teachers on other teachers, both from their own school or from other schools, seems to be limited. For teachers in the group it is easier to carry out in their own classes some activities being related with what has been worked during the ICE's group meetings, even if their school is not open to change. But in a lot of cases these activities are isolated in their school and most of the teaching staff are not aware of them and are reluctant to change because they are not used to share their experiences. They feel it is too demanding or they take refuge in their lack of knowledge.

"I have done this interesting thing… those from the school do not even know that I have done it, but…" (A-1-Q2.11)

"First you influence in your classroom, then in the school" (A-2/3-Q3.24)

"When a school is too closed (not opened to changes) with a stabilized teaching staff, there are some dynamics that are impossible to break (…) You have to manage in your own classroom: you make a bit of this (any innovation) and a bit of that (what school usually do)" (A-2/3-Q 3.59/60/61)

"(Problems are) not when you want to bring something to your own class but when… some colleagues (from ICE's group) explain that when they want to convince others (from their school) to work in a different way is hard" (A-1-Q 2.52)

"Not everyone in the teaching staff are in (want to change) (…) sometimes you can only count on one or two people and is hard (to change things)" (A-2/3-Q 3.31)

"You explain what you have done in your class (to the rest of the teaching staff) (…) It is usually hard for teachers to open their classroom and show what are they doing" (A-2/3-Q.3.36)

"This (any change proposal) can't be bothered by teachers to do because demands a higher level of preparation" (A-1-Q. 2.27)

"Sometimes you find that teaching staff's alibi (…) a lot of times real and other not so much, to do not change is this lack of knowledge, of training" (A-1-Q 4.43)

According to ICE teachers other barriers that hinder teachers and schools to be opened to innovations and changes are reported such as the feeling that the curriculum will not be achieved or the fact that a lot of schools base their programs on the text book contents, limiting the flexibility that the introduction of new approaches would require.

"There is reluctance because there are some subjects to be finished, a curriculum to be done, a book to be fulfilled…" (A-4-Q 4.56)

In punctual cases, colleagues knowing the existence of the ICE's group and its contributions, ask for some advice to the participating teachers that are considered as a kind of expert thanks to the time devoted to reflect about the teaching tasks. The fact that their colleagues could see in practice the ideas of the group makes easier the engagement of the interested teachers.

> *"Working with ICE's group makes you feel yourself more confident and with more criteria (…) this gives you a kind of moral authority with your colleagues (…) You see that they ask you: and how would you do this or that?"* (A-1-Q2.70)

> *"What really helps you (to be at ease) is to see it (any innovative proposal). In those practical sessions where people (teachers) see how to use some material or how to work in context is necessary"* (A-4-Q. 4.44)

In some cases, this influence has been increased by sharing with all the teaching staff some basis of the group knowledge, but this would require the commitment of all the teaching staff and the involvement of the school administration, that is easier when teachers from ICE's group belong to it, and being facilitated if the school culture includes innovation projects or trainings at all teaching staff level. In these cases, also the involvement of families is reported as important (not essential, but necessary).

> *"As I am the coordinator of upper primary I have no problems no propose any change"* (A-1-Q 2.24)

> *"As all teachers in the teaching staff have heard the same message, it means that (…) you have some common things"* (A-1-Q2.61)

> *"We talk about innovations during the educational cycle's meeting*" (A-2/3-Q3.70)

> *"Things you have learnt (working with ICE's group) (…) are introduced when talking with teachers about general topics (during teaching staff meetings)"* (A-4-Q4.46)

> *"School Administration did really pledge for a change (…) That helped (…) but first step is the total participation of the teaching staff. An important part of the teaching staff has to be convinced"* (A-4-Q4.74)

> *"To achieve any change (…) You have to make all teachers enthusiastic with changes"* (A-2/3-Q3.81)

> *"In the case of the families (the importance of their convincement), maybe not so much but it's also important. On the contrary, any situation that could happen is being questioned and is being related to a way of working with which they are not agree"* (A-4-Q4.74)

Influence to teachers from other schools is situated in another level and questioned by the group participants in some cases, being achieved only by the few articles written by teachers from the ICE's group but without a direct contact or by the punctual initiatives organized at a training level (workshops and trainings), none of them with tracking of the experiences outcomes. Being this kind of dissemination not a priority for the group, again the lack of time is reported as the reason why this influence is not wider.

"*In the school where I worked (my) influence was important (…) In other schools, it is nearly inexistent"* (A-4-Q 4.65)

"ICE's group is a launch pad (…) You have the possibility, if you want to, to share (with educational community in general)" (A-1-Q2.77)

"We have not enough time (to publish any article) (…) We devote personal time to the ICE's group activity" (A-2/3-Q 3.76)

"If you are in a school is harder to publish anything (…) If you have the support of someone in the ICE (…) you feel more confident to publish. But if you don't have this support, you think: what I am doing is not important" (A-2/3-Q 3.78)

"I think that it has more repercussion when you do it in your own school. I don't know if publications (of articles or similar) have (the same repercussion)…" (A-2/3-Q 3.79)

"I think that this is one of the things that we should repeat (talking about the exhibition experience) (…) to do workshops to reach more teachers that do not have the training or knowledge" (A-4-Q 4.42)

"Spreading through the educational community? When you write an article or… but you don't know exactly who has read you (…) Workshops I think that arrived to an important number of people but articles… you cannot know (who have you influenced)" (A-4-Q 4.66)

In general, then, teachers in ICE's group feel that if they could count on some time devoted to the dissemination of their knowledge among their colleagues, it would be easier to influence them, but this would require again the involvement of Administration and school administration giving more time to teachers to prepare their classes what would offer a time space to share with the rest of the teaching staff the new approaches and the proposed practices.

Just this involvement of the Administration and the one of all teaching staff and the commitment of the school administration already mentioned is the key requirement highlighted by teachers from CDEC's group when talking about the success of their influence in other school teachers. As mentioned before, the fact that the main purpose of this group was train teachers to be able to develop training sessions in all Catalan regions helped the CDEC's group to spread their influence beyond the group itself in an effective way.

"*At other schools (not its own school) level, I think that with the trainings (that CDEC teachers design for other schools) you inevitably influence. And as in all the assessment (of the trainings) apart from some little exceptions there is a very positive feedback*" (B-2-Q2.72)

But, this effectiveness is related to different causes. On the one hand, it the kind of training CDEC teachers designed completely adapted to the needs stated or identified in the schools and also due to the feeling of proximity, being them also primary school teachers.

"I think that influence in schools has been quite positive (…). Possibly (due to)(…) the fact that we are colleagues. I mean, you are not talking from a higher level, you talk from the same level of teachers. You know their problems because you are also working at schools" (B-2-2.73)

On the other hand, the aforementioned commitment of the school administration and the involvement of all the teaching staff, usually in a long term period, are pointed out as one of the main facilitators.

"It is necessary that school administration believes in the project (…) we firstly talked with the school administration to plan the training sessions" (B-2-Q2.54/2.55)

"If the school administration does not belief that all teaching staff has to be involved (…) facilitating the timetable, etc… it would not be possible to influence people and to carry out the training" (B-3-Q3.41)

"Nowadays, is quite usual to have workshops, with few hours. And that is not enough (…) Our trainings were more extensive in time, with major involvement" (B-2-Q2.82)

This involvement was clearly facilitated for the Administration support to the initiative and, according to teachers in the CDEC groups, to the fact that there was an incentive behind –the ICT resources received by the schools-.

"Schools have to see something material (in reference to the ICT resources) in order to change their mind" (B-2-Q2.62)

Additionally, teachers in the CDEC group do tend to publish their results usually, increasing influence beyond the group and also beyond the designed training sessions for other schools. Nevertheless, they think that they would need to publish even more to make the initiative more sustainable and to reach more teachers beyond their direct influence.

"This has been also a lot of work on (the coordinator's) part; in the sense of making us to publish (…) we have done some articles and (…) other publications" (B-3-Q3.59)

"If our activity has been extended beyond the schools… I don't know, I think that we have missed time to write, we have not written enough" (B-2-Q2.74)

However, this impact beyond schools seems to be confirmed when teachers have been contacted to explain their experience even outside Catalunya.

"We have been invited several times to (mentions different conferences carried out in Spain). I mean that we are also called (by other science education institutions abroad the country)" (B-3-Q3.60)

f) Other characteristics influencing the group activity: voluntarity nature and other structural features of the group

Final topic to be highlighted regarding these professional development initiatives is related to their voluntarity nature and the fact that it takes place out of teachers' schools. There are some factors promoting this situation. On the one hand, teachers confirm that it is hard to replicate the teachers' profiles in the groups within a school.

> *"I think that this (the fact that in a school not all the teaching staff is opened to work on science education innovations) is the reason why it is necessary to go out of your school"* (A-2/3-Q 3.34)

On the other hand, it is also accused the kind of mandatory training proposed by the Administration, more devoted to general topics such as general management (for teachers belonging to the school administration) or other transverse topics.

> *"The field of training we are used to, in which we use to move… ones to know only regarding a specific topic and make punctual seminars or similar" (A-1-Q 2.79)*

> *"When you are working in the school and you attend to trainings or conferences or you read something, you never have time to reflect and to assimilate everything (…)" (B-2-2.41)*

But, in the case of ICE's group, despite the group characteristics give answer to the mentioned lack it could be also an inconvenient. Teachers admit that being a voluntary activity, with not a fixed objective, that takes place only once per month and, in some cases, far from their own school or home, it requires an extra effort from their side, being easy to spend more than two months with no contact with the group.

> *"In my case I could improve my attendance, and I guess that it happens to other people (…)What I explain regarding my attendance… I suppose that is also a problem for others in the group and becomes a problem for the organization of the group (…) the coordinator does not really know with how many people can she rely on" (A-4-Q. 4.39)*

> *"For me (the fact that the meeting is in Barcelona) is a difficulty… for me and for other people"(A-4- Q 4.40)*

> *"(When there is a common objective) you are more under pressure… if you miss one meeting you lose one month"(A-4 Q 4.41)*

On the contrary, CDEC's group teachers confirm that their time reduction has been a key feature to lead the group activity to successful results.

> *"If we have not had the time reduction at the same time (than the other colleagues) to meet all and to received the training it woul not been possible (…) It has been essential to have this time reduction"* (B-3-Q3.34)

2. To what extent is this professional development group an effective initiative to foster teachers' professional development taking into account the theoretical frameworks of professional development and professional learning communities?

Considering the fact that both group's activity has not been interrupted since its creation, about seven to ten years ago, and that most of their first participants are still engaged with the group we could think about the success of the group purposes.
Nevertheless, it would be necessary to assess some aspects to be able to find solid evidences of its effectiveness. Being this research focused on the analysis of the groups themselves, without access to the outcomes of the students being influenced by teachers participating in the group, evidences have to be collected from teachers.

Bearing in mind what has been introduced as characteristics of effective professional development (see Table 2.1, General Theoretical Framework) when talking about teachers' professional development, some features of the initiative can we assessed in the light of these characteristics.

First feature to be highlighted is the duration of the initiative. Contrary to what is usual for teacher training, these initiatives have never been designed with a concrete beginning and a concrete end. They are *long-term* and an *ongoing* process that, as Gunskey (2000) stated, allows teachers to be continuously in contact with innovations and to gradually evolve avoiding a fragmented approach (typical of traditional teachers' training programs) and being able to incorporate the complexity of the real practice. For teachers, their participation in each group means a way of being permanently trained, being aware of the novelties in science education.

> "*What makes you to continue evolving, making you progress, learning and incorporating new things is what for me supposes this (ICE's) group (...) To continue learning as a teacher*" (A-4-Q4.38)
>
> *"If you take part of this kind of group, you get yourself updated*" (A-4-Q4.50)
>
> *" (The group allows us) to be up to date about innovations and to be constantly engaged with innovations" (A-2/3-Q*3.28)

In this sense, another important aspect mentioned when characterizing an effective professional development initiative is the consideration of *how teachers learn*. Beyond the socio-cultural view of learning, about which we will talk further on when analyzing the collaboration among teachers in the group, we can consider the important link with practical issues that exists in the groups' approach and the fact that what is worked within the group is born from teachers own interest. With this approach in mind, we can confirm that this initiative overcomes one of the main flaws of traditional teachers' professional development initiatives. Avoiding the dissemination nature of existing initiatives, the analyzed groups have found a way to involve teachers through their own practice and this point is, as we have seen in the previous section, a key meaningful feature of the groups clearly valued by teachers in the group. (see b) Link to practice).

On the other hand, even though ICE's group activity is based on real practice it is true that it is not located in teachers' school. This factor could make us think that the *systemic view* required to any effective professional development initiative is missed. Nevertheless, when teachers try to adopt what it has presented and developed during the group meetings to their own school, this systemic approach is already incorporated, not only when they take into account their school context but when they are enrolled in tasks that require more responsibility (Villegas-Reimers, 2003). In the case of CDEC's group this systemic view is clearly incorporated, being teachers in charge of carrying out school based training programs.

In the case of ICE's group, another feature that could be considered missed is found when assessing to what extend the group activity is focused on teachers' subject-matter knowledge. To this matter we could confirm that in the first years of the group activity this subject-matter mastering was dilute within a focus on pedagogical knowledge. The fact that some teachers affirm that the lack of content mastering does not seem to be a constraint to be able to carry out any innovation, being the *how to teach* more relevant than the *what to teach* , is a clear example of this.

> *"The idea of how to teach what you want to work things. Not the importance that sometimes (is given) to what to teach but to how to teach " (A-1- Q. 2.40)*

However, in last years the group has been more focused on the subject as it is proved by the intensive sessions devoted to chemistry and physics during last two scholar years. It is then hardly surprising that teachers themselves confirm that their work with the group have helped them to overcome their science knowledge lack thanks to their participation in the group.

On the contrary, teachers from CDEC group seem to be more concerned about their scientific content knowledge from the beginning, as can be confirmed by the Chemistry book already written by teachers and the one of Physics that is to come.

Two last aspects must be analyzed when talking about the effectiveness of the initiatives. First one is related to the *collaboration* among teachers in the group and other actors and second aspect refers to the *reflection and inquiry* regarding the own practice as a focus of the professional development initiative. To talk about this collaboration, pointed out by some authors in terms of *community*, we should assess the group activity from the PLC framework developed before within which, and as we have already seen, this inquiry process has a central role.

As mentioned before, and related to the way teachers learn, is the need of collegiality and cooperation understood from a socio-cultural view as crucial for teachers learning. In this sense, there is no doubt that both groups' collaboration goes beyond the collegiality for organizational purposes that characterizes teaching staffs in schools. The fact that teachers in each group met to talk specifically regarding science education confirms it.

But, is this collaboration a real PLC? Answering this question we find some difference between both groups. On the one hand we should check if ICE's group fit with main PLC characteristics (together with general community features). We can confirm that teachers in the group share values and vision and that, of course, they interact and actively participate in the group dynamics.

> "*A (common) knowledge is created*" (A-2/3-Q. 3.15)

The fact that each teacher has the opportunity to present its own proposals and state its professional interests shows the group concern regarding individual views. However, it is hard to confirm interdependence among participants in the group as well as the existence of meaningful relationships, mainly due to the fact that there is not a sense of collective responsibility because it does not exist a common goal to be achieved, as we have seen when talking about the fact that this initiative is a voluntary one.

This lack of interdependence is clearly overcome in the case of CDEC's group. According to teachers statements, their work in the group has only sense if their cooperation with the other participants is taken into account.

> *"One of the basic features is that, from the beginning, we work on pairs (…) It was essential (…)"* (B-3-Q3.24)

> *"What is amazing is that one had an idea and another made three somersaults on it (meaning that reflect on the proposal and improved it) (…) There is a constant feedback* because we work as a real team*"* (B-3-Q3.55/3.56)

According to the PLC framework introduced before, we could confirm that this kind of initiatives improve teachers self-efficacy, what would be closely related with students achievement as an ultimate outcome. In these sense, we could confirm that this improvement is reported by teachers in the groups. For teachers taking part in the ICE's group, discussing with their colleagues about the teaching materials and strategies makes them feeling that they increases their self-efficacy. They report how their self-confidence has been boosted after years being collaborating with the group and how they face new challenges without fear, even when the outcome of this challenge is not clear.

> *"The feeling of feeling confident, more confident… Working in the ICE gives you… it has given to me more confidence"* (A-1-Q 2.69)

> *"One of the things in which I find more contrast with my first professional stage (before being part of the group) is that in my first phase you work with closed staff and now you think: ok, we will work on the Universe what, what are we going to do? We will see (…) And this tranquility, for me, is a very important change"* (A-1-Q. 2.95/2.96)

> *"You see that you are able to move in a more rich and diverse context… much more of that context limited by the text book"* (A-1-Q.2.92)

Additionally, they confirm that thanks to their group participation they feel with more discernment to assess any proposal to be implemented in their science classroom. They are able to assess if what is being proposed (from the science education research community or the Administration by new polices, for example) has sense and could be adapted to their own context.

> "*Sometimes you read an article (from teachers' journals) (…) and, for me, both good and bad things are published. (…). But, what does it that is good or not? (…)When you are alone, it is hard to… but when you are in a group it helps to develop discernment. I mean that, it (the participation in the group) has helped me to create discernment."* (A-1- Q2.81/2.82/2.94)

In the case of CDEC teachers, this self-confidence is also related to the long-term collaboration with the group and is confirmed when they recognize that they have taken responsibilities that they wouldn't took before being participating in the group.

> *"That's one of the most enriching things that I remember (…) the high degree of responsibility that we had to assume to be able to carry out the trainings" (B-2-Q2.37)*

Moving to the need of a reflection and inquiry process within the group activity, we could confirm that this reflection is an important aspect of ICE's group activity and a key one for CDEC's group. In the first case, and as we have seen when talking about its objectives and its dynamics, it is confirmed that teachers consider that is important to reflect about what is presented by other colleagues. Nevertheless, this reflection is made in a non systematized way, meaning that there is not the desirable *inquiry* process that would require an effective initiative to guarantee a professional development and teachers themselves ask for a deeper analysis of what is shared in the group.

> *"There is not an intention of assessing what is presented (…) Is more a sharing intention" (A-1-Q2.10)*

> *"I have not yet found the place for a discussion that allows going further (…) There is only a sharing of several experiences, but there is not a reflection about a concrete point" (A-4-Q4.39)*

Related to this, is the fact that teachers do not use to design teaching and learning materials in group to be subsequently tested by each teacher and then to work together on their experience. According to the coordinator this is due to three main factors: first one is the heterogeneity of the group in terms of level of education; the second factor is more related to the lack of content knowledge; and finally, also the heterogeneity of knowledge in terms of didactical approaches is reported as one factor related with the failure of any group's teaching and learning material design proposal. For the coordinator this is a huge task that is still not achievable by the group and that has been only successful when the challenge was low. [extract from the coordinator's questionnaire answers]

> *"Only those teachers more experts (in terms of didactics) are able to do it."*

> *"It has been only successful when we have work on general topics like classroom conversation (rather than subject centered teaching and learning materials design)"*

On the contrary, the dynamics of CDEC's group helped teachers to carry out this inquiry process, at the beginning being shared with science education researchers and later as an usual practice in teachers' activity. According to teachers, what helped them to achieve this degree of inquiry was, on the one hand, the influence of the coordinator and, on the other, the fact that they were asked to develop and test new science teaching and learning materials.

> *"We work in group, my colleagues analyze what I do and then we will discuss about it" (B-3-Q3.24)*

> *"This was also very important. The assessment is very, very important… our self-assessment. All the assessment strategies that (the coordinator is mentioned) she is a specialist on it (…) that made us to question yourself" (B-3-Q3.56)*

> *"We developed science teaching and learning materials. Sometimes we tested them in our own schools and with our own students and others we made together some proposals that we shared and we requested schools (where they were carrying out training programs) to test them (…)* (B-2-Q2.25)

To sum up then, and analyzing each initiative from both the new professional development paradigm and, more specifically, the PLC framework, we could confirm that they present different profiles. In the case of ICE's group, this initiative fits partially to what would be expected for an effective initiative (see figure 2.3). According to what we have exposed before, we could highlight three main features to be improved in this initiative. In terms of collaboration, it would be necessary that the group share more common objectives in order to improve the quality and the outcomes of their collaboration. Projects as the one initiated this year (a teachers' training program) is oriented to this collaboration increase. The same happens with the focus on subject. As commented before, during last years it has been an increasing interest of the group on working around subjects, going more in depth on them. Finally, the point that rests still without any improvement sign would be the inquiry process. As we have seen, there is a lack of reflection regarding what is exposed by teachers themselves or by research.

Following the same analysis, and in the case of CDEC's group, we could confirm that this initiative responds better to what would be expected for a real PLC. Figure 2.3 highlights that this initiative shows real strong scaffoldings when talking about their capacity to reflect and inquiry about their own practice or about the proposals they made when developing new science teaching and learning materials. This is related with other strong basis of the group, such as their long-term and on-going process approach and the program design proposed when the group was initiated. As seen when analyzing this program, both teachers' learning, from a socio-constructivist point of view and, consequently, the necessity of real collaboration between participants were required as essential guidelines of the group's activity. In that regard, the role of the coordinator seems to be a key factor. The only two things that could be improved in this group could be maybe to increase the systemic view when proposing new science teaching approaches and a major focus on subject. First aspect has been spoiled now that the Administration support has been reduced and teachers have no free time to work together with schools, what was, according teachers, one of the key successful features of the proposed program.

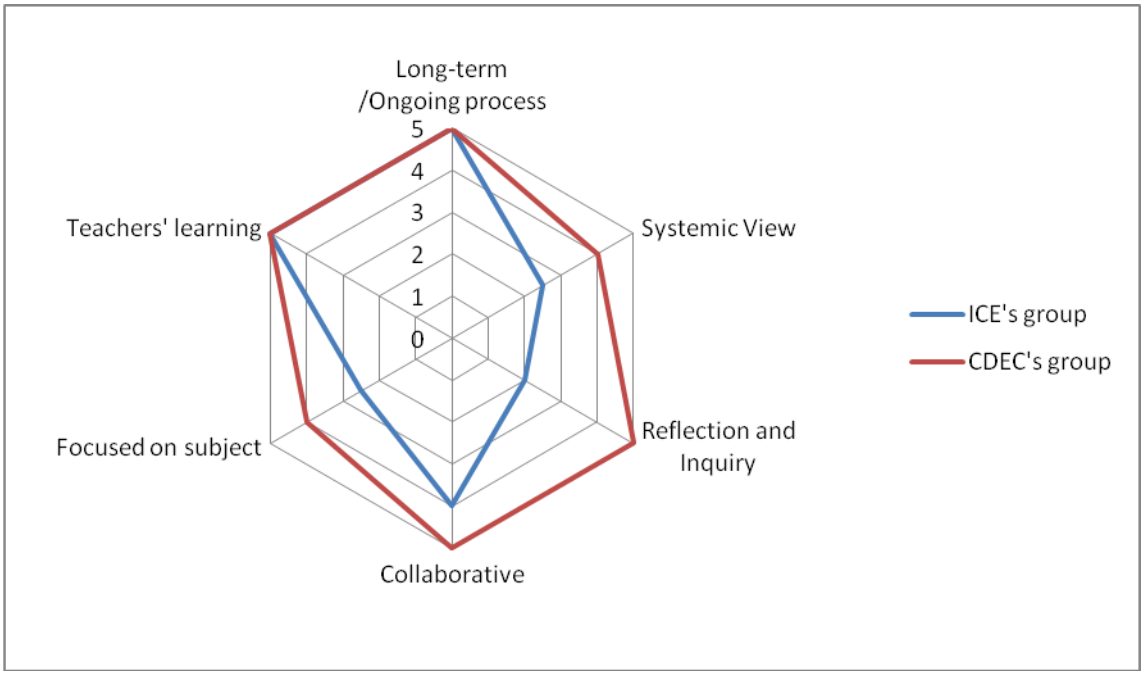


Figure 2.3: PLC profile of ICE's and CDEC's group

2.2.5. Conclusions

This comparative case study done by analyzing two existing field actions has offered an analysis of two teachers' continuous professional development initiatives that are characterized by their potential in front of what is usually done with regard to teachers training programs. On the one hand, both initiatives are planned as **long term** programmes that have consolidated their **sustainability** in contrast of the one-shot training programs that are traditionally offered to teachers. Additionally, they are voluntary teachers' group initiatives taken by teachers who have a desire to innovate their teaching practice. Finally, both initiatives hold a contact with science education researchers, seeking some degree of reflection. All these characteristics of the analyzed initiatives are usually missing in most common teachers' professional development proposals. Being then these initiatives quite innovative in terms of their approach, closer to the new paradigms of teachers' professional development that we have presented in this compendia of case studies (Guskey 2000,Marcelo 1994), some positive outcomes on teachers' professionalism would be expected.

With regard to this development, our analysis of participating teachers' perceptions and viewpoints points out to some **improvement on the participants teaching professionalism** First, participating in the analyzed teachers' continuous professional initiative has given to teachers, according to their own viewpoint, a framework based on research results that helps them to understand and to recognize good aspects of science teaching. This framework has leaded them to work in a specific way and to reflect in order to improve. Second, teachers in both teachers' groups confirm that they have improved their practice and thus, have increased their **self-efficacy** beliefs by being able to bring to practice these new approaches based on science education research results. However, in the case of CDEC's group, this self-efficacy feeling is higher than that of the ICE initiative, being the participating teachers not only responsible of developing and implementing new teaching and learning materials based on these science education research results but also in charge of designing and giving teachers' training programs. This formative character of the initiative implies a **high responsibility** for the participating teachers that according to their own statements has been supported by this self-efficacy feeling increased when participating in the program.

When trying to identify which of the characteristics of the groups have helped to reach this professional development, some common aspects stand out. First of all, it is clear that the intentional **participation of science education researchers** is a key point for these kinds of initiatives. This collaboration, represented by the groups' coordinators and by the well-known science education researchers that have been invited to participate in the group activities, has some characteristics that have to be highlighted. This research support is usually under demand, that is, the topics that are presented and discussed come usually from teachers' interests or are related with certain identified needs. According to teachers, this **adaptation to their own needs** and, consequently, to the real teaching practice makes the difference in these teacher training programs. Finally, one of the features that must be highlighted regarding both groups is the fact that in both cases, teachers participate **voluntarily** and this participation is a response to their **personal interest** on science education, which is not a common characteristic of most Spanish primary school teachers, who see themselves as generalist teachers without the need of a particular expertise in

science. Being this interest in improving practice and particularly in Science Education the starting point of the analyzed teachers' groups and field actions, this case study does not offer guidelines regarding how to promote in standard primary school teachers a desire to improve their practice in particular in the Science field.

According to our theoretical framework for professional development, the formation of a professional learning community between participants of a CPD initiative is a desirable objective, as these PLC are an fruitful locus of teachers' professional development. In this sense, one of the main differences that could be highlighted between both ICE and CDEC teacher group initiatives is the **degree of formation of a professional learning community** that each group has achieved, either consciously or unconciously In the case of ICE's group, and even though it has a lot of characteristics that could suggest that we are in front of a solid PLC, this community has some weakness that would need to be improved. On the one hand, even the reflection is present in the group, is not usually a systematic and deep reflection on and about practice, but only an exchange of experiences quite often at the technical level. As warned by some authors (Visscher and Witziers 2004) this kind of soften approach has to be distinguished from a real PLC, where the systemic analysis of practice is the driven force of the professional development of teachers within the community. Behind this lack of real reflection we could find the fact that, in opposition to CDEC's group which seeks to design a teachers' training program for other teachers external to the group, ICE teachers do not have a joined objective. Despite all teachers belong to the group seeking for their professional improvement of practice, there is not a joined task or goal they want to achieve as a group that joints them and could be the focus of their joined reflections. This is particularly important taking into account that teachers belong to different schools, which makes their joined vision more difficult than that of a PLC taking place within a school. Additionally, and even though research is present in ICE's group by means of the coordinator and the science education researchers figures that usually collaborate with the group, there is not a systematic reflection on and adoption/adaptation of science education research results as in the case of CDEC's group. In this second group, participating teachers are usually asked to adapt research results shared during the group sessions to new proposals that are in turn revised together with the science education researchers, giving **sturdiness to the process reflection** made by the group. Related to this higher predisposition for a deeper reflection we find two causes that clearly arose from our analysis: on the one hand, CDEC teachers had a reduction of part of their **time** as teachers with the only purpose of participating in the training, while ICE teachers do have to use their free time to take part of their group. This makes participation in the CDEC group a professional practice (part of their teachers' work or task) which, as a result, has to produce clear and tangible outcomes. On the other hand, CDEC nature as a group for training teachers to be future teacher trainers makes necessary for them to master research results and make their own adaptations, in addition to give all the group a **clear joint goal** that lead to a major commitment of all participants.

Finally, there is another difference between both groups and is the fact that in CDEC's group the feeling of real **mutual trust** is higher than the ICE's one. In this sense, ICE's group is a pseudo-community, where teachers do feel an agreement with everything and positivism of all approaches shared by colleagues. On the contrary, CDEC teachers have arrived to a degree of confidence between all group participants that allow real criticism when reflecting about colleagues practice, a key feature of a real PLC according to the literature (Stoll and Louis, 2007). ICE's group would need then to overcome this lack of critical friendship in the future if the group wants to progress toward a group that supports real change of practice as a result of personal and joint reflection on practice.

Be that as it may, and despite the existing differences, both initiatives result interesting enough to try **to extend and replicate** their philosophy to other teachers group, both out or within schools. To do so, our analysis points out some key features that would need to have in mind when designing new continuous professional development initiatives inspired in this field actions. According to what we have seen, in order for teachers' change to be in the adequate direction and for teachers' reflection to be focused in crucial aspects, it seems important that teachers have the possibility of be in close contact with science education researchers that adapt their discourse to these teachers' needs and doubts. In this sense, it is not only the research presence, but the fact that it is fitted to the purpose of the teachers' group and it is not understood as an expert-non expert relationship but in a more participatory way. In addition, in the case of CDEC, researchers do not only share their theoretical rationales but guide and give feedback to actual implementation in practice.

Another interesting aspect is the crucial **support of the Administration**, which has shown to be quite important **in terms of allowing the time that teachers need to** make feasible this contact with research, reflection in, on and about practice, peer collaboration and so on.. The administration also provides the sense of professionalism of these tasks that are not actual teaching: the idea that learning to become a better teacher or teacher trainer is part of their job. This is related with the relevance given to the initiative by teachers' themselves.

Finally, the way teachers' collaboration, reflection and action are supported by the facilitators or coordinators of the teachers' group has shown also very important. This guiding task has more influence in teachers' collaboration when the activities of the group are directed towards or focused on a joint goal to be achieved.

2.3. Case Study Report 2: Group of Teachers from the MDL School

The case study report entitled *Group of teachers from the MDL School* is a report on a long-term and continuous training programme carried out within the *Mare de Déu de Lourdes* School, a programme that was already up and running when the TRACES project began. The initiative for this programme came not only from the school's management board, which proposed an initial training activity for teachers, but also from teaching staff themselves, who on several occasions requested that the programme be extended in terms of time, the numbers of teachers involved and content.

The training programme is run by a researcher, a member of the TRACES project in Spain, who is assisted by a number of co-workers in order to study and analyse the initiative, the aim being to determine the influence which the proposed training has on professional development and whether it leads to changes in educational practice.

The report which follows describes the programme and sets out the theoretical framework in which it is embedded.

2.3.1. The local context of the field actions

a. Table of descriptive information of the unit of intervention

Type	*Continuous in-school training (voluntary) / innovation in teaching*
Size	*12 teachers*
Level	*Primary*
Profile	*Half of the teachers had more than ten years of experience, while four had less than five years teaching experience*
Origin	*Teacher-led initiative*
Responsibility	*Teachers and a university-based teacher educator (researcher on the teaching of mathematics)*
Relationship with educational authorities	*Initiative partially funded by the regional government (Generalitat de Catalunya[36]), but with full autonomy*
Level of investment	*High (ten hours of group training, one hour per week in the classroom, two hours per term with the teacher educator)*
Time scale	*Three years*

b. Qualitative description of the unit of intervention

The study was conducted with a group of teachers from the *Mare de Déu de Lourdes* School (hereinafter, MDL School), a state-subsidized faith school[37] in the town of Mataró, 30 km to the north of

[36] The *Generalitat de Catalunya* is the administrative body that governs the Autonomous Community of Catalonia (Spain).

[37] The MDL is privately managed but has funding agreements with the Catalan government.

Barcelona. The school, with two tiers, has 581 pupils distributed across the different stages from primary to compulsory secondary education.

The present research forms part of a training project for teachers at the MDL School. The training began with a series of talks and meetings held during the 2010-2011 academic year, the aim of which was to reflect upon the competency curriculum. Teachers from primary stage one asked for more extensive training that would enable them, in the classroom, to fulfil the curricular requirements regarding the development of numerical thinking. The training model, designed by a teacher educator/researcher from the *Universitat Autònoma de Barcelona* and accepted by the staff and management of the school, has three elements: broad training as a group, the observation by teachers of classes given in their respective classrooms by an expert (referred to as *model classes*), and, finally, group reflection by teachers from each primary stage regarding the practice they have observed. The topic addressed in the model classes was based on the implementation of a project designed to bring innovation to the mathematics classroom, the focus in this case being on number development and mental calculation strategies.

At the start of each term during the 2010-11 academic year the teacher educator organized a series of model classes for primary stage one teachers, and these served to introduce the innovative material. The teachers were present in the classrooms as participant observers, and over the following weeks they themselves continued to implement the innovative strategies.

At the request of teachers and with the approval of management this initial training project was then extended to include all primary-level teachers for the two subsequent academic years (2011-12 and 2012-13) (see Appendix 11).

Teachers' profile

The teachers taking part in the project form a homogeneous group. They are all primary teachers at the same school, and most of them are full-time class teachers. The greatest differences are found in their years of experience. The following table summarizes the profile of participants.

Teaching level	Primary: Stage one (6-8 years)	6
	Primary: Stage two (8-10 years)	6
Years as part of school's teaching staff	< 3 years	3
	3 - 10 years	3
	> 10 years	6
Years of teaching experience	< 5 years	4
	> 5 years	8
Gender	Male	2
	Female	10
Post	Class teacher	8
	Support teacher	2
	Supply teacher	2

The project requires each teacher to dedicate one hour a week to a class in which they implement the innovative mental calculation strategies with their pupils, and they must also be involved when the teacher educator visits the school. During these visits (three per year, one at the start of each term) both the class and support teachers act as participant observers in the model class for their corresponding group of pupils. The school's management promotes the participation of all teachers by adapting timetables, and the teachers themselves are willing to participate even if the model class coincides with their non-teaching time. Subsequently, during their lunch break, all the teachers from each primary stage take part in a group reflection about the classes they have observed. The flexibility

and willingness to take part shown by the teachers makes them a group of considerable interest from the research point of view.

Profile of the teacher educator

The teacher educator is a researcher on the teaching of mathematics, and holds doctoral and Master's degrees in mathematics teaching from the *Universitat Autònoma de Barcelona* (UAB). She has more than twenty years of experience as a primary school teacher and as a teacher of mathematics at secondary and university level. She holds a degree in mathematics teaching from the *Universidad del Atlántico* (Barranquilla, Colombia), a degree in psychology and pedagogy from the *Universitat Oberta de Catalunya* and completed her primary-level teacher training at the UAB. Her last six years of experience as a primary school teacher were gained in a state-subsidized school in Catalonia. For the last five years she has taught prospective primary and infant teachers at the Faculty of Education of the UAB. She has more than eight years of experience teaching mathematics at secondary and advanced level, and has also worked as a lecturer in differential calculus in faculties of engineering and mathematics at several universities in Barranquilla (Colombia). Her training as a researcher in the teaching of mathematics, her experience as a teacher educator of prospective primary school teachers and her vast experience as a teacher and lecturer of mathematics across the different stages of the education system mean that she can rightly be considered an expert mathematics educator in relation to this training model, and she is both teacher educator and researcher within the TRACES team in Spain.

In collaboration with other researchers and teacher educators from the Department of Teacher Training in Mathematics and the Experimental Sciences of the UAB she designed the mental calculation project and implemented it in a school in Badalona (Barcelona, Spain), where she worked for six consecutive years. Her reflections on the implementation of this project led her to develop materials for teaching mental calculation in primary schools (calculation handbooks for years 1 to 6), and it is these materials which serve as the basis for the innovation being implemented with teachers from the MDL School.

In the training process being studied here the role of the teacher educator has three main components:

1.1. As an expert in mathematics teaching she provides the broad training to the group of teachers.

1.2. She demonstrates good mathematical practices related to the development of numerical thinking and mental calculation strategies, referred to here as model classes.

1.3. She coordinates the subsequent group reflection on the observed classes. In these sessions the teacher educator listens to the needs expressed by the teachers, helping them to think about their interests and, where appropriate, proposing topics for discussion and clarifying any doubts which may arise.

Description and theoretical basis of the teacher training intervention

Stages Term	**I**	**II**	**III**	**IV** ***This stage is introduced in primary stage two, and is not recommended for primary stage one***	**V**
1st	Series of problems	Solving the quick calculation worksheet	General strategies with simple arithmetic operations (<100)	_____	_____
2nd	Series of problems	Solving the quick calculation worksheet	General strategies with simple arithmetic operations (<100)	General strategies with simple arithmetic operations (>100)	_____
3rd	Series of problems	Solving the quick calculation worksheet	_____	_____	Implementing the workshop on board games (strategies and chance)

Table 2.6. Outline of the innovation project

Characteristics of the innovation project on number development and mental calculation strategies

The innovation project on number development and mental calculation strategies requires participating teachers to dedicate one hour per week (on a specific day) to mental calculation, in addition to their standard mathematics classes. Number sense is addressed through an understanding of the decimal position system, the conscious and well-founded use of the properties of numbers and operations, and, finally, through the identification of mathematical language in contextualized problems and the application of numerical knowledge.

Each session involves the setting of contextualized problems and exercises of mental calculation, and these are addressed in the classroom in two ways: 1) pupils working individually on specific activities of mental agility and on mentally solving contextualized problems; and 2) pupils working as a group, in which they verbalize and justify the strategies they have used in solving the problems, and where the teacher supervises their participation in order to examine these strategies in greater detail and reach a consensus over their use.

The aim of this dual approach is to enable pupils to understand the meaning of arithmetic procedures, i.e. that they learn to use them knowingly, rather than mechanically, as ways of acting upon numbers and arithmetic structures. Furthermore, participation and the communication of ideas are encouraged as key elements in the construction of mathematical knowledge. In this regard, pupils' difficulties are taken into account and they are able to learn at their own pace, with mistakes being treated as learning opportunities. The project also promotes reflection and awareness of the learning process among pupils, encouraging them to assimilate and make links to previous learning and out-of-school experiences when discussing the strategies and heuristics they used during the problem-solving process (NCTM, 2000).

Characteristics of the training model involving reflection on the model classes given by an expert

This type of training, based on model classes, draws upon some of the basic ideas of the approach to study used in Japanese classes, namely the setting of objectives, the observation of class teachers in a real classroom and a subsequent group reflection in which observations and opinions are shared. However, it does not consider other elements such as prior planning, the unequal role between, in our case, the person giving the model class (expert) and those who observe it, or the sequential nature of the study process in Japanese classes (Isoda, Arcavi & Mena Lorca, 2007; Fernandez, 2002).

The model classes are based on good teaching practices carried out by an expert, where this can be understood as "a classroom situation where pupils and teachers collaborate by means of conversations through which they build bridges between school language and everyday language by referring to contextualized mathematical activities that are cognitively stimulating. The development of these practices requires knowledge about mathematics, about other subjects, about how people interact with one another and, more generally, about the world around us" (Planas & Alsina, 2009, pp. 16-17). An important aspect of these model classes as good teaching practices, in terms of understanding the processes of teaching and learning of numerical thinking in the primary school context, is the scaffolding used by the expert when managing classroom interactions, namely:

- The task requirements, which are matched to the pupils' interests and take into account their individual characteristics and emotional states.
- The management of tasks and communication in the classroom, which enables pupils: 1) to explain their ideas and correct their own mistakes through the feedback they receive; 2) to regard mistakes as a learning opportunity; and 3) to develop an attitude of perseverance as regards the search for strategies and solutions (Planas & Alsina, 2009, p. 17)

The aim of the training model is to present practising teachers with a series of structured opportunities that integrate different elements of their professional knowledge, for example, the relationship between mathematical knowledge and knowledge of the specific pedagogical content of mathematics, or how the teacher defines his or her participation in the 'practice' of teaching mathematics. In accordance with the work of Llinares (2007) this proposal derives from the need to make connections by means of specific tasks (the observation and analysis of good practices demonstrated by an expert in the actual classrooms of the teachers participating in the training, followed by reflection on the observed practices) whose purpose is to integrate and transform teachers' professional knowledge in a coherent and systematic way. In this training model, special emphasis is placed on three aspects:

1. "Highlighting the idea of mathematics teaching as a practice that must be understood;
2. The role which may be played by 'conceptual and technical tools' when developing the processes through which these practices are implemented;
3. The relationship between the social and personal domains in the learning process (in both initial training contexts and in relation to life-long learning), operationalized through the development of processes of interaction between persons" (Llinares, 2007, p. 3).

From a sociocultural perspective (Llinares, 2007; Planas & Alsina, 2009) we understand teacher training processes as spaces for learning and professional development that promote changes in the way teachers participate in mathematical practices in the classroom, and in how they understand them. We therefore consider continuous teacher training as a space for developing the professional competences of teachers, those which enable them to understand the teaching of mathematics, such as:

1. Reconstructing/constructing conceptual tools and technical resources for analysing and developing good mathematical practices in the classroom.
2. Observing specific practices in the classroom (model class).
3. Evaluating and analysing specific classroom practices (competency of didactic analysis).
4. Constructing new knowledge as a result of reflection (both individual and group) *on* and *about* mathematical practice in the classroom (theory-practice relationship).

The intervention process

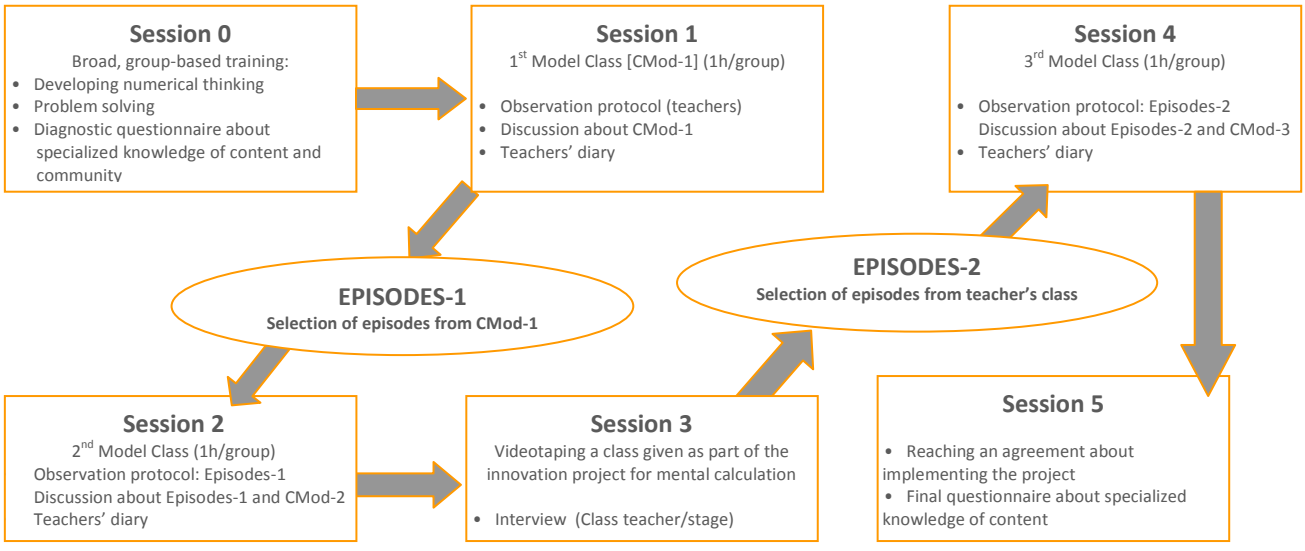


Figure 2.4. The intervention process

The first decision made when designing the training programme was to adopt a perspective on teachers' learning and professional development that would help them to build conceptual and technical tools for developing numerical thinking in the primary classroom. As a result the training has three parts. The first consists of broad training for the whole group of teachers, in which they are introduced to some of the

findings from research on mathematics teaching, specifically as regards the processes of teaching and learning that underpin the development of numerical thinking in primary pupils (Session 0, see Figure 2.5). The aim of this initial contact is to provide teachers with a number of theoretical and methodological reference points from the innovation project, with respect to mental calculation strategies and the development of numerical thinking.

The second part of the training focuses on the observation of model classes (Sessions 1, 2 and 4, see Figure 2.10) in which the teacher educator approaches mathematics teaching as a cyclical process involving two inter-related facets: mathematical knowledge and the learning processes of pupils (Font, 2007; Planas & Alsina, 2009). In this regard the teacher educator considers that in order to develop mathematical knowledge in the classroom it is necessary, at all stages and in each model class, to make internal and external connections between mathematical terms and concepts.

Following Rico (2006) it is assumed that the different meanings of a mathematical concept are determined by the conceptual structures in which it is located, by the symbol systems which represent the concept, and by the objects and phenomena out of which the concept emerges and which give it meaning (triad: Representation-Phenomenon-Definition). In the school context a mathematical concept may be viewed as having a variety of different meanings. We would argue that this is precisely because the same concept can have multiple meanings which are determined by the internal and external relationships of the reference concept. According to Rico the internal connections reinforce mathematical language, give meaning to each notion through its links to the conceptual structure in which the expressed concept is located, and lend the concept both objectivity and the potential to be used for the purposes of argument. The external connections provide references based on individual experience or on culturally accumulated experience, and they include ways of acting in certain situations, of tackling problems, of processing information and of adapting to models.

Figure 2.5. Still image from a model class

(Class teacher and support teacher observing the teacher educator in the classroom)

Consequently, the theoretical framework which is applied by the teacher educator in the model classes, assumes that the process of doing mathematics, or mathematization, implies, firstly, that problems are translated from the real world to the world of mathematics (process of horizontal mathematization).

- "Identify the mathematics that may be relevant to the problem.
- Represent the problem in a different way.
- Understand the relationship between natural, symbolic and formal languages.
- Find regularities, relationships and patterns.
- Recognize isomorphisms with other already-known problems.
- Translate the problem to a mathematical model" (Rico, 2006, p. 287).

Once the problem has been translated into a mathematical expression the idea is then that the process may continue and pupils can consider questions in which they use mathematical concepts and skills (process of vertical mathematization).

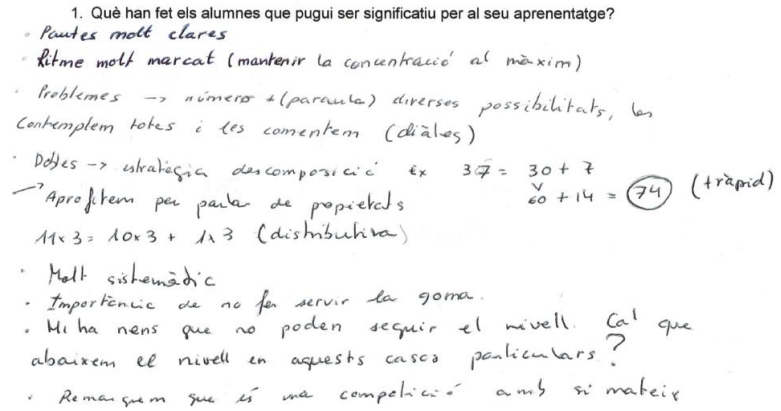
- "Use different representations.
- Use symbolic, formal and technical language and the corresponding operations.
- Refine and adjust the mathematical models; combine and integrate models.
- Present arguments and generalize" (Rico, 2006, p. 287).

Finally, the mathematical activity produced in the classroom should help pupils both to interpret results with a critical eye and to justify the whole process of mathematization.

- "Understand the scope and limits of mathematical concepts.
- Reflect upon mathematical arguments and explain and justify results.
- Communicate the process and the solution.
- Be critical of the model and its limits" (Rico, 2006, p. 287).

The third part of the training involves reflection *on* and *about* the mathematical practice observed in the classroom, the aim being to generate new knowledge and professional competences among teachers as a result of the relationship between theory and practice. In this regard, three tools are used that help participants learn how to teach as a result of learning how to use and generate new knowledge through teaching (Llinares, 2007, p. 3):

- Didactic analysis of the model classes (observation protocol);


1. Què han fet els alumnes que pugui ser significatiu per al seu aprenentatge?

- Pautes molt clares
- Ritme molt marcat (mantenir la concentració al màxim)
- Problemes → número + (paraula) diverses possibilitats, les contemplem totes i les comentem (diàlegs)
- Dobles → estratègia descomposició ex 37 = 30 + 7 / 60 + 14 = 74 (ràpid)
  → Aprofitem per parlar de propietats
  11 x 3 = 10 x 3 + 1 x 3 (distributiva)
- Molt sistemàtic
- Importància de no fer servir la goma.
- Hi ha nens que no poden seguir el nivell. Cal que abaixem el nivell en aquests casos particulars?
- Remarquem que és una competició amb si mateix

Figure 2.6. Observation protocol of a primary stage two teacher

- Reflection based on the selection of episodes from the model classes and of episodes from classes given by teachers who are implementing the innovation project (reflection protocol), and

Figure 2.7. Still image of a reflection session involving primary stage two teachers

- Teachers' online diary, in which they share opinions about the training.

Projecte de càlcul mental i jocs de taula. Diari del professorat (14-15/09/2011)

Què he après avui que em pot servir per a millorar la meva pràctica docent?	Sample Question 2		Curs
D'aquest curset en tret només aspectes positius, dels quals destaco l'última sessió en que es va insistir en les estratègies a seguir en el càlcul mental i en l'explicació de la desena. El fet d'aprofundir en aquests conceptes m'ha permès adquirir més seguretat per treballar aquesta assignatura. A vegades creus que no domines prou el tema, no trobes les paraules adequades o bé dónes per suposat que els nens no entendran allò que intentes explicar. Però després veus que els nens et segueixen, que cada setmana van millorant i que els hi agrada aquesta assignatura. Tot això es degut al treball del dia a dia i a l'ajut d'aquest curset que fa que vagis millorant. Un clar exemple de com em pot ajudar el trobo en el cas de la Núria, alumne amb dificultats en el càlcul mental, amb aquesta formació espero trobar els recursos necessaris per a ella.		PI-3	1r.
EN AQUESTA ÚLTIMA SESSIÓ HE VIST QUE ÉS MOLT IMPORTANT QUE ELS NENS I NENES TINGUIN MOLT CLAR LA POSICIÓ QUE TÉ CADA XIFRA DINS EL NÚMERO. PER TANT A L'AULA S'HA D'INSISTIR MOLT QUE ELS ALUMNES DIGUIN: "POSICIÓ DE LA DESENA", "POSICIÓ DE LA CENTENA" O EL NÚMERO QUE TÉ LA POSICIÓ DE UNITAT.		PI-4	

Figure 2.8. Page from the teachers' online diary

2.3.2. Case study report

a. Central problem of the Case Study

i. Presentation of the problem

The current Spanish curriculum is competence based and follows the guidelines of the PISA project, which offers a functional model of how mathematics are taught and learned. According to Rico (2006) this curricular framework places the emphasis on "mathematical knowledge that is applied in relation to a multitude of tasks and in relation to a variety of different contexts, this being achieved through a range of reflexive means based on personal intuition, in other words, based on personal competences and skills that are sustained by a variety of cognitive processes" (Rico, 2006; p. 281).

If the objective is that pupils become mathematically competent it is necessary, in the classroom, to develop general processes such as "thinking and reasoning, arguing a case, communicating, modelling, posing and solving problems, representing and using symbolic, formal and technical language, and applying operations" (ibid., p. 283). However, and as pointed out by Adler, Ball, Krainer, Lin and Novotna (2005), "many practising teachers, for different reasons, have not learned some of the content they are now required to teach, or they have not learned it in ways that enable them to teach what is now required. In particular, curriculum reform processes in mathematics across different countries resulted in many teachers now having to teach a curriculum that is quite different from the one for which they

were educated" (p. 361). This highlights the need for continuous training that strengthens teachers' competences.

Given this situation the present case study analyse the extent to which the chosen form of continuous training (i.e. one based on group reflection following the observation of model classes given by an expert) can act a driver of change in relation to the mathematical classroom practice.

ii. Theoretical framework

This case study, together with the other case studies in this report, aims to analyze a high potential initiative in promoting teachers professional development. For that reason, the general theoretical framework on professional development already introduced is the umbrella that supports the analysis of the three case studies.

In order to study the ability of a training model — whose focus is individual and group reflection on the knowledge required to teach mathematics — to act as a driver of change in the classroom it is first necessary to specify certain aspects related to these issues. This part of the report is divided into two sub-sections that set out a theoretical basis for the research in relation to the following key aspects: a) the knowledge required to teach mathematics; and b) the notion of number sense and mental calculation.

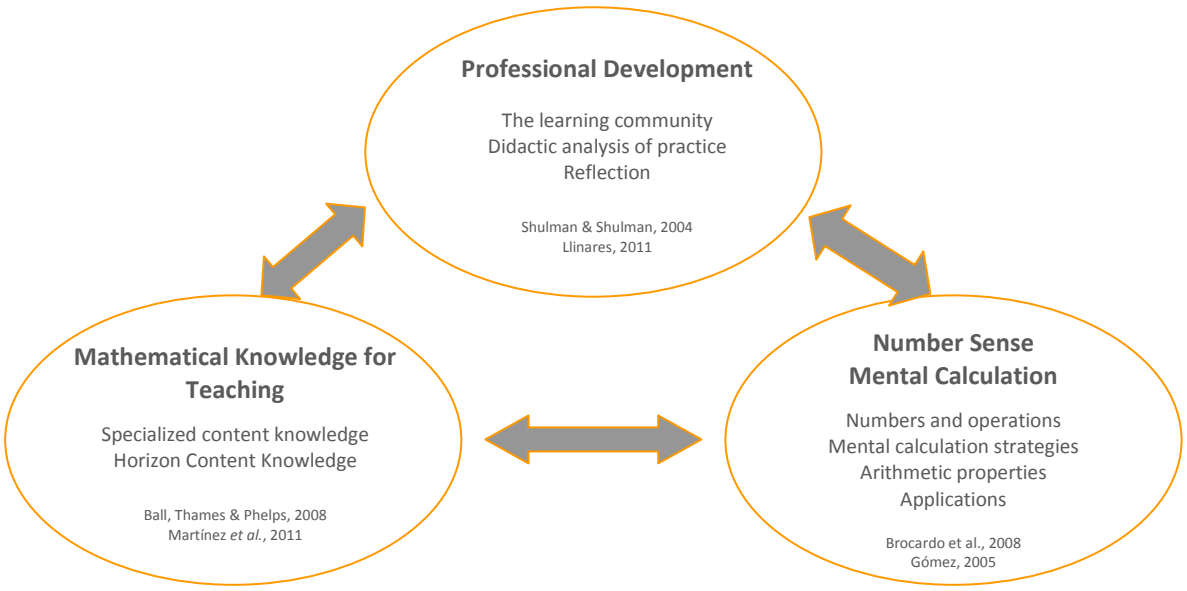


Figure 2.9. Outline of the theoretical framework

The next section sets out in greater detail our views on mathematical knowledge for teaching, since we consider that in relation to training, "what is essential is a model in which teachers' learning is anchored in the real work of instruction, with the content demands and children's learning placed front and centre as the driving force of professional development" (Hill et al., 2008; p. 501).

The knowledge required to teach mathematics

So far we have highlighted the importance which reflection and interaction among teachers and/or between teachers and a teacher educator has as regards professional development. Llinares (2007)

points out that because teachers have to manage the teaching and learning of specific content in a variety of situations it is necessary to analyse them in order to identify the knowledge required and the best ways of using it for optimal decision making.

Research on the impact of teachers' knowledge on the teaching process provides "evidence for the proposition that stronger teacher knowledge yields benefits for classroom instruction and student achievement" (Hill et al., 2008; p. 431). However, what is particular about the teacher's knowledge? What mathematical knowledge should a teacher have in order to teach, and in what ways should he or she know it? Is it sufficient for a teacher to have an abundance of mathematical wisdom?

Shulman (1986, 1987) highlighted the complexity of professional knowledge and distinguished seven components, three of which he regarded as fundamental and specific to each subject: (1) *content knowledge* refers to knowledge of the discipline; (2) *pedagogical content knowledge* consists of the ways of representing and formulating the subject that make it comprehensible to others; and (3) *curricular knowledge* includes knowledge of the scope and sequential order of a given subject's syllabus content across an academic year and schooling as a whole. From these results, a number of studies have been carried out regarding the knowledge required for teaching, and particularly for teaching mathematics.

Ball, Thames and Phelps (2008) regard mathematical knowledge for teaching as "the mathematical knowledge needed to carry out the work of teaching mathematics" (p. 395). These authors also offer a specific way of categorizing this knowledge which is useful, in the context of the present study, for analysing the reflections that emerge in the group as a result of the training programme. Based on Shulman's findings Ball *et al*. (2008) went on to argue that in addition to a knowledge of mathematics (common content knowledge), mathematical knowledge for teaching also included specialized content knowledge that enabled mathematics to be taught, the latter being different to that required by another profession which also used mathematics but for other ends. This specialized knowledge includes:

- knowing how to present mathematical ideas, finding appropriate examples
- recognizing what a particular representation implies, relating different representations to one another
- knowing how to adapt text books, knowing how to modify tasks to make them easier or more difficult
- being able to anticipate pupils' difficulties, responding to 'why' questions
- knowing how to explain or evaluate the explanations given by pupils.

According to Ball *et al*. (2008) this specialized knowledge goes hand in hand with knowledge of content and students, insofar as teachers must anticipate what their pupils think and what they might find confusing, be able to foresee what will interest and motivate them, and know what tasks they will find easy or difficult. Thus, teachers must be able to listen to and interpret their pupils' thinking, and even add to it in a language they will understand. Above all they need to be aware of the preconceived ideas and errors which their pupils may present in relation to a specific piece of mathematical content.

Another focus of interest of our study concerns the elements that lend continuity and globality to knowledge. Ball *et al.* (2008) recognized the importance of a global perspective on mathematics, referring to it as *horizon content knowledge*. In the work of Hernández and Figueiras (2010) and Martínez *et al.* (2011) this domain is considered as a broader form of knowledge, insofar as it comprises a global vision of students' mathematical education and makes connections which enable "the meaning

of mathematical content in schools to be constructed in terms of continuity" (Martínez *et al.*, 2011; pp.430-431).

With regard to horizon content knowledge, Martínez *et al.* (2011) consider three types of connections:

- within-concept connections, which enable a concept to be seen in all its facets
- inter-concept connections, which link different representations of a concept, or different concepts with one another
- temporal connections, which derive from pupils' previous and future knowledge and which enable errors to be addressed and foreseen (Fernández & Figueiras, 2010).

Rowland, Huckstep and Thwaites (2005) also ascribe considerable importance to connections. They propose a conceptual framework known as the *Knowledge Quartet* (KQ) comprising four categories which they consider offer a good working space for reflecting upon mathematics for teaching. The first category, *Foundation*, refers to the mathematical knowledge and beliefs which teachers acquire before and during their training, as well as to their way of teaching and the role of the teacher in the teaching and learning process. The second category, *Transformation*, concerns the ways and contexts in which knowledge is used for preparation/planning and for actual teaching. In relation to the third category, *Connection*, Rowland *et al*. state that in addition to "the integrity of mathematical content in the mind of the teacher and his/her management of mathematical discourse in the classroom, our conception of coherence includes the sequencing of topics of instruction within and between lessons, including the ordering of tasks and exercises. To a significant extent, these reflect deliberations and choices entailing not only knowledge of structural connections within mathematics itself, but also awareness of the relative cognitive demands of different topics and tasks" (ibid., p. 263). Finally, the fourth category, *Contingency*, refers to the ability to respond to pupils' needs and to know how to deviate from lesson plans when classroom events that were impossible to foresee make this appropriate. Such events would involve ideas, whether correct or erroneous, which children unexpectedly express and which require an adequate response from the teacher in order to generate knowledge.

The notion of number sense and mental calculation

The specific area of mathematics with which the present study is concerned is the development of number sense. There are two main reasons for this focus: firstly, it was requested by the group of teachers involved, and secondly, the topic addressed is relevant to the development of logical and mathematical thought among primary school learners.

We will now attempt to make clear what we understand by number sense and why its development is addressed from the perspective of mental calculation. This is no easy task, for as Godino, Font, Konic and Wilhelmi (2009) point out, the term is relatively recent and implies a number of skills "including flexible mental calculation, numerical estimation and quantitative reasoning" (Greeno, 1991; p. 170, cited by Godino *et al*., 2009). The word flexibility referred to mental calculation implies to consider that "the most appropriate method will vary for a particular type of calculation, depending on the particular numbers involved" (Mathematical Association, 1992, p. 10).

The importance of these aspects is internationally recognized, with, for example, the *Principles and Standards for School Mathematics* stating that "understanding number and operations, developing number sense and gaining fluency in arithmetic computation form the core of mathematics education for the elementary grades" (NCTM, 2000; p. 32). It can be seen here that in addition to highlighting the importance of the content the concept of *number sense* is distinguished from mental calculation. In the Spanish context the decree which sets out the minimum standards for primary education (MEC, 2006) defines the development of number sense as follows: "the reflexive mastery of numerical relations

which can be expressed through skills such as: the ability to break down numbers naturally, understanding and using the decimal numbering system, using the properties of operations and the relationships between them to perform mental calculations […]. Above all, children should be able to perform calculations with different procedures and to decide which procedure is most appropriate in each case. The aim across the stage is that children become fluent in their calculations and are able to make reasonable estimates, such that a balance is achieved between conceptual understanding and competence in calculation" (p. 43096).

In order to analyse the mathematical content used by teachers during the training programme in relation to the development of number sense in their pupils, it is useful to turn to the categorization proposed by Brocardo *et al.* (2008), who considers that a good understanding of number sense includes the following aspects:

- The concept of number, which includes understanding the regularities of numbers, the multiple ways in which they may be represented, the meaning of their absolute and relative magnitude, and the use of reference systems to evaluate a an answer or the rounding up of a number to make calculation easier.
- Number operations, including understanding the result of operations, their properties and the relationships between them.
- The application of knowledge and skills regarding numbers and operations to situations where a calculation is required; this includes the ability to relate the context to the calculations, an awareness of the existence of multiple strategies, preparing so as to make effective use of representations, the flexibility to use the most appropriate for a type of calculation given and being sensitive to the need to check data and the result.

Gómez (1995a) states that the development of mental calculation strategies helps give meaning to the concept of number and to the operations that can be performed with them. This author also considers that such strategies provide an ideal focus for group work in the classroom: "discussing the advantages and drawbacks of one method or another, highlighting the meaning of — or background to — the steps involved, translating them into the horizontal language of equals signs and brackets in order to unify the description, the use of explanation and examples, helping pupils to use the facts of the number system, and applying the invariant properties and modifications of the four operations are all tasks that can be used to help children engage with mathematical knowledge and activity, and they have strong motivational — and possibly recreational — components" (2005, p. 24).

However, and as has been pointed out in previous sections, teachers will only be able to develop children's number sense if they themselves have already consolidated such knowledge. In this regard, Gómez (1995b) proposes, in a context of initial teacher education, reflection on the use of non-traditional calculation strategies (column method) in order to increase the emphasis on properties, language and numerical relationships. This author argues that such reflection leads to a better understanding of arithmetic procedures and enables them to be used knowingly, rather than mechanically, as ways of acting on numbers.

b. Research questions in this case study

The aim of this research is to study the effect of training and of teachers' knowledge on their professional development and, as a consequence, on their classroom practice. This aim coincides with the objective of the TRACES project, which seeks to analyse research-based activities in order to determine the extent to which they may have a transformative influence in the classroom. In the case of this particular study, which analyses the training initiative being carried out in the MDL School in Mataró, the primary research question is as follows:

To what extent this professional development initiative based on model lessons of number sense and mental calculus strategies fosters teachers' professional development taking into account the theoretical frameworks of professional development and professional learning communities?

In addition to this general question we also pose a more specific research questions about the training programme used, namely:

What aspects of the professional development of MDL primary school teachers have evolved and how during a teacher education intervention based on joined common reflection of Mathematics' model lessons about of numerical sense and mental calculus strategies?

Which aspects of the teacher education model -based on common reflection of model lessons- have more incidence on the professional development of the participant teachers?

In order to address these research questions the case study will analyse the ways in which the kind of training carried out in the MDL School has helped promote, firstly, professional development among teachers working at primary stages one and two, and, secondly, the formation of learning communities, in both cases according to the criteria set out above when describing the theoretical framework.

2.3.3. Research methodology

This case study concerns a group of teachers from the same school in which a three-year training initiative based on model classes was begun in the 2010-11 academic year. The interpretative qualitative approach taken by the study is consistent with the purpose and design of the initiative, and enables us to characterize the professional development of the teachers across different points of the training.

a. Data gathering strategy

The data collection instruments are built into the training programme and were developed in accordance with its objectives. In order to respond to the proposed research questions and to increase the reliability of the data a number of different instruments were used, thereby enabling us to triangulate the information sources and check their convergence. All the instruments were designed in conjunction with the teacher educator and were validated by the group of researchers from the TRACES project in Spain (see Table 2.7).

Point in time	Data collection instrument	Code
T0 (Sept-11)	Initial questionnaire on community and classroom practice Initial questionnaire on specialized mathematical knowledge about numerical thinking Video recording of the group training sessions Protocol sheet for the external observer	Q-Com-T0 Q-SMK-T0 V-Train-T0 PS-Obs-T0
T1 (Sept-11)	Protocol sheet for reflection on the observed model class Video recording of the group reflection sessions Teacher's diary	PS-Ref-T1 V-S1-T1 V-S2-T1

		Diary-T1
T2 (Jan-12)	Protocol sheet for reflection on the episodes chosen from the model class Video recording of the group reflection sessions Teacher's diary	PS-Ref-T2 V-S1-T2 V-S2-T2 Diary-T2
T3 (Feb-12)	Video recording of mathematics class/teacher from primary stage 2	V-matS2-T3
	Video recording of mental calculation class/teacher (1 per primary stage) Teacher interviews	V-calS1-T3 V-calS2-T3 I-S1(2nd)-T3 I-S2(3rd)-T3
T4 (Mar-12)	Protocol sheet for reflection on the episodes chosen from the teachers' classes Video recording of the group reflection sessions Teacher's diary	PS-Ref-T4 V-S1-T4 V-S2-T4 Diary-T4
T5 (Apr-12)	Final questionnaire on community, practice and specialized mathematical knowledge Video recording of the consensus meeting	Q-Final-T5 V-CM-T5

Table 2.7. Data collection instruments

Prior to beginning the training sessions two initial questionnaires: one, concerned specialized mathematical knowledge about numerical thinking while the other, focused on community and classroom practice. The questions and situations featured in the questionnaire on specialized mathematical knowledge (see Appendix 14) were taken from the Principles and Standards for School Mathematics (NCTM, 2000) and from the book by The Mathematical Association (1992) on mental methods in mathematics. The data provided by this instrument reflect the baseline level of two of the professional development indicators related to mathematics teaching that are defined in the next section. The initial questionnaire on community and classroom practice (see Appendix 13) provides information about the other three professional development indicators linked to reflection and community.

The third data collection instrument is the protocols for group reflection by teachers from each primary stage in conjunction with the teacher educator. These protocols are designed after an initial review of the data, the purpose of which is to detect topics for reflection which have not been addressed in detail so far and which are regarded as important for the group's professional development. This is done by focusing on episodes from a model class given by the teacher educator, as well as on episodes from classes given by two teachers and which formed part of the mental calculation project. These class episodes are used as material with which to reflect on different aspects of classroom management and content, on the process of teaching and learning, on the role of the teacher and on the difficulties and potential of pupils (Callejo, Valls & Llinares, 2007).

Finally, the two teachers who had agreed to have one of their project classes videoed were interviewed so as to provide further material for discussion with all the teachers in the final group reflection session for each primary stage. Both of these teachers had worked at the school for more than ten years and were receptive to the training initiative. One taught primary stage 1 and the other primary stage 2.

Having recorded the classes given by the two teachers the interview protocol was developed after an initial reading of the teachers' online diary and after listening to the audiotapes of the group reflection involving the teacher educator and the teachers. The purpose of the interview was to gather

information about aspects that had received less attention in the data already collected. Five blocks of questions were created, corresponding to the five indicators of professional development that are listed in the next section (see Appendix 19). During the interview the teachers viewed the episodes selected from the video of their class, and were asked to give their approval for the material to be used in the group reflection with the other teachers from their primary stage. The two interviews were conducted individually with each teacher during one of their non-teaching periods on a normal working day, and were audio recorded.

b. Data analysis strategy

In order to detect evidence of professional development among the teachers who have participated in the training programme based on group reflection following observation of model classes related to an innovation project on number sense and mental calculation strategies, and with the aim of identifying which aspects of this training model have an influence on the professional development of these teachers, we defined a series of professional development indicators that were based on the proposed theoretical framework. The idea is to use these indicators to explore how teachers develop over time as a result of the training programme. The professional development indicators are as follows:

- **Positioning oneself on a continuum**: This refers to the professional competency of teachers that enables them: 1) to understand the teaching and learning of mathematics as a continuum, both *vertically* (across different academic years) and *horizontally* (in the context of the curriculum for a given year and for different subjects); and 2) to establish *connections with the context* and be able to adapt to complex situations that emerge in the classroom, including the consideration of mistakes as learning opportunities (*Horizon knowledge* in Ball *et al.*, 2008; *Connections* in Martínez *et al.*, 2011; *Connection* in Rowland *et al.*, 2005; *Practice* in Shulman & Shulman, 2004; Font, 2007).

- **Understanding specific content and the classroom methodology that specific content requires**, in our case, the development of number sense. This includes the understanding of content, the use and understanding of different ways of representing it, the interpretation of pupils' thinking and the use of specific language (*Understanding* in Shulman & Shulman, 2004; *Specialized content knowledge* and *Knowledge of content and students* in Ball *et al*., 2008; Brocardo *et al.,* 2008; Gómez, 1995b).

- **Recognition of external contributions**, from both the training programme and research on teaching.

- **Reflection *about* practice and *for* practice:** This refers to the different aspects of observed practice that are reflected upon (from classroom management to the specific content addressed), the result being that the teaching of mathematics becomes a practice that is understood; this indicator also considers the way in which knowledge for practice is accessed and reconstructed (Llinares, 2007; Escudero, 2009).

- **Participation in community:** This is understood in terms of the characteristics described by Westheimer (1998), the emphasis being on the interaction between teachers at the same curricular stage, as well as on the relationships with the 'school' community, in which there is an interaction between teaching staff as a whole, the school's management, pupils and their families (Marcelo, 1994; Escudero, 2009).

The data obtained through the abovementioned instruments were analysed using a range of approaches. For example, teachers' responses to the initial questionnaire on specialized mathematical

knowledge and community and classroom practice were organized and analysed by means of systemic networks, as proposed by Bliss *et al.* (1983). This approach enables the data to be organized into categories that are linked to the indicators, and the interpretation of this information (organized into systemic networks) provides a baseline overview of the teachers' professional development. In order to obtain this overview of the group we opted to analyse the responses by question rather than by teacher. In the case of the questionnaire on specialized mathematical knowledge we distinguished teachers according to the primary stage at which they taught. This makes it easier to identify differences and similarities in teachers' responses and enables us to infer possible relationships between curricular stage and professional development.

Another source of data was the observed classroom practice, both of the teacher educator and of the two teachers who agreed to be videoed. In order to analyse these data we first partially transcribed the selected episodes and then analysed them using the qualitative analysis software Atlas.ti. This approach enabled us to identify and establish relationships between the previously defined professional development indicators at different points of the intervention.

The procedure for referencing the data was as follows: we noted the code corresponding to the instrument used to collect the data in question (see Table 2.7), followed by the line where the citation appeared in the transcription, in the case of written data files, or the time in minutes and seconds in the case of video recordings. We then added in brackets the code corresponding to the teacher in question: TS1-# for primary stage 1 and TS2-# for primary stage 2.

2.3.4. Results

a. Positioning oneself on a continuum

As noted above when describing the theoretical framework, positioning oneself on a continuum as regards classroom practice is a professional competency that enables the teacher to have a global view of the content that is taught. Achieving this global view means that the teacher understands the teaching of mathematics as a continuum both vertically and horizontally, and is also able to make connections with the context.

Horizontal continuum

This is the professional competency that enables the teacher to make connections between different elements of mathematical content that are being addressed at the same time (Martínez *et al.*, 2011). In other words:

- Considering a concept in all its facets
- Linking different representations of a concept
- Linking different concepts to one another

In order to identify teachers' baseline position with respect to this aspect of professional development we analysed their response to question 8 from the initial questionnaire on specialized mathematical knowledge, which is illustrated below (see Figure 2.10).

The mathematical concept implicit in problem 8 of the questionnaire is multiplication, understood as repeated addition. Starting from this meaning of multiplication the associative and commutative properties of addition facilitate the introduction and justification of the distributive property of multiplication over addition; they also favour the application of number breakdown based on the

positional value of the number system and the use of mental calculation strategies (multiply by 10). The use of these properties allows meaning to be ascribed to the algorithm of multiplication by two or more digits and facilitates mental and written calculation.

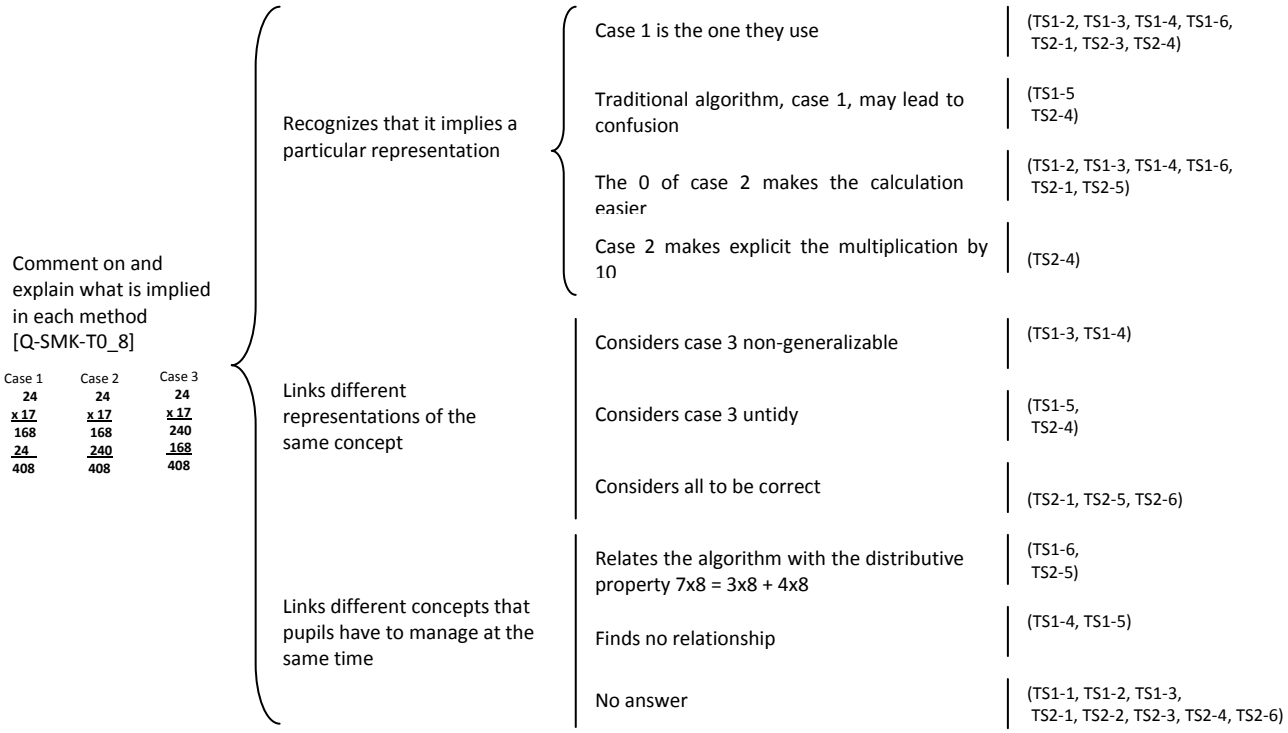


Figure 2.10. Systemic network for problem 8 [Q-SMK-T0_8]

The teachers' responses reveal that most of them do not recognize the potential of cases 2 and 3 as regards understanding the concept of multiplication and the reasoned justification of the algorithm for this operation. Only one teacher (TS2-4) explains that in cases 2 and 3, 240 is the result of multiplying 24 x 10, and only three (TS2-1, TS2-5, TS2-6) of the twelve teachers consider all three cases to be correct. Others respond as follows:

> *"In this case* [Case 3] *the answer is correct because he multiplies x 1 and it comes out the same, but if there was a different number there it wouldn't be right. So, the method needs to be explained again". (TS1-4)*
>
> [In the explanation of case 2] *"The zero in 240 has no effect here but it has to be included".*
> [In the explanation of case 3] *"Wrong placement of tens and units…". (TS1-5)*

As regards the connection between the multiplication algorithm and the distributive property, only two of the twelve teachers (TS1-6, TS2-5) considered, at the start of the training programme, that there is a relationship between the algorithm presented and the operation 7x8 = 3x8 + 4x8. This suggests that the teachers do not relate the concepts implicit to the algorithm with mathematical concepts addressed in previous academic years, for example, number breakdown based on the positional value of the decimal number system and the commutative property of addition and multiplication.

As can be seen in the analysis of the initial questionnaire most of the teachers, at the start of the training, found it difficult to make connections between mathematical content (properties of the

decimal system and of operations) and algorithms or calculation strategies, such that they become linked and meaning is ascribed to the different representations of the same concept. Likewise, at the start of the training the teachers seem to prefer to use traditional algorithms and, in most cases, find it difficult to understand other techniques that give meaning to the operation. This reflects an inflexible approach to numerical thinking which, in turn, makes it difficult to choose and develop the most appropriate mental methods for the calculation in question.

> *"They also recognize that mechanical and repetitive practices are commonplace and that they should give greater emphasis to other more reflexive approaches (for example, the proposal to study the algorithms of basic operations: moving away from a memory-based study to reflection on the algorithm as the basis for the study of operations, of the positional number system, etc.). It is striking that they propose that mathematics 'acquires meaning' when it is 'translated into language' ". PS-Obs-T0.066*

In the first reflection session on the observed model class the teachers, especially those from primary stage 1, focused predominantly on classroom management and on the difficulties caused by their pupils' immaturity.

> *"Very clear instructions. Pace tightly controlled (maintaining their full concentration)". PS-Ref-T1.058-059 (TS2-4)*

Given this baseline level of the teachers, the teacher educator and the research team decided to introduce the didactic analysis of classroom episodes as an instrument of training and professional development. This didactic analysis sought to focus reflection on the global view of mathematics education with the aim of helping the teachers to build knowledge that would enable them to make connections, such that "the meaning of mathematical content [could be] constructed in terms of continuity" (Martínez *et al.*, 2011; pp. 430-431). To this end we selected an episode from a class given by the teacher educator in September, in which she dealt with a pupil's response to the question of what 3 x 11 is. In this episode the teacher educator explores and develops with the pupils the concept of multiplication as repeated addition, starting from number breakdown (based on the positional value of the decimal number system: tens and units) and applying the distributive property of multiplication over addition. This simplifies the calculation of the product into immediate mental operations that can be understood by the pupils (see Table 2.8):

Written representation on the board	Transcription of episode-1, first part
33 (10 + 10 + 10) + (1 + 1 + 1) 	Teacher educator: How do you do it, 3 times 11? Pupil: What was I thinking? T: Yes P: Three tens, and then I put 3 […] T: She's done it well, breaking down the tens and units. T: She's said to herself: three tens is ten plus ten plus ten [writes (10+10+10)], because she has three tens. And then she's done the three units [writes (1+1+1)], [...] one plus one plus one. [...] T: So the eleven [draws an 11], she's done it as three times [draws line with her finger that joins the 1 of the tens with the 10+10+10] three tens, and three times [line that joins the 1 of the units with 1+1+1] three units.

Table 2.8 Partial transcription of episode-1, first part

It should be noted that the decision to introduce the didactic analysis of classroom episodes, with the focus on analysing how mathematical knowledge is managed in the classroom, proved to be a positive step, because in the following reflection session the teachers' reflections included specific aspects of the specialized mathematical knowledge required at this educational stage. Specifically, the teachers commented in their diaries:

> *"What has become clear to me is that the most important thing is that the children understand why certain operations are done and what they mean, rather than just doing them mechanically but without knowing why". Diary-T2.050 (TS2-1)*

> *"For a long time I've thought that we always ask our pupils for the algorithms and I've asked myself whether that is really so important. It is, but I think it is even more important that the oncept is clear. After that meeting my colleague and I decided to teach multiplication by applying the distributive property, and the children understood it straightaway". Diary-T2.060 (TS2-2)*

This illustrates that the teachers have begun to explain the meaning of other algorithms which had not been worked on previously in the training but which are taught in their mathematics classes. For example, teachers from year 4 asked the teacher educator for help in giving meaning to the division algorithm. This provides significant evidence of professional development, although it is not generalizable to all the teachers or to all cases, since it is not easy to consider mathematical content along such a continuum.

Vertical continuum

Another key aspect of positioning oneself on the mathematical continuum consists in connecting the content being worked on at present with that which pupils have already tackled in previous years or that which they will encounter in the future. These connections therefore derive from pupils' previous and future knowledge and enable the teacher to provide guidance and avoid mistakes (Fernández & Figueiras, 2010).

At the start of the training (point T0) there was little evidence that the teachers made these kinds of connections. In the first model class, which took place during the first week of the school year, the teacher educator worked on solutions to the problems set by examining the pupils' own interventions. We can infer that the opportunity to observe this class helped the teachers to incorporate this aspect into their reflections, since after the class five of them highlighted in their diaries, as a new aspect, that the pupils' strategies had been rich and varied. Furthermore, they noted their increased awareness of the importance of considering pupils' prior knowledge in the classroom.

> *"What surprised me is the number of strategies that the children look for in order to carry out the operations and solve the problems, if you give them the chance to do so". Diary-T1.048 (TS2-1)*

> *"I've learnt that it's important to show the pupils mathematical strategies so that they can make links between what they already know and what they are learning". Diary-T1.063 (TS2-6)*

The training carried out with the teachers from primary stages 1 and 2 led to meetings and agreements being reached with the school's Head. Being able to discuss mathematical content not only with colleagues from the same primary stage but also with teachers from other years (both earlier and later) enabled them to think more about the future implications of what they were teaching in the present:

> *"The other day, for example, it was really good, we had a meeting of primary stages 1 and 2, and it went well. D. [name of the school's Head] was there too […] everybody was saying 'look, what I find is this or that'… And D., who teaches secondary level – well, he doesn't at present but he will, he's at that level – he says: 'Well that's great for me, because later at secondary level we do this*

and this…'. So it's then you realize… With division, for example, the discussion [among teachers] that there is at the moment: 'Shall I do it by subtraction or not?' If you do, then the child who finds it hard will be more confident, and the one who isn't, well the time will come when he or she will do it without subtracting, but let's at least start... and here D. said he agreed because when he does polynomials then it's much easier because the children already understand..." I-S2(3rd)-T3_04:53-05:00 / 05:23 - 05:56 (TS2-2)

"I also realized that it was important to be rigorous when using mathematical symbols (= / + / -) so that pupils have a solid foundation when they move up through the years". Diary-T4.017 (TS1-2)

Within the view of mathematics as a vertical continuum we include those situations in which the pupils makes a mistake and the teacher considers it in terms of misunderstood knowledge or as a difficulty that needs to be addressed. Managing mistakes in this way means that they are treated as learning opportunities.

At the start of the training half of the teachers did not answer the question on the initial questionnaire about using pupils' mistakes in applying an algorithm as a learning opportunity [Q-Com-T0_7]. Others responded by saying that the solution to such mistakes and/or difficulties lay in systematic work on the algorithm rather than in an understanding of positional value, of the meaning of operations and of the properties implied in the algorithm.

"*I explain again where the tens and units are, and where to put them" Q-Com-T0_7 (TS1-4)*

After the first observation session involving a model class, in which the pupils were not allowed to use a rubber to work on their mistakes, two teachers commented:

"Stopping them from using a rubber helps them to see their learning process. They can see how they progress". PS-Ref-T1.119 (TS2-4)

"The pupils are used to using a rubber all the time. Learning that mistakes can be used to discover what went wrong and to do it themselves is something really significant". PS-Ref-T1.123 (TS2-5)

These comments suggest that some teachers have begun to see the pedagogical potential of mistakes. However, the video recording of one of the teacher's classes revealed that there are also occasions on which the pupils get the wrong idea, thereby making them have their doubts, but the teacher fails to explore the matter in a way that might guide them or clarify the content:

[To multiply 25 x 11] Pupil: *"For example, in 25 x 10."*
Teacher: *"Umm."*
P: *"Ah, of course, you can't do 10 x 5 and 1 x 2, can you?"*
T: *"If you do it that way, you'll never... you'll be slower. You see..."*
P: *"Yes, yes."*
T: *"Learn how to do it this way. It's quicker."*
P: *"OK." V-TS2 (3rd)-T3_36:43- 36:57*

Thus, although there is some evidence of a growing awareness of mistakes as learning opportunities there does not appear to have been a substantial shift among the teachers.

Connections with the context

Another aspect related to positioning oneself on a continuum involves the connections made with the extra-mathematical context, connections which promote the development of mathematical knowledge. For example, (1) showing pupils how to solve *contextualized* and meaningful problems by applying

mental calculation strategies; (2) a subsequent activity based on analysing the mathematical properties and structures that model the contexts used, thereby enabling pupils to take a broader perspective (*decontextualization*); and (3) the connections made on the basis of constructed mathematical content, creating new contextualized situations in which pupils can recognize or apply the strategies and concepts they have been working on (*recontextualization*) (Font, 2007).

Generally speaking, in both the group training and the initial questionnaire it was clear that all the teachers had a positive view of contextualized problems:

> *"They also regard as positive the association between the mathematical content being worked on and the pupils' 'experience'". PS-Obs-T0.047*

> *"Putting the pupils in real situations makes the operations easier to perform" Q-SMK-T0_9 (TS2-5)*

At all events, given that the mental calculation project both sets contextualized problems and systematically requires the use of the properties of operations in strategies, it is worth noting that when one of the teachers spoke of the difficulties he had in making connections between different mathematical contexts in the classroom, several other teachers agreed. This suggests that such difficulties are widespread among teachers at this primary stage:

> *"This morning, with the* [problem] *of the table legs and the chairs, you got to the distributive property which I have explained very mechanically in the classroom… and I didn't know how to relate this problem to the distributive property" V-S2-T2_22:11-22:30 (TS2-5)*

The above results suggest that teachers recognize the usefulness and importance of understanding mathematics as a continuum along which the connections they make give meaning to the content being taught and facilitate pupils' learning. However, real difficulties remain in terms of putting this into practice. The clearest example of this obstacle is the failure to take advantage of opportunities to address mistakes through the arguments put forward by the pupils themselves.

b. Understanding specific content and the classroom methodology that specific content requires

The indicator 'understanding specific content and classroom methodology' refers to the knowledge required to teach mathematics (Ball et al., 2008). This is specialized knowledge, both in terms of the approach to content and the management of pupils' learning.

Specialized knowledge of content

This includes skills such as knowing how to present mathematical ideas and find appropriate examples, recognizing a particular representation and relating different representations to one another, and knowing how to adapt text books to the pupils needs.

Right from the start of the group training the teachers expressed their difficulty in managing the content proposed by the project.

> *"They expressed doubts about whether they had sufficient mathematical knowledge to work on the basis of problem solving (they considered that in order to apply the proposed rules one needed to 'have mastered them')". PS-Obs-T0.104*

This view, expressed at the start of the training, was corroborated by the responses to the initial questionnaire on specialized mathematical knowledge (Q-SMK-T0_3), which revealed a difficulty in analysing arithmetic properties and the meaning of the operations that underpin algorithms or calculation strategies. This was illustrated by the fact that half of the teachers, including four from primary stage 1 (TS1-2, TS1-3, TS1-4 and TS1-6, along with TS2-2 and TS2-6), did not provide a

mathematical argument for the different numerical situations, while a further three teachers (TS2-1, TS2-4 and TS2-5) only did so for one of the methods.

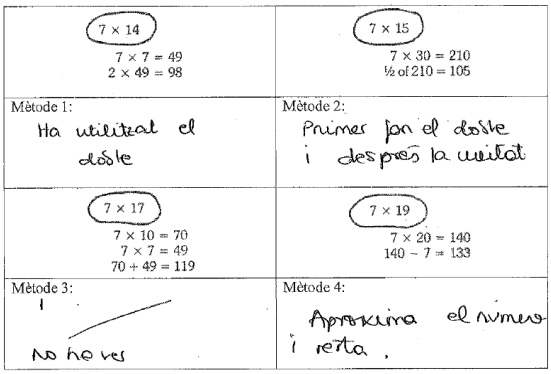


Figure 2.11. Example of a response to question 3
on the Initial Questionnaire on Specialized Mathematical Knowledge

The difficulty in identifying the number sense involved in the strategies used to solve the four multiplication problems presented in question 3 of the questionnaire is illustrated by the fact that only two teachers (TS2-1 and TS2-5) found it easy to explain the different strategies to their pupils:

> *"I think methods 1 and 2* [would be more difficult to explain in written form]*, maybe because I find them more difficult".* Q-SMK-T0_question 3 *(TS2-2)*

From the outset, however, the teachers considered that the systematic approach proposed by the project on mental calculation strategies would, over the school year, help them to overcome their difficulties regarding mathematical knowledge, an aspect which they felt to be an obstacle on several occasions. This illustrates that the teachers regarded the implementation of the project as a learning opportunity and they entered it with a more positive view of the future:

> *"*[The teacher considers she has] *Difficulties due to a lack of strategies (mastery of the subject). I can overcome this through practice and the experience of working in this way" PS-Ref-T2.014 (TS2-1)*

The first session of the mental calculation innovation project was run by the teacher educator, with participating teachers acting as observers in their respective classrooms. As noted in the previous section the subsequent group reflection did not explore in detail the specific mathematical content that had been worked on (this being the case especially among teachers from primary stage 1). It was decided, therefore, to introduce a tool, namely the selection of classroom episodes, to help teachers analyse and give meaning to the teaching situations involving specific mathematical content that emerged during the model class, the aim being to help them develop the professional competency of didactic analysis.

From the model class that was videoed in September we selected two episodes that focused on managing pupils' learning of specific mathematical content. These episodes were then viewed for didactic analysis during the group meeting held at the start of the second term. To this end, teachers were given a protocol sheet (see Appendix 17) containing questions designed to help them reflect upon the specialized mathematical content that was present in the episodes: mental calculation strategies, positional value and properties of arithmetic operations.

The second episode (the first has already been described when discussing the previous indicator) involved study of the decimal positional system, considering its properties (positional value and base 10) as strategies that facilitate the addition of exact tens. At the same time, work was repeatedly done on the commutative property of addition as a tool for quick mental calculation (see Table 2.9).

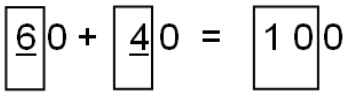
Written representation on the board	Transcription of episode-1, first part
	T: 60 + 40 = 100 [she writes it on the board]. How come we can do it so quickly? What am I focussing on? [...] P1: On 6 plus 4 equals 10 T: What 6? 6 what? P1: 60 T: 6 ... P2: 6 tens T: 6 tens [draws a box around the 6] plus 4 tens [draws box around the 4], everybody knows that, that's first year stuff, they make 10 [draws box around the 10]… what? Ps: Tens. T: Tens. One hundred. One hundred is 10 tens, isn't it? Ps: Yes! [They become excited]

Table 2.9. Partial transcription of episode-1, first part

The subsequent reflection meeting revealed a shift in teachers' contributions, with evidence of greater competency in didactic analysis. This indicates that incorporating the analysis of selected episodes and the use of the observation sheet to guide their reflections on mathematical content has helped them to focus on the mathematical skills they need to manage their pupils' learning of number sense. Furthermore, this approach made it easier for them to express the difficulties they would face when attempting to manage the different strategies proposed by pupils in the selected episodes. Both the teachers and the teacher educator felt positive about the use of video as a way of co-constructing professional knowledge that would help them with their classroom practice. Despite the difficulties expressed, several teachers stated that the concepts learnt in the reflection meeting, through analysis of the mathematics present in the episodes, had helped them to feel more confident as regards classroom management. Therefore, we can infer that the use and analysis of selected classroom episodes promotes the professional development of teachers.

> *"Exploring these concepts in greater depth has made me feel more confident about teaching this subject. You sometimes think that you don't know enough about a topic, you can't find the right words or you assume that the children won't understand what you're trying to explain. But then you find that they do follow you, that each week they improve and they enjoy the subject". Diary-T2.043 (TS1-6)*

Both the model classes and the general training consider the use of mathematical language and of the different representations of concepts, these being important aspects of specialized knowledge of mathematical content. In this regard, it is worth noting that the information obtained through both the initial questionnaire and the group reflection on the selected episodes shows that the teachers did not refer explicitly to the properties of arithmetic operations when explaining mental calculation strategies to their pupils. In the model classes the teacher educator uses specific mathematical language both in order to explain something and to complement the arguments put forward by pupils of all ages when attempting to solve problems. In line with this, the two teachers who were interviewed both felt that the training had led to a greater and more constructive use of the properties of arithmetic operations and mathematical language in their respective classrooms.

> *"We're sometimes afraid of… of talking to the children… because, well… with the terms you have to use… What I mean is that sometimes, so that they understand… a little… of what you're trying to explain… well, you explain it in another way, without saying the word for what you're going to explain. For example… if you're explaining the commutative property, well I wouldn't call it that*

because I'd think that the children were too young to begin learning these terms, you know? But of course, I see that she [the teacher educator] does it… even though the children have no idea what the commutative property is, she… And as they listen to her, well, it begins to sinks in […] and eventually they're perfectly clear about what the commutative property is and what it's for and how to use it" I-S1(2nd)-T3_06:00-06:43; 07:04-07:13

A key element of professional development to be noted from all this is the teachers' awareness of having incorporated into their practice those aspects which have been co-constructed during the training, for example, the explicit use of strategies for managing arithmetic properties and mathematical language.

Specialized knowledge among pupils

Another important aspect of specialized knowledge concerns the relationship between content and the pupils in question. In other words: Knowing how to explain or evaluate the explanations given by pupils; Being able to listen to and interpret pupils' thinking, and, if necessary, to complement it in language they understand; Being able to foresee what pupils will think and where they might get confused, predicting what interests and motivates them; Predicting which tasks they will find easy and difficult, and knowing how to modify tasks to make them easier or harder.

One of the classroom tasks proposed by the project is that pupils verbalize and justify the strategies used, and that the teacher is able to manage this. The aim of managing the pupils' participation is to explore in greater depth and reach a consensus regarding the variety of strategies that emerge during the different processes of problem solving. One of the outcomes which the teachers regarded as positive was that encouraging pupils to verbalize the different strategies used in the mental calculation class led to increased participation. In relation to this, the teachers expressed their difficulty not only in interpreting their pupils' responses but also in complementing them when necessary:

"Representing what the pupils have in mind, how they've performed the operation using a graph… this is perhaps the most complicated aspect. The idea… of going one step further and talking about properties..." PS-Ref-T2.019 (TS2-3)

The comments made by teachers during the group reflection suggest that the observation of model classes and the didactic analysis of episodes have helped them to be aware of the resources used by the teacher educator in order to foresee the difficulties and obstacles faced by the pupils, and to take steps to promote their learning:

"The numerical representation you put on the board after each explanation is really important". PS-Ref-T2.046 (TS1-4)

"Explaining out loud how they've solved the problem helps them, and others, to understand, the different ways of reaching a solution". PS-Ref-T2.052 (TS2-1)

In terms of evidence of professional development in this regard, it is noteworthy that at different points during the training the teachers have seen for themselves that the resources and strategies discussed in the reflection groups were effective in fostering pupils' learning. For example, some of them commented that they were now able to understand what their pupils found confusing and could provide them with tools for overcoming these difficulties:

"Working on number position… I'd never considered that. It's true, I didn't understand why a child didn't understand me, [that after] 199 came 200, and so on… There are some things about numbers that children find difficult… and I say to myself, well how can that be, it's so easy! That's what I find… If you work on number position and that… well, afterwards everything is so much easier for them. Mathematical reasoning is much simpler". I-S2(3rd)-T3_06:47-07:15

As noted above, the final group reflection session was dedicated to the didactic analysis of two episodes selected from classes given by two teachers. Both episodes contained aspects of specialized content that had been worked on during the training, and included certain errors alongside positive examples of management (see Table 2.10). These episodes were chosen by the teacher educator so as to provide learning opportunities and with the aim of constructing professional knowledge among all participants in the group reflection (the teacher educator, the teachers who gave the observed classes and the teachers who acted as observers). In order words, the goal was to produce evidence of a learning community.

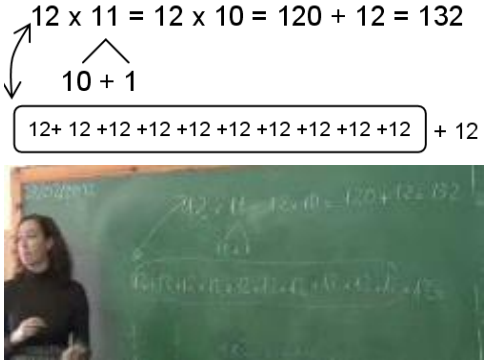
Written representation on the board	Transcription of I-S2(3rd)-T3_42:33-43:02
	TS2-2: I realized, when I was doing it, that they didn't understand what I meant by multiply by... by 11. I know they know what multiplication is, that it's the addition of the same number, but I realized that they didn't get it when the number was large. That's why I had the idea of putting 12+12+12+12+12... and then most of them got it straightaway… in fact, almost all of them know how to use this strategy now. It was hard that day. But, as we repeated it again, well most of them… maybe five of them haven't, but out of 25…

Table 2.10. Partial transcription of interview I-S2 (3rd)-T3, referring to episode-2

During the interview with one of the teachers whose class had been videoed, she explained how she realized that her pupils were finding it difficult to understand the strategy for multiplying by 11, and how, at that point, she felt confident enough to manage and resolve the situation by using the concept of multiplication as repeated addition, representing this in both graphical and numerical form and making explicit use of the distributive property.

The group reflection produced similar evidence, as during the didactic analysis the teachers explored number sense in greater depth and put forward arguments that illustrated how both their and their pupils' specialized knowledge was increasing. It should be noted, however, that many of them acknowledged that they needed to internalize this knowledge further so as to use it more effectively in the classroom.

"It'll be some time before I can explain it really well". PS-Ref-T4.363 (TS1-4)

c. Recognition of external contributions

This indicator explores the extent to which the teachers regard research on teaching and the training programme as resources they can draw upon for their professional development. Specifically, it considers their recognition of those aspects where these external contributions have an influence that benefits both teachers and pupils.

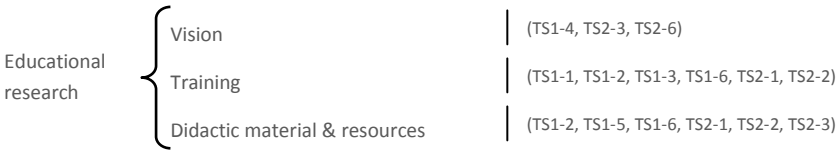


Figure 2.12. Extract from the systemic network for question 1 [Q-Com-T0_1f]

In order to obtain a baseline view of what teachers expected from research on teaching and the training programme we analysed their responses to questions 1f and 2 on the initial questionnaire about community and practice. Let us consider the first of these questions: what role does educational research have as regards your professional development?

The analysis reveals that from the outset teachers recognize the important role played by educational research in relation to their professional development, especially as regards the creation of teaching material and resources and for their learning. With respect to the training they had requested from the research team the teachers showed great interest in its practical and didactic aspects, without much attention being paid to the mathematical content itself. This is illustrated by the fact that ten teachers referred to the practical and didactic nature of the training, while only one (TS1-5) was hoping for more in-depth training about specific mathematical content.

> *"Practical, specific and in-depth in terms of becoming aware of the concepts and methods worked on". Q-Com-T0.105 (TS1-5)*

When analysing the evolution of this indicator we will begin by looking at what influence the teachers feel the different aspects of the training model have had on their professional development and on the development of number sense in their pupils.

Recognition of the influence of training on one's own professional development

Most of the teachers consider that the observation of model classes has provided them with tools that can be used in their own teaching of mathematics.

> *"During the first session it was really good to see how someone else runs the class on calculation, because you see things that you could improve, both in terms of keeping the children's attention and helping those of them who get lost more easily… or simply in terms of explaining the problems or strategies being worked on in other ways". Diary-T1.056 (TS2-2)*

> *"For me, personally, it's really useful to learn how to teach and behave in front of the children, how to structure the class so that they understand better, and what vocabulary to use in class". Diary-T4.005 (TS1-1)*

However, the group reflection on observed practice (model classes) is also regarded as being a significant contribution of the training model. Most of the teachers felt that it has enriched their own learning as it has provided an opportunity to get input from both the teacher educator and their own colleagues. This shows that the group is considered as a learning community in which they all co-construct professional knowledge that, in turn, benefits their classroom practice.

> *"The subsequent reflection with [name of the teacher educator] and other teachers from my curricular stage was really useful because each teacher spoke about her concerns and the others could give advice… and [name of the teacher educator] did too". Diary-T1.017 (TS1-3)*

Similarly, at the different points of the training most of the teachers consider that the didactic analysis of videos is a powerful way of exploring in greater depth the knowledge they need to teach mathematics, both in terms of content and their approach to their pupils. This is illustrated both by the teacher diaries and the comments made during the group reflection sessions where they had to analyse classroom episodes.

> *"It was a really useful session that produced lots of good ideas, because with the videos they showed us we could see different situations, different strategies for solving problems and different ways of approaching these situations". Diary-T2.025 (TS1-3)*

"Being there in the classroom is very different from watching it on a screen. The latter enables you to analyse the situation better and you can see what needs to be worked on or how classroom management could be improved". PS-Ref-T2.217 (TS2-3)

Finally, the didactic analysis of classroom episodes featuring members of the teaching staff themselves is viewed very positively both by the teachers who were filmed and their colleagues.

"All the training we've done with the team from the TRACES project has been really positive and interesting, but I think this last aspect was even more useful because we've been able to watch ourselves (well, two of our colleagues) giving a class, whereas at the time you're not so aware of what's going on. (Maybe we should video ourselves more often)". Diary-M4.024 (TS1-4)

Recognition of the progress made by pupils as a result of the training and the way of working

In the initial training sessions held with all the teachers they expressed concerns about the pupils' difficulties with developing number sense.

"[The teachers] consider that their pupils find it hard to understand and learn the properties of numbers (commutative property, associative property, etc.), as well as the relationship between different representations, the latter aspect being something they felt needed to be worked on". PS-Obs-T0.049

As the project has progressed all the teachers have recognized notable progress in many of their pupils. These changes concern different aspects of mathematical competency, for example, the development of calculation strategies, which are used more fluently by pupils who had benefitted from the project during the previous academic year:

"In the session we had on 15 January I realized that the children can now easily find strategies for doing the various operations, because of the foundation they've got from last year. They're pretty clear about the position of the digits in a number and it's easier for them to do the operations". Diary-T2.050 (TS2-1)

At different points of the training many of the teachers have also referred positively to the increased speed with which their pupils can perform mental calculations and the greater concentration they now show:

"This term some of them have also begun to skip the additions and do the multiplications directly, when this has been a quicker and better strategy". Diary-T2.082 (TS2-6)

"The children with an attention deficit are improving, but of course, they still find it more difficult. Because attention is really important when you're doing a project like this". I-S2(3rd)-T3_09:37-09:50

Another aspect viewed as positive by several teachers is that their pupils seem to have a clearer idea about mathematical reasoning and arguments. They attribute this to the emphasis placed on these aspects by the teacher educator in the model classes.

"Since I've been using this programme in my classes I've noticed how, little by little, the pupils are quicker at making calculations and their reasoning is clearer, and this helps them a lot when it comes to solving problems, which before they found much more difficult". I-S1(2nd)-T3_01:36-01:48

Related to the above they also state that their pupils seem more willing to tackle problem-solving, this being linked to the fact that the project seeks to create a climate of trust in the mathematics classroom, such that the pupils feel they are the protagonists in their own learning.

"More confidence on the part of pupils when tackling problems. It's great to see their willingness. They're very active and keen to take part." PS-Ref-T2.023 (TS2-3)

"I see an enormous difference compared with when I was teaching primary stage 2, with what the children were doing then and now. You would spend much longer doing any problem or operation... with something like series they would say 'Series, oh no, please', or with problems it would be 'What me, oh no, what a pain!'. And why did they say this? Because they found it really hard. Now, on the other hand, you can see... they're keen, well, they like it" I-S2(3rd)-T3_01:55-02:18

Despite the progress they see in many of their pupils, however, the teachers continue to be concerned about those children who are not responding to the project work.

"As the programme sessions go on I can see that the children are making leaps and bounds in terms of calculations. However, I think there are some pupils who find it quite difficult and the results could still be a lot better. With these pupils I'm not really sure what to do in order to improve their performance". Diary-T2.018 (TS1-2)

[In a meeting with the school Head and the teachers from primary stages 1 and 2] "Everybody talked about where they had seen an improvement. We all think, well, those that don't... It's hard sometimes, because a child that... I've got one, for example, who loses heart when doing problems because he can't do any of them. And of course, you feel bad for that child, don't you? But then you also see that he's sticking at it. Or if he's managed one, then you get him to take part…". I-S2(3rd)-T3_05:02-05:21

Although most of the teachers said they wanted to find ways of meeting the needs of pupils who find the work difficult, so that they could keep up with the mathematical activity being done in class, only one teacher said that this should be done at the same time as enabling more able pupils to progress at their own pace. This teacher made clear that the project had enabled him to manage the different learning speeds of his pupils.

"So I do ask myself: what happens to the children who don't understand the strategies or the calculation problems? On the other hand, those who do understand are being given lots more tools for developing their mathematical reasoning". Diary-T2.061-062 (TS2-2)

A further recognition of the contribution to be made to professional development by research on teaching is that many of the teachers asked for the training to be continued and extended to other areas such as the sciences.

"It would be really good to do a course on teaching mathematics, on how to apply the different concepts in class, the resources... etc." Diary-T2.012 (TS1-1)

"They're already considering doing the same with sciences, because, well… anything that means an improvement…" I-S2(3rd)-T3_30:33-30:43

The analysis of the above aspects allows us to infer that, in general, the teachers recognize the influence of external contributions to their professional development. However, the progress which, in most cases, they attribute to the training and the innovation project (which incorporates findings from educational research) does not prevent them from raising concerns about their own limitations when it comes to managing the different speeds at which pupils learn. This is especially the case with respect to those pupils who find it difficult to keep up with the pace of mathematical activity proposed by the project.

d. Reflection about practice and for practice

This indicator refers to the ability to reflect upon one's own practice and the observed practice of others, such that this becomes a tool that helps teachers to learn more about themselves and about the teaching and learning process (Llinares & Krainer, 2006). The aim is that teachers understand and are able to analyse, evaluate and question their own classroom practice (Marcelo, 1994; p. 334).

At the start of the training it was clear that the teachers found it difficult to reflect upon classroom practice, especially their own, and to draw conclusions from it that would help them improve as professionals. Questions 3 and 4 of the initial questionnaire about community and practice asked the teachers to identity positive aspects of their practice, as well as those they needed to improve. Only four out of nine teachers (of the twelve participants there are three who have never given a mathematics class) analysed their teaching practice, reflecting on aspects related to content or classroom management.

> *"I think they enable the pupils to take part. I try to make the activities dynamic and interesting for them." Q-Com-T0.119 (TS1-2)*

> *[Aspects regarded as positive] "It's easy for me to explain the things that I'm clear about". [Aspects that need to be improved] "The areas where I struggle a bit, such as geometry". Q-Com-T0.125/141 (TS2-1)*

The present training model establishes individual and group reflection as a way of promoting professional development. During this process there has been a shift in the comments made by teachers about the practice they have observed. Initially, they merely described what they had seen without evaluating the observed practice in such a way that new knowledge might emerge. Generally speaking, they focused more on the role of pupils than on the way the teacher educator managed the class. Indeed, during this first stage of the training most of the teachers' comments concerned classroom management rather than the management of specialized mathematical content.

> *"Some children use their fingers, whereas others can already do it in their head. Some of them count the numbers in each column, while others know that there are ten numbers in each column and do it in their head. When doing the problems, lots of the children have stopped using words and just put the number. After three-quarters of an hour they were no longer paying attention, they were making noises and talking more". PS-Ref-T1.008-012 (TS1-1)*

In the second reflection meeting the teachers watched a video of two episodes selected from a model class and this enabled them to focus on specific aspects of specialized teaching knowledge that are key in terms of developing children's number sense. Following this didactic analysis, conducted with colleagues and the teacher educator, there was shift in their responses. Indeed, the use of this instrument helped the teachers recognize the need to evaluate and question certain aspects of the observed practice and, as a result, elements of their own classroom practice.

> *"The opportunity to see what I don't explain very well and how I can do it". PS-Ref-T2.206 (TS1-4)*

> *"Reflecting on new ways of doing a maths class (not calculation). There needs to be an inter-relationship* [arrow pointing to 'calculation']*". PS-Ref-T2.221-222 (TS2-5)*

The fact that two teachers agreed to have their classes videoed so that certain episodes could be selected for subsequent reflection is further evidence of professional development as a result of the training, which seeks to encourage teachers to reflect about and for their classroom practice. This shows that the teachers have come to recognize the importance of analysing their practice as a way of constructing the professional knowledge that will help them improve their performance. After filming the two calculation classes (one from primary stage 1 and the other from primary stage 2) the two

teachers were interviewed (separately) and shown an episode from their class with the idea that it would be used in the subsequent group reflection session. During the interview (see Appendix 18) they were asked what they thought of the episode and how their colleagues might be helped by watching it. Although both teachers found it quite difficult to analyse their own practice their comments revealed that they had begun to reflect more about specialized mathematical content, about their pupils and about classroom management.

> *"Maybe I was too specific… I'm not sure. [...] The children… well, they were getting involved. And... they've done the same problem three different ways. [...] I don't know, tell me what you think, what do you see. [...] I was talking about tens, about... I don't know... Hmm, I don't know what I was talking about". I-S1(2nd)-T3_28:30-28:36; 29:16-29:29; 30:36-30:39; 30:58-31:09*

> *"They were quite attentive… I mean… most of them were like... I don't know... [...] Let's see, well, there are several things. First: how to teach, getting them to be clear about what multiplication is… they didn't get it, what it meant to multiply by 11. … Later on I realized that I also worked a bit on position, because some of them did know how to do the addition and they were adding the hundreds with I don't know what, and then there was this moment… 'remember that these are the tens'…, I don't know… if that's useful or not" I-S2(3rd)-T3_43:58-44:01; 44:57-45:18*

In the subsequent reflection upon these episodes the teachers, together with the teacher educator, analysed in greater detail the mathematical knowledge required to develop number sense in their pupils. Most of the teachers viewed this opportunity for reflection as positive, as it provided them with tools for constructing the professional knowledge they needed to improve their classroom practice.

> *"It's important to solve problems using different strategies. And they should all be on the board so that the children can see that there's more than one way of doing it". PS-Ref-T4.030 (TS2-3)*

> *"I think the children would understand better with the help of material they can handle. They have to know that the three solutions refer to the same problem. The strategy and the concept have to be related." PS-Ref-T4.085-087 (TS1-4)*

The two teachers who were videoed and whose episodes were used for group reflection commented that this aspect of the training, i.e. group reflection upon classroom practice, enabled them to improve specific aspects about which they had not previously been aware of the need to improve.

> *"We realize what we need to change, in my case, we analysed a video of me teaching and I could see that there are times when I could have done things differently with the children but at the time I didn't see that… but I'm sure that on another occasion I won't make those mistakes, or at least I'll try not to". Diary-T4.007 (TS1-1)*

> *"After seeing myself on video I realized where I went wrong when explaining the strategy, referring to mathematical language* [use of the = sign]. *In fact, I've noticed over the last few days that some of the pupils are making the same mistake so I'm correcting it. I'm much more aware of that kind of mistake". Diary-T4.056 (TS2-2)*

The second aspect explored by this indicator is reflection *for* practice, in other words, the extent to which reflection upon one's own and others' practice leads to an awareness of the need to change certain ways of working. During the group discussion the teachers analyse the observed practice and, at the same time, begin to draw conclusions about aspects they need to work on in their own classrooms. At this final stage of the training most of the teachers highlight aspects related to the management of content.

"In the session we did as a group, with the videos, [the teacher educator] wanted us to recognize the positional value of numbers, and that was really useful afterwards in terms of always using it in the classroom". Diary-T2.004 (TS1)

"From the session we had yesterday, 21-3-2012, I want to highlight the importance of the relationship between the concept (addition-subtraction-division...) and the mathematical representation when it comes to solving problems. What I mean is that we have to pay close attention to when we ask a pupil to put a graphical representation of a problem on the board, when we ask them how they've done it or how they've solved a problem we've set them. Because sometimes a child will justify the answer… or because they know the answer they'll put things on the board that don't follow from the problem and that can confuse the others". Diary-T4.016 (TS1-2)

The teachers also emphasize aspects related to classroom communication, both in terms of giving pupils time and space to discuss and share their calculation strategies with one another, as well as the way in which the teacher complements the pupils' contributions by translating them into mathematical language that everybody can understand. In this way the teachers become aware that this way of doing things enables them to develop and improve the strategies used by pupils, at the same time as allowing the children to listen to each other's ideas and arguments (NCTM, 2000).

"I learnt that all the children have a strategy for doing the exercises, especially for solving problems, and therefore you should try and listen to them as much as possible." Diary-T1.028 (TS1-4)

"Saying out loud how they've solved the problem helps them and others to understand the different ways of arriving at the answer." PS-Ref-T2.052 (TS2-1)

To conclude this section it is worth noting that reflection about and for practice has taken place above all in the meetings between the teacher educator and the teachers from each primary stage. The teacher's diary was designed to encourage reflection not only upon practice but also about each teacher's own learning as a result of the training. However, the teachers found it somewhat difficult to use this instrument of reflection, and generally speaking they used it more at the insistence of the project team rather than of their own initiative. This suggests that they did not regard this instrument as being especially useful in terms of their professional development.

e. Participation in community

Participation in community is considered on different levels (Shulman & Shulman, 2004). Having analysed the individual level through the previous indicators we will now analyse the notion of community among teaching staff as a whole, this being considered as a learning community in accordance with the dimensions set out by Escudero (2009). We will also examine the school itself as a community, one which includes the management board, the pupils and their families.

Teaching staff as a whole

According to Escudero (2009) a learning community has social relationships, a culture and a method for investigating the practice that characterizes it. In the case of the community that concerns us here the relationships among teachers were, from the outset, friendly and collaborative in nature. This is illustrated by the willingness shown by all the teachers at the start of the school year as regards the proposed group training (see Appendix 13).

"The group appears relaxed, friendly, interested and willing at the start of the session." PS-Obs-T0.007, cf. PS-Obs-T0.020

However, there were certain differences in the approach of teachers from primary stages 1 and 2. The external observer who watched the initial training session for elementary and primary stage 1 teachers noted, in relation to 'group climate', that there was a collaborative attitude, including in relation to errors made:

> *"While working on the questionnaires they discussed them in detail with what seemed to be a collaborative attitude." PS-Obs-T0.009*

> *"When they make a mistake (in response to the question: how many tens are there in 1412?), they are keen to discuss and learn from it." PS-Obs-T0.011*

By contrast, when observing the session involving teachers from primary stages 2 and 3 the observer noted:

> *"Although they do discuss the questionnaire among themselves they tend to work more individually than did the previous group." PS-Obs-T0.022*

> *"During the presentation they sometimes seemed a little perplexed. This could be because the presentation is more complex (in terms of content)." PS-Obs-T0.024*

Another difference can be seen in the analysis of the initial questionnaire on community and classroom practice (Q-Com-T0_1). In response to the question about the role of colleagues with respect to one's own professional development, all but one of the teachers from primary stage 1 referred to the contribution of joint work, whereas only one teacher from primary stage 2 (TS2-1) mentioned this aspect (see Figure 2.13). This information, together with the observations of conversations in the teachers' room, the dining room and the group reflections with the teacher educator, indicates that the school climate is characterized by friendly and collaborative social relationships.

As regards the shared pedagogical culture the responses to the initial questionnaire placed limited emphasis on their vision of teaching and learning and knowledge (see Figure 2.23): only two teachers said they had a shared teaching objective (TS1-2, TS2-6), while two others considered that in terms of their professional development the role of colleagues was to share knowledge (TS1-1, TS2-3).

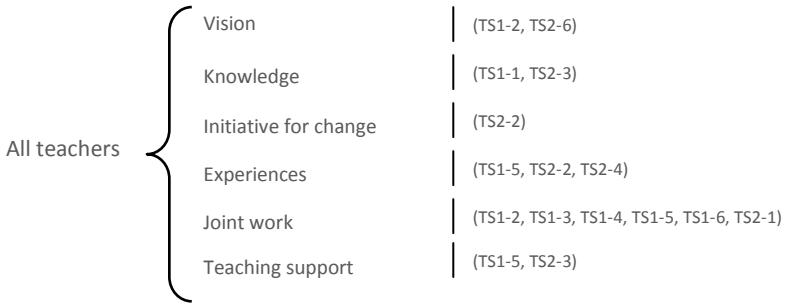


Figure 2.13. Extract from the systemic network corresponding to question 1 [Q-Com-T0_1a]

As pointed out in previous sections the training model pays special attention to group reflection on mathematical content and pupils' learning. In this context, one of the teachers interviewed recognized that a shift had taken place, as they now saw the need to reflect and take decisions as a group so as to help them improve their professional practice in a more coordinated and unified way.

> *"And doing this has been good for that… so that we all follow… a similar line. How to work with mathematics, or at least with mental calculation. And from that basis lots of other things can be done." I-S2(3rd)-T3_30:21-30:31*

The third characteristic proposed by Escudero (2009) involves formulating and carrying out research on practice, the aim being to generate knowledge about practice and to access and reconstruct knowledge for practice. At the start of the training there was no evidence that this kind of process took place in any systematic way during meetings of teaching staff. This is illustrated by the difficulties expressed in the initial meetings (see the fourth professional indicator) regarding reflection upon classroom practice. However, following the meetings held in January and May with the teacher educator most of the teachers saw that their own professional development could benefit through discussion with colleagues.

> *"Sharing opinions with your colleagues from the same curricular stage helps in managing the subject… it gives a sense of continuity. Problems can be solved with strategies that maybe we hadn't considered." PS-Ref-T2.247 (TS2-3)*

> *"In terms of the reflection we did afterwards, at lunchtime, I think it's really positive that we all reflect together on what we've done, how we behaved, the mistakes we see each other making and which can then be rectified… and together we see more things that help us to move forward with the project." Diary-T4.006 (TS1-1)*

It should also be noted in this section how teachers from the same year have begun to meet in order to discuss ways of explaining content to their pupils, and also how they take advantage of the visits of the teacher educator to ask her advice in this regard. In fact, even teachers from primary stage 3, who have yet to begin the innovation project on mental calculation, have used these visits to ask or check with the teacher educator about different ways of explaining mathematical content or of working with pupils who find the subject difficult. This indicates that as regards the learning community the teaching staff as a whole can work as a group and are interested in what could be learnt from research on teaching, represented in this case by the teacher educator.

> *"We've been talking* [the two teachers from primary year 3] *about how we could* [explain multiplication by numbers with more than one digit]. *And we wanted to ask you* [the teacher educator] *about the different ways we might do it." V-S2-T2_36:29-36:35 (TS2-1)*

The learning community formed by the teacher educator and teaching staff at the MDL School has undergone changes as the training has progressed. This may be due to a change in the membership of the community or in the relationships between those involved. While the results described above show that changes have occurred during the training it should also be noted that this group of teachers already formed what might be called a 'pre-community', there being from the outset a climate of trust and an openness to the training initiative being proposed.

School

Marcelo (1994) considers that schools cannot change without the commitment of teachers, and teachers cannot change without the commitment of the institutions in which they work. Throughout the innovation project the MDL School has shown itself to be a friendly and collaborative environment, with the Head and the management board giving their full support to the training processes.

One way in which the school has taken on board the innovation project in number sense and mental calculation strategies is by allowing the programme to be run during the normal timetable for primary stages 1 and 2. As one of the teachers interviewed put it, it's an hour a week *"we never miss"*. [*I-S1(2nd)-T3_02:16*]

The training project relies on the initiative not only of the teachers who ask for training but also of the management board. The Head's aim is to promote the school in relation to its competitors in the area

by improving the quality of the teaching offered. To this end, the management board regards as important the professional development of staff.

The interview conducted with the two teachers showed that the objective of better teaching was shared by both teaching staff and management.

> "*This is a small school. We don't have many resources and we're always on the look-out for ways of doing things better… of having things that other schools can't offer… honestly… and I think that that's a great* [word not comprehensible]. *So, we work a lot on the level, on the level of everything… of the school. And for many, many years now we've been saying that we weren't getting anywhere with mathematics.*" *I-S2(3rd)-T3_28:37-29:04*

> *"I asked* [the Head] *to do it* [the training], a little too with sciences.*" I-S1(2nd)-T3_17:36-17:37*

Another demonstration of the management board's interest in the professional development of staff is that the project has now been submitted to local government (see Appendix 21) with a view to obtaining funding, to raising awareness about the teachers' work and in order to recognize publicly the time and effort they have put in outside the official timetable.

Clearly, the management's board's commitment to professional development has meant that staff have not lacked the material resources required, but it has also served as an incentive for those teachers involved in the project. None of the teachers from primary stages 1 and 2 were excluded from the process, not even those who had just joined the school, those who taught specific subjects (foreign languages, music) or the most longstanding staff members.

Mention should also be made of the decision taken by teachers at primary stage 2 to involve the families of year 3 pupils in relation to explaining multiplication by numbers with more than one digit (see Appendix 20). This innovation in the way of introducing operations is based on the application of aspects of content that have been discussed and analysed during the training: using the properties of the decimal numbering system (position) and the meaning of arithmetic operations, which form the basis of the mental calculation project. This evidence of the school as community is reflected in the wish to explain to and involve parents in their children's learning, being transparent with them about the methods used.

> *"The other day with* [name of the other teacher from the same year] *we were talking… so, getting started with multiplication… how are we going to do it? OK, we can do it in two ways so that the children understand. Because I was already imagining some of the parents… some of the things I saw when we did subtraction by regrouping… they didn't teach them because it wasn't the way they knew how to do it." V-S2-T2_36:14-36:28 (TS2-1)*

This initiative draws upon the willingness of families to become involved in their children's learning, and also highlights the awareness among teachers that their profession is a task to be shared with the parents of their pupils.

> *"Those in year 3, some of them had already started to change… the children themselves. Then there were some parents who asked me: 'Can I show him my way of doing it?'." V-S2-T2_36:53-37:02*

The above indicators provide a measure of the extent to which the training initiative is able to promote professional development among this group of teachers, with such development being understood according to the characteristics set out in the theoretical framework. The analysis reveals that professional development has taken place, although not in the same way for all the indicators.

This group of teachers has shown commitment and has made significant progress as regards mathematical content. They have carefully examined ways of explaining this content so as to give meaning to the operations and foster the emergence of different problem-solving strategies among their pupils. Indeed, they have changed their way of explaining and managing mathematical knowledge in the classroom, to the extent that some of them have got parents involved with these new ideas so as to promote a more collaborative approach to the teaching of mathematics. They have also witnessed their pupils' abilities and, in the classroom, the children's own voices have come to play a role in the teaching and learning process. Nevertheless, many of the teachers imply they need more time to take on board the content.

As regards positioning oneself on a continuum the teachers have become aware of the importance of this concept, but they continue to find it difficult to work with the material from a horizontal and vertical perspective. Another aspect where difficulties remain is the use of mistakes as learning opportunities. In many cases, the failure to take advantage of erroneous or partial arguments among their pupils is based on a lack of awareness of the situation. The group reflection sessions have seen some progress being made in this regard, although it remains to be seen how this aspect of the training is transferred to the classroom, there being a need for further work on the role of evaluation in relation to the processes through which mathematics is learnt.

One of the areas which the teachers initially found most difficult was reflecting on their own classroom practice. However, some of them have become aware of the difficulty they have in terms of positioning themselves on a continuum with respect to mathematics, and this illustrates their development on this indicator. Among the two teachers who agreed to have their classes videoed so that episodes could be selected for group reflection, the opportunity to reflect upon specific aspects of their teaching has led to an increased desire to change their classroom approach.

Finally, evolution in terms of community is illustrated through the evolution of its members. This group of teachers started on a relatively strong footing, as the school climate was such that they were able to show their weaknesses and turn to others for help. A good example of this is the episodes selected for group reflection, and this community atmosphere has strengthened the elements of the training model. It now remains to be seen whether the pedagogical culture and investigative reflection upon and for classroom practice will be carried over into other subject areas.

The analysis of indicators enables us to respond to the first question posed at the outset: what aspects of the training programme have an influence on the professional development of this group of teachers? Specifically, the analysis has shown that there are a number of key features of the training model that have had a particular impact in terms of professional development.

The first of these is the focus of the innovation project, i.e. developing number sense and mental calculation strategies, and the approach it has taken, namely the way of tackling contextualized problems based on getting pupils to argue the case for the different strategies used, and the systematic work on strategies that use arithmetic properties and the decimal position system as tools that can make calculation easier. By dedicating an hour a week throughout the school year to this way of working, teachers have been given a basis from which to examine specialized mathematical knowledge.

It should be recognized, however, that the ability of the innovation project to promote professional development has depended greatly on the didactic analysis of classroom episodes that were specifically chosen by the teacher educator and the research team for use in the group reflection sessions. This enabled, firstly, the observation of an expert who was able to incorporate elements of educational research into classroom teaching, and secondly, reflection upon those aspects which were important to

work on in the project. Although the teachers initially found it difficult to carry out this kind of analysis it can be concluded, on the basis of the discussions regarding content, the meaning of different representations and the ways of explaining them, that there has been a significant shift in the teachers' ability to reflect upon and modify their classroom practice.

This didactic analysis, initially limited in scope, acquired greater depth when teachers were given the opportunity to observe the episodes selected from the model classes and the classes given by two colleagues. This way of focusing on key elements offered the teachers, especially the two who agreed to be videoed, with interesting ways of approaching their professional development. One aspect which the teachers felt was not useful in this regard was the teacher's diary, which has been used more as material to be submitted to the research team rather than as something which they themselves might benefit from.

A final aspect which we consider to be essential when it comes to promoting professional development is time, this being something which the training model requires in abundance. Indeed, the progress described above was achieved over a matter of months, not weeks. Furthermore, some of the teachers have said they need still more time to take on board all the reflections produced during the meetings and, above all, to implement the ideas fully in the classroom.

2.3.5. Conclusions

The professional development initiative described in this case report has been shown to have had an impact on the teachers and to have influenced classroom practice. Key elements in this regard include the management of mathematical content and pupil involvement in the classroom, as well as the ability of teachers to draw upon educational research in forming a learning community and as a basis for change.

Some aspects of the initiative may need to be reconsidered in order to improve it and to ensure it has a lasting influence. For example, key issues such as evaluation have yet to be addressed, and it remains to be seen whether central features of the training model such as the instruments used for reflection and didactic analysis will continue to be used outside the training context.

At all events, this case study provides an example of a long-term and continuous training programme designed to promote the professional development of teachers, one which requires high levels of involvement by teachers, the school and the research team. The programme enables teachers to discuss classroom practice not only with their colleagues but also with educational researchers, thereby allowing the sharing of knowledge and experience and leading to the creation of a shared pedagogical culture.

There are, however, a number of questions that remain to be answered. The first is whether a training programme that requires such high-level input from a research team is really viable at national or international level (given that in addition to the full training days the initiative requires continuity over a number of years). This raises the question of how it might be implemented across several schools. A further issue is related to the continuity of the processes of reflection about and for professional practice, both at the individual level and among a school's teaching staff as a whole. Given the complexity of — and demands upon — the primary school timetable it has to be asked whether regular time can easily be set aside for group reflection on real and specific aspects of classroom practice.

2.4. Case Study Report 3: Group of Teachers from the MDR-Amilcar School

The case study report entitled *Group of teachers from the MDR-Amilcar School* is a report on a long-term and continuous intervention programme carried out within the *Mare de Déu del Roser – Amilcar* School, a programme initiated within the TRACES project. The initiative for this programme came from the school's management board, which asked for an initial training activity for teachers. The teachers' educator team offered a training programme regarding science competences, more specifically a training intervention programme that included the design, implementation and reflection of learning sequences regarding central scientific concepts.

The training programme has been run by a researcher, member of the TRACES project in Spain, who is assisted by a number of co-workers in order to study and analyse the initiative, the aim being to determine the influence which the proposed training has on professional development and whether it leads to changes in educational practice.

The report which follows describes the programme, sets out the theoretical framework in which it is embedded and analyzes the factors influencing the expected professional development.

2.4.1. The local context of the field actions

a. Table showing the descriptive characteristics of the intervention.

Type	*Continuous in-school training (voluntary) / innovation in teaching*
Size	*25 teachers*
Level	*Kindergarten and Primary*
Profile	*Most of the teachers had more than ten years of experience, while only four had less than five years teaching experience*
Origin	*Management board-led initiative*
Responsibility	*Teachers and a university-based teacher educator team (researcher on the teaching of science)*
Relationship with educational authorities	*Initiative partially funded by the regional government (Generalitat de Catalunya), but with full autonomy*
Level of investment	*Very High (36 hours of group training, 2 hour per week for preparation of the sessions and review of the teachers' designs)*
Time scale	*Two years*

School and teachers' profile

The present research is based on a professional development programme for kindergarten and primary school teachers from the *Mare de Déu del Roser – Amilcar* School (hereinafter, Amilcar School), a semi-private faith school[38] in the city of Barcelona, with two tiers and 798 pupils distributed across the different stages from kindergarten to non-compulsory secondary education.

[38] The Amilcar School is privately managed but has funding agreements with the Catalan government.

However, Primary and Secondary schools remain quite separate, both in terms of space (secondary school classes are situated in another part of the building) and in type of functioning (there is no School Principal; this position/the school administration is shared/divided between the Primary school coordinator and the Secondary school coordinator).

The teachers taking part in the project form a homogeneous group. They are both kindergarten and primary teachers at the same school, and most of them are female and full-time class teachers. The greatest differences are found in their years of experience. The following table summarizes the profile of participants.

Teaching level	Kindergarten (3-6 years)	9
	Primary: initial cycle (6-8 years)	6
	Primary: intermediate cycle (8-10 years)	6
	Primary: High cycle (10-12 years)	4
Years as part of school's teaching staff	< 3 years	3
	3 – 10 years	3
	> 10 years	19
Years of teaching experience	< 5 years	4
	> 5 years	21
Gender	Male	3
	Female	22
Post	Class teacher	18
	Support teacher	7

Table 2.11 Amilcar teachers' profile

In general, kindergarten and primary school teachers have specific science content knowledge. Initial training for primary and pre-primary teachers has an important pedagogical content but lacks specific subject content and didactics knowledge associated (see baseline document). Continuous training programs are not usually focused on the scientific content and how to use it in the classroom but more on technical procedures (as the use of new technologies, etc.) or on theoretical concepts that don't relate with their everyday activity.

In Amilcar School, kindergarten and primary teachers have a low sense of community and there is very little collaborative work between teachers from different grades or even from the same grade. Some processes like the design of the classes, research of materials or reflection on the implementation are done individually. This can be due to structural and organizational issues, as well as to a lack of practice. The complex and bad-distributed building structure, as well as the lack of a common space, such as a teachers' room, makes it very difficult for teachers to meet with their colleagues. In addition, no specific time for working together is given to teachers, and their timetable is not designed taking this issue into account.

Amilcar School is self-considered an innovative semi-private school that offers innovative educational initiatives within the School. English and computer basic skills are taught since kindergarten, Science is taught in English in secondary school and the school is well known for achieving a 100% of students reading at 6 years old. The School actively participates in various external programmes as *Green Schools* (regional government initiative that promotes schools that try to innovate in sustainable projects that involve the educational community) or *The Fonix* (English language inter-school contest). However, the necessary participation in all these high demanding projects becomes an external pressure for most of the teachers.

In addition to that, the internal functioning of the School is quite traditional and hierarchical, and decisions are taken only by the School Administration and then communicated to teachers as something to be done. This non-democratic decision-making process produces a negative sense of imposition between teachers. They feel obligated to do things they sometimes don't agree with, as for example, the change of the grade in which they teach.

In general, and as a consequence of what it has been said, teachers have a general feeling of being controlled and continuously evaluated by the School administration, by the local community and even by the parents of their students. These external and internal pressures have generated and established some dynamics within the School. As an example, the use of the textbook has always been an obligation for teachers, and before the intervention program, most teachers didn't even consider not doing a part of the textbook. The training courses are not decided by teachers either and any kind of training is seen as another obligation to meet along with the others.

All these specific characteristics of the School and the dynamics generated within the teachers' community should be considered as local potentials and constraints when implementing the innovative teacher education initiative here proposed.

Profile of the teacher educator

The main teacher educator of the intervention is a researcher on the teaching of science, and holds a Bachelors Degree in Physics (1999) and a PhD in Experimental Science Education from the *Universitat Autònoma de Barcelona* (UAB). University teacher in the Department of Mathematics and Experimental Sciences in the Faculty of the UAB since 2010, she teaches science education to undergraduate and graduate students. She is also a researcher in the CRECIM (Research Center on Scientific and Mathematics Education) and she is in the executive board since 2005. In this sense, she has an extensive work experience and contact with both teachers in training and practicing teachers who serve as tutors.

She also collaborates regularly with the training programs of her Autonomous Community (from the Education Department) via Institutes of Education Sciences (ICEs) of Catalonia. In addition, the main researcher D.Couso has an extensive experience in the creation of Professional Learning Communities and long term teachers team work in primary, secondary and university levels (over 7 years for the group of teachers Scienctia Omnibus, for example)

As a researcher, she has won several national and international competitive fellowships (FPI, *Batista i Roca* Fellowship, *Marie Curie* training site) and she has worked on several international projects (STTIS, EUDIST, CROSSNET, GIMMS, Materials Science) related to Teachers Professional Development and Research-Based Design of Science teaching units, which are her main areas of research. She has done pre-doctoral stays at King's College of London (with Prof. Paul Black) and at CSSME University of Leeds (with Prof. John Leach and Hillary Asoko). Currently responsible for the coordination of the Master of training of secondary school teachers of physics and chemistry of the Network Secretary REMIC and she is the main investigator of the national project on the scientific Competence of science teachers-COMPEC.
Her intense and complete career as a science education researcher, especially in areas of Teacher Professional Development and Research-based design, her experience as a teacher educator of prospective and on-going teachers at all levels, as well as her collaboration in a number of projects in topics such as Professional Learning Communities or Scientific Competence of teachers mean that she

can rightly be considered an expert science educator in relation to this professional development initiative, and she is both teacher educator and researcher within the TRACES team in Spain.
In collaboration with other researchers and teacher educators from the Department of Teacher Education in Mathematics and the Experimental Sciences of the UAB she designed and implemented the Amilcar School teacher training initiative here proposed.

b. Qualitative description of the intervention

As in most Catalonian Schools, each school year teachers from Amilcar School have to attend a training course within their working hours. It is usually a standard official training which topic/content is chosen by the School Administration and which format is mainly a theoretical transmissive conference where teachers have little to say.

On the contrary, the analyzed teacher education initiative sought to involve teachers in a higher degree. This initiative was related to an initial training sessions with all the teachers (from kindergarten to primary) held during the 2010-2011 academic year, the aim of which was to reflect upon the competency curriculum. It was the first opportunity for the teaching staff to work together on science education and have a first approach to the scientific competency of the curriculum. Due to the success of this first training programme, the management board asked for a deeper training programme aiming to improve the professional development of teachers and helping them to incorporate the scientific competency in an everyday basis.

This programme, that was mandatory for all teachers from kindergarten to primary school levels, was designed and developed within the TRACES project framework by a teacher educator/researcher team from the *Universitat Autònoma de Barcelona* and was focused on the design, implementation and reflection of science lessons.

During the programme, teachers were asked to design the science lessons under the supervision of the educators' team, to implement these designs in their own classrooms and to do a common reflection on the implementation done. These tasks required a high implication of all the participants: the project and the management board asked each teacher to attend to an initial and final meeting and to four training sessions, this time by groups of cycle level (two hours long). They were asked to design and implement at least two lesson units, using the training sessions for both the design of the units and the reflection about their implementation. Additionally, teachers worked in group (by cycle) by themselves to develop and adapt their own proposals, what supposed a total dedication of 30 hours per school year. This is the usual time devoted to the training courses that the management board sets as obligatory for all teachers each School year.

The initial and final meetings were designed to be done with all the teachers' board together. At the initial meeting, and introduction of the intervention was done by presenting the time schedule and the rationale behind the intervention, that is, the scientific competence approach held by the educator/researcher team. In this meeting, teachers' ideas about this scientific competence and their expectations regarding the training programme were collected (see Appendix 7) On the other hand, at the final meeting teachers will be asked[39] to share their work with the rest of the teachers' board, and make a common reflection and evaluation of the intervention done and of their own work.

[39] At the moment of writing this document, the final meeting was still pending to be carried out.

Even though the training programme was addressed to all the teaching staff from kindergarten to upper-primary levels, training sessions were made by cycle level in order to work more in depth with each teacher. During these sessions, teachers and teachers' educator team worked on some ideas about the design of the lesson units and the scientific content related, and some planification tools – as a table for design (see Appendix 6) or the learning cycle approach– were offered by the teachers' educator team for the design of their lesson units.

After these first sessions, teachers were asked to use these tools for the design of their lesson units and send their drafts to the teachers' educator team via e-mail, for revision and feedback. Once the design was ready and implemented in their classes, sessions were addressed to promote common reflection about the implementations of the designs and further improvements for next designs were also done.

Problema a resoldre:	**Preguntes:**	**Continguts:**
Hi ha química a les nostres vides?	- En aquest moment quina reacció química veus al teu voltant? - Les pots veure? - Es fan soles o algú les està provocant? - És perillosa una reacció química? - S'han de portar a terme en llocs específics? - Només les porten a terme persones especialitzades? - Creus que la química forma part només de la vida moderna? - Creus que al segle XIV o XV portaven a terme ja reaccions químiques? - Segur que has vist alguna vegada com es fa un bistec a la planxa?. Creus que hi ha algun canvi químic en aquest procés? - A l'hora de rentar hi ha una reacció química?	1. Història de la química: l'alquímia. 2. Canvis o reaccions químiques. a) Diferència entre canvi químic i canvi d'estat. b) Matèria i substància. c) Propietats de la matèria. d) Producte i subproducte. 3. Mètodes a aplicar. 4. La taula periòdica. 5. Influència de la química a les nostres vides.

Figure 2.14: Example of table for the design. 2nd design: Physical vs. chemical change. High cycle teachers

RECORREGUT DEL SOL DURANT EL DIA

(Pas del dia, de les hores, on arriba, on comença a tocar el sol?)

1ª SESSIÓ

PREGUNTES IMPORTANTS:

- D'on ve el llum quan és de dia?
- Com és que a la nit no hi veiem si no encenem el llum?
- Tenim sempre sol al pati? Hi ha estonetes que no el veiem?
- Com veiem que el sol ha arribat al pati?
- Deixa algún dibuix al terra el sol quan es reflexa en el pati?
- Quan és l'hivern i fa fred es fa de nit abans?
- Quan és de nit tenim llum al carrer?
- Sabem per on surt el sol?
- I després, que fa, es va movent?

Activitat:
Fer un dibuix del recorregut del sol, quín camí fa el sol

2º SESSIÓ
Visualitzar imatges o un video del recorregut del sol
Imatges o videos del moviment dels gira-sols.

3ª SESSIÓ
Explicació d'un conte sobre el recorregut del sol

4ªSESSIÓ
Fer una observació directa del moviment del sol en diferents moments del dia.
Es presentarà als nens un dibuix o imatge del lloc del pati que hem triat per a fer l'observació i ells mateixos aniràn marcant el lloc on veuen el sol, en el diferents moments de l'observació.

Figure 2.15: Example of design. Design 2: Astronomy, kindergarten teachers

Regarding the implementation of teachers' designs with their own students, teachers' educators help was offered as optional. Additionally, video recording of the implementations was also proposed in order to help to analyze and reflect the designs. Only a few teachers accepted to be video recorded or have the presence of a teacher educator within their classes.

Figure 2.16: Implantation of second design (states of matter). Initial Cycle

In the course of the program, teachers were also asked to complete two types of online diaries: training session diary and implementation session diary, with the aim of giving them a useful tool for reflection about their own practice and training, and also to know their opinions and ideas raising from the training sessions and their implementations of the designs in the class (see figure 2.17 and Appendix 8 and 9)

1	Etapa	Data de la Sessió	1. Què hem fet avui que em pot servir per a millorar la meva pràctica docent? Per què?	2.□Què crec que faltaria fer?
7	C. Inicial	20 - 10 - 2011	Ens va anar bé que ens donéssiu unes quantes idees per així nosaltres després poder elaborar un parell de preguntes productives. També ens heu guiat per poder trobar la manera d'enfocar un sol contingut dins d'un tema molt ampli i de manera diferent.	Trobar la manera de saber evaluar qualsevol contingut, tot i que en aquest cas no ho consideràvem necessari.
8	Infantil	21-10-11	Preguntem als nens si saben el que és una castanya. On estan les castanyes abans d'arribar a la botiga? Si van al bosc que ens portin castanyes Que vigilin quan agafin les castanyes perque...ja veuran... Mitjançant la incògnita intentem motivar aquesta recerca i crear així una ambient de curiositat	Aniria bé poder fer una sortida per observar en directa el lloc on neixen les castanyes i viure amb ells aquest descobriment
9	Infantil	24-10-11	Alguns nens que han anat a la muntanya i nosaltres hem portat castanyes. Presentació de la castanya al grup classe Posem les castanyes en una safata (Totes amb tots els seus abrics) i anem passant taula per taula per a fer la observació directa. Volem que els nens-es puguin manipular amb ells i observar la seva textura . Els nens experimenten que punxen Alguns no les volen tocar	Seguir esbrinant a la propera sessió
10	C. Mitjà	25 octubre	Concretar quins aspectes de la matèria treballarem a classe per desenvolupar-lo amb l'ajut de la formació. Aclalrir dubtes referents als nivells d'estiudi que s'adapten dels nostres alumnes. Parlar dels fenomens que procurarem introduir a l'aula per tal que els alumnes en treguina algunes conclusions. Acotar els aspectes sobre la matèria que pretenem implementar.	Buscar eperiències que puguin dur-se a terme a l'aula. Concretar les preguntes i preveure les posssibles respostes que n'obtindrem. Pensar diferents tècniques per recollir les observacions per tal que cada nen ho assimili de la millor manera possible.

	Etapa	Tema	Període d'implementació	Sessió	1. Com ha anat la sessió d'avui? (Què destacaries i per què? Què ha estat fàcil d'implementar ?...)	2.□Quines de les coses que havies dissenyat s'han pogut portar a l'aula fàcilment? Per què?	I quines de les coses que havies dissenyat no s'han pogut fer? Per què?
2	C. Inicial	Els animals i la relació amb l'entorn	3 Nov-1 Des	3	Molt bé, millor del que esperàvem. Destaquem que els alumnes han pogut arribar fàcilment a la conclusió que nosaltres ens haviem plantejat com a objectiu: Com es relacionen els animals amb l'entorn?	La introducció al tema per mitja de vídeos del youtube perquè els alumnes han tingut una visió més propera a la realitat. Aquest punt de partida ha facilitat que els nens i nenes poguessin arribar a donar resposta a les preguntes proposades posteriorment.	Per sort cap
3	C. Inicial	Caixes: 1ª sessió	3 Nov-1 Des	1	Avui 3/11/11 hem fet la primera sessió d'implementació: Les caixes per centrar el tema. La sessió ha anat molt bé. Han sortit paraules de vocabulari que no esperava. A més, a la seva manera, ho han sapigut explicar força bé.	Les preguntes productives...han facilitat, el seu enunciat, el poder aterraar i començar el tema amb un enfoc experimental.	Ninguna
4	C. Inicial	Els Sentits	3 Nov-1 Des	1	He fet dues sessions, una a 1rA i l'altra a 1rB. Ha consistit en treballar el "toca- toca". Les dues sessions han estat fantàstiques. Els nens s'han divertit molt i han après. M'ha sorprès com intentaven endivinar allò que tocaven, sentien, oloraven,..., buscant recursos bastant encertats, com va ser en el cas de la bossa d'infusió. Ha resultat fàcil d'implementar. A la tarde, amb grup petit, hem fet un resum d'allò que sabien dels sentits, amb visualització de làmines i em realitzat la còpia. Ha estat molt positiu.	En el "toca -toca", jo només he ajudat. En la meva sessió de la tarda he pogut aplicar allò que havia preparat que eren unes làmines sobre els sentits. Els nens les van entendre fàcilment, s'ho van passar bé i van arribar a consolidar els coneixements dels cinc sentits (tenia un grup d'onze nens-es i podia treballar de forma molt individualitzada). En falten fer dues implementacions a l'hora de la lectura, amb petit grup,ja t'enviaré el comentari.	He pogut fer allò que havia dissenyat.
5	C. Inicial	Activitat Esmorzem	3 Nov-1 Des	1	La realització ha estat fàcil....d'un fet hbitual com és esmorzar hem fet un joc.	Tot...el fet de fer-hi lusicament no ha suposat cap dificultat. Potser, ressenyar que el fet de tancar ulls els posa inquiets....alguns els han obert...potser caldria haver demanat algo per tapar ulls...	Cap
6	C. Inicial	Activitat TOCA TOCA	3 Nov-1 Des	1	Ha anat bé per l'ajuda de la professora de reforç. Aquesta activitat s'ha de realitzar amb dos mestres a l'aula. PEr poder recollir dades i per poder portar-la a terme sense que es faci eterna pels alumnes i perdin la motivació.	En principi tot. S'ha engrescat i això ha fet que repetexien respostes perque volen participar i diguin coses a la babalà....No han estat tot. Han estat els alumnes que tene més dificultats els que per participar han optat per aquest opció.	RES
7	C. Inicial	Activitat Copia	3 Nov-1 Des	1	Destacar res....ha estat una activitat més reproductiva.	Tot	Res

Figure 2.17: Page of the teachers' training and implementation diaries online

A common reflection about their own implementations and possible improvements for next designs was also done within the training sessions. The teachers' educator team has adapted to each teacher (or group of teachers) tempo when designing and implementing. For example, with some teachers, "training session 2", was devoted to do the design 1, while with others (the ones who had finished their design and had already started implementing the unit) "training session 2" was used to have a common reflection of the implementation 1 (**see Figure 2.18).**

Figure 2.18 summarizes the whole intervention process followed by each of the cycle level teachers in Amilcar School. In some cases, the design process needed to be developed during more than one training session what supposed an adaptation of the intervention planning depending on each cycle level.

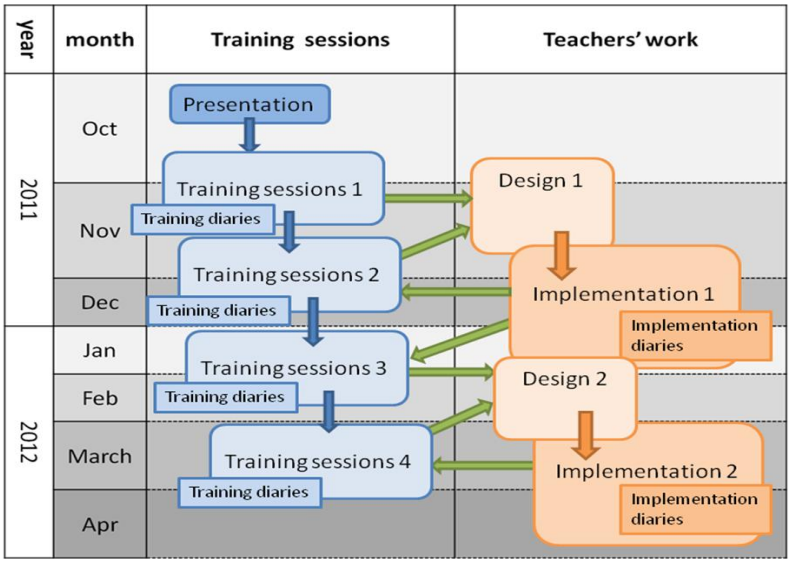


Figure2.18: Intervention process in Amilcar School

It has to be highlighted that the teachers' educator team has been constantly adapting the initial design of the training model to the real context of the School and the teachers, taking into account the external and internal constraints, and responding to the real possibilities of the teachers in each moment.

Theoretical basis of the teacher training intervention

Beyond the characteristics of the school and the participants, the design of the programme was, of course, influenced by the expected outcomes and the science education approach held by the educator/research team and also by what is considered as an effective professional development program. On the one hand, teachers' and school's sustainable development to guarantee this kind of science education was seek by the designed training program. On the other hand, what supposes a scientific competence teaching and learning and the necessary teaching strategies to promote it were behind the educator/research team proposals

According to the general framework that supports all case studies presented in this report, the training program analyzed in this case study is framed in the new paradigm of teachers professional development, a paradigm that, far from the traditional training programmes, tries to be an ongoing process and takes into account teachers active participation being closer to their actual practice, highly related to innovation and focused on self reflection. Specifically, the designed initiative seeks to promote a new school and professional culture by developing a *professional learning community* (PLC). For these reasons, the training program was designed bearing in mind the importance of a focus on the subject, participation in authentic cooperation, and an inquiry/reflective stance from teachers sharing the common goal of fostering students', but also their own, learning. Training sessions were planned to be done by teachers collaborating by cycle and supported by the research team, who was responsible of guiding the reflection by bringing innovation to teachers' proposals.

Within the proposed teacher training intervention, the main idea that underlined and guided all the work with teachers – when designing, implementing and reflecting on the science lesson units – was the scientific competence teaching and learning. In the framework of the 2006 PISA assessment focused on the scientific competence, three dimensions or processes are defined as necessary for its development (OECD, 2007, p 13): identify scientific problems, explain phenomena scientifically and use of scientific evidence.

According to some authors (Sanmartí, 2008, ENCIENDE, 2011) scientific competence-based teaching implies not only to teach particular contents but to promote the students capacity to use and apply these contents in new contextualized situations, in order to solve real problems. Therefore, during the intervention process, teachers were asked to design and implement science lessons guided by this scientific competence approach, trying to foster the use of everyday problematic situations as starting and ending point. Fostering the already mentioned competence-based teaching was the aim pursued by teachers' educator team, bearing in mind the dimensions of the scientific competence. In the training sessions, the teachers' educator team emphasised the use of *good questions* when designing, especially at the beginning of a lesson unit, as a useful way of teaching students how to *identify scientific problems*. On the other hand, it is necessary for teachers to know and understand the important scientific models or critical teaching content, which include and underline all science topics/ideas in the curriculum, in order to make students competent in *explaining phenomena scientifically*. Finally, teachers' designs were asked to incorporate a way of working based on inquiry and argumentation, as complex processes that allow students to become competent in *using scientific evidence*.

Trying to implement this approach in the science education classroom of Amilcar School would mean an important change on what teachers were doing. According to the teachers' educator team, first thing to be developed with teachers is the necessity of planning the lesson units to be implemented. An effective tool to help teachers to plan their lessons according to the scientific competence-based teaching would be what is known as *learning sequence*, based on a *learning cycle* (Jorba & Sanmartí, 1994), with 4 different phases or steps.

The different phases of the learning cycle as well as different activities associated have been addressed with teachers when designing their lesson units, both in the training sessions and in the revision of their designs via e-mail. These activities include critical sequencing of contents from those more close to the students' ideas to those more difficult to be constructed, taking then advantage from students' standpoint in order to organize content progression, conceptualizing and abstracting the main ideas of the lesson unit (scientific models) and finally, definition of a coherent evaluation (one that addresses the important ideas and it is coherent with the learning process done in the classroom) (ENCIENDE, 2011). A change on the type of evaluation carried out by teachers has been considered a central task to be promoted during the intervention, seeking to achieve a real change on teachers practice (Jorba & Sanmartí, 1992).

In order to achieve high levels of scientific competence within students, there has been a training effort to help teachers not to master the scientific knowledge but the didactical knowledge (in the sense of didactical transposition) necessary for the students to show scientific competence. With this aim, teachers' educator team have promoted the reflection on the important ideas of science or *scientific models* (Schwarz & Gwekwerere, 2007) that should be mastered regarding every scientific topic, and the reduction and critical selection, from of all the contents present in the textbook, to those necessary for students to build these central ideas. For pre-primary and primary school education those models that should be developed with the students would be: living being, matter, Earth and physic systems. Working around these models, each of the contents included in the science competence curriculum could be met. That is the reason why teachers participating in the training programme were asked for designing their activities having in mind the scientific central model they wanted to work on. Table 2.12 summarizes the lessons designed by teachers indicating the models that are worked behind each content.

Cycle	Grade	years	1st Design	2nd design
High	6th	11-12	Ecosystems (Earth and living being)	Physical vs chemical change (matter and physics systems)
	5th	10-11		
Intermediate	Sp (PE)*		Games about states of matter (matter)	Games about Physical or chemical changes (matter and physics systems)
	Sp (read)*		------	Story with chemical changes (matter)
	4th	9-10	Physical vs chemical change (matter and physics systems)	The flight of the birds -relation function- (living being)
	3rd	8-9	States of matter (matter)	Water cycle (Earth and matter)
Initial	Sp (read)*		Support in the classroom	Support in the classroom
	Sp (Engl)*		Vocab 5 senses and part of activity	-----
	2nd	7-8	------	Water cycle (Earth and matter)
	1st	6-7	The 5 senses -relation function- (living being)	
Kinder	Sp (Engl)*		Vocab Living being	Astronomy: lights and shadows, day and night, sun, moon and stars, gravity force (Earth and physic
	Sp (read)*		------	
	Sp (Relig)*		Values, respect to life beings	
	P5	5-6	Chestnuts (living being)	

	P4	4-5	Chestnuts (living being)	systems)
	P3	3-4	turtles, snails (living being)	

**Sp = Specialist. PE=Physical Education. Read=Reading. Engl=English. Relig=Religion.*

Table 2.12: Science topics worked in each grade or cycle and in each design (1 and 2). In brackets: scientific model for each design topic

Teachers' understanding of these basic science models is also necessary to make them able to design coherent and continuous lessons throughout the primary school that use the same models over and over but with a greater level of complexity in the content. This is what we call positioning in a continuum, or spiral curriculum (Sanmartí, 2002, p.185)

The teachers' educator team tried to emphasize this idea along the training sessions, encouraging teachers to work, if necessary, on the same topic as their colleagues of other grades, and explaining them that they are not repeating the lesson, but reinforcing the same basic scientific model with another level of complexity.

Having this modelling process in mind and considering the learning sequence mentioned before that starts with a concrete situation to go to an abstract one, an inquiry based science education (IBSE) approach, stated by the research community as a central strategy for science education (Barrow, 2006) is considered appropriate to allow students to construct the models. For this reason, the educator team asked to the teachers to bear in mind this inquiry process in their designs, starting by what is called a *good question* (that question that engage students and gives them the keys to investigate), using practical work as a way of taking the phenomena to the classroom and constructing a model that can give answer to this question but also to more general and abstract questions.

2.4.2. Case study report

a. Central problem of the Case Study

i. Presentation of the problem

The current Spanish curriculum is competence based and follows the guidelines of the PISA project, which offers a functional model of how science is taught and learned. If this scientific competence has to be achieved by students and reach the expected levels, teachers' quality must be assured since it has been identified as the most important influences on student learning (OECD 2005).

The challenge that this new science curriculum framework together with the lack of knowledge on both didactical/pedagogical and subject matter content, point out to the need for an updating of teachers' professionalism. Continuous training programs must be then addressed to support teachers in this process.

Nevertheless, traditional training programs have resulted to be not effective enough (Black and Atkin 1996; Darling-Hammond 1997; Furió et al. 2001; Jimenez-Aleixandre and Sanmartí 1995; Pintó 2005) what makes necessary to propose innovative professional development programs that overcome the mentioned inefficiency.

In this context, this case study aims to analyze an example of an innovative professional development program designed within the TRACES project and characterized by the improvement of teachers' scientific competence in order to change their science teaching practices.

ii. Theoretical framework

This case study, together with the other two case studies already presented, aims to analyze a high potential initiative in promoting teachers professional development. For that reason, the general theoretical framework on professional development already introduced is the umbrella that supports the analysis of the three case studies.

However, this case study has its particular framework, based on scientific competence-based teaching that has to be also considered when analyzing teachers' professional development: a) Learning sequence; b) Models and position in a continuum; c) Model-based inquiry science education.

Science competence and learning sequences

As mentioned earlier in the justification of the Case Studies, current Spanish curriculum is based on competences, guided by the framework for basic competences of the DeSeCo project (OECD, 2007). Within the core competencies mentioned by the OECD, scientific competence is defined as the ability to use scientific knowledge to identify questions and draw conclusions from evidence, in order to understand (explain) and help make decisions (act) about the natural world and the changes that human activity produces. Thus it is necessary to have knowledge, not with the aim of repeating it, but of knowing how to use it in order to act (Sanmartí, 2008).

Scientific competence-based teaching implies not only to teach particular contents but to promote the students capacity to use and apply these contents in new situations, in order to solve real problems. This interest on bringing the real world into the classroom would need an attempt to contextualize these problems in students' familiar environment in order to connect with students' interests and promote decision making in the real world (ENCIENDE, 2011).

Initially based on Piagetian ideas, the learning cycle (Karplus, 1977), modified by Jorba and Sanmartí (1994), offers an appropriate framework to organize the scientific knowledge acquisition in schools. We consider it as a useful referent for teachers when building their own lesson designs.

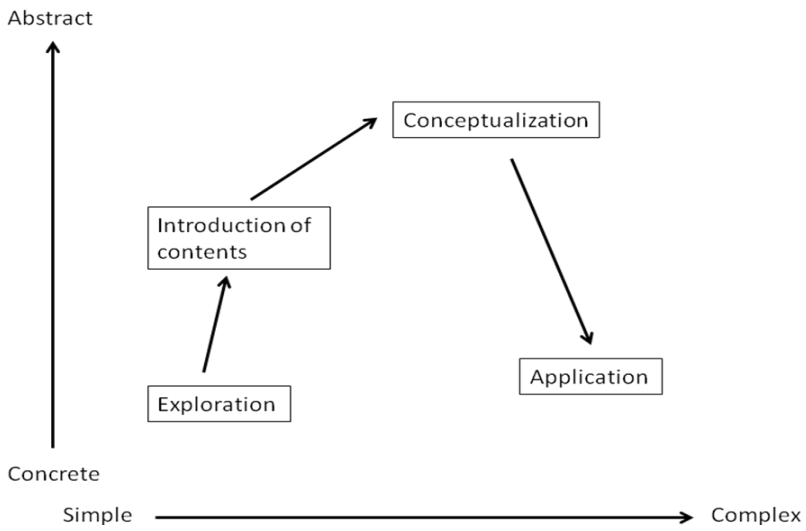


Figure 2.19 Phases of the learning cycle

The learning cycle proposes 4 main stages/phases in the teaching-learning process (see Figure 2.19), that go from a simpler to more complex situations/contexts, but from concrete situations to more abstract ones and back to concrete situations. In an initial phase, exploration of the previous ideas of students should be done, using *good questions* that problematise a common and simple situation of the real life. Using and questioning these first ideas that emerged from the exploration phase, scientific concepts and processes should be introduced to students while helping them to link the new knowledge with their previous points of view in order to construct the scientific contents of the unit. In the next stage, there is a Conceptualization (sometimes called synthesis), i.e. abstracting the main ideas from the scientific content already worked in order to build up the basic models in science. A final stage is needed in order to make students competent in applying the knowledge acquired in a new real situation. For that reason, activities at the end of a learning cycle should require the use of contents already worked along the learning sequence in a new contextualized and complex situation.

Traditional assessment (based on memorization of definitions and mostly descriptive questions) doesn't have a lot of sense in the framework of scientific competences. An evaluation based on competencies promotes inferential, creative and evaluative questions that mobilize knowledge to be applied in contextualized situations and to solve real problems. It is increasingly considered by the science education research community that if you want to change educational practice it is necessary to change the assessment, i.e. its purpose and why and how something is evaluated. Innovation in designing lesson plans and innovation in assessment are inseparable activities that condition each other (Jorba & Sanmartí, 1992).

Scientific Models

Trying to help students to be competent in science, it is needed to reduce scientific contents (that can't be worked deeply enough with the available time which leads to a very superficial work in the classroom) to those core contents that are essential and that are an umbrella covering all scientific contents on the curriculum (ENCIENDE, 2011). We are talking about what science education research calls *scientific models.* When talking about models we refer to those representations constructed as conventions within a community to support disciplinary activity (Windschitl, et al. 2008), that is, those representations that embody portions of a scientific theory and include any set of rules, representations, or reasoning structures that allow someone to generate predictions and explanations (Schwarz & Gwekwerere, 2007).

Model-based inquiry as an approach for scientific competence teaching and learning

An interesting approach that could integrate the theory presented until now is the inquiry based science education (IBSE) approach, which is stated by the research community as a central strategy for science education (Barrow, 2006). Based on the National Science Education Standards of the NRC five essential characteristics are highlighted: 1) scientifically oriented questions that will engage the students; 2) evidence collected by students that allows them to develop and evaluate their explanations to the questions; 3) explanations developed by students from their evidence to address the questions; 4) evaluation of their explanations, which can include alternative explanations that reflect scientific understanding; and 5) communication and justification of their proposed explanations.

Trying to incorporate the modeling process mentioned before and considering the learning sequence that starts with a concrete situation to go to an abstract one, a specific approach of IBSE would be

required. We are referring to a more conceptual component of IBSE (Viennot, 2011), a model-based inquiry approach (Windschitl, et al. 2008; Schwarz & Gwekwerere, 2007) that leads students to look for the answer to the question by constructing a model that can give answer to this question but also to more general and abstract questions. To do so, the inquiry process is made by the connections between the phenomena, usually an experiment or practical experience done in the science classroom, and the scientific theories represented by the model that is pursued. This connection resonates and enriches with has been for years claimed for practical work in science classroom: a process to help students to connect the domain of objects and observables with the domain of ideas (Tiberghien, 2000; Millar, 2009).

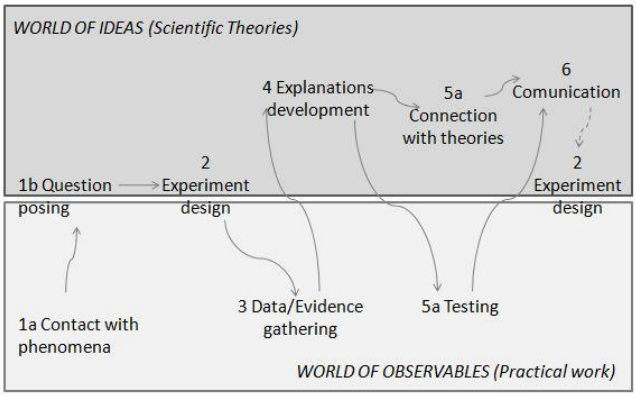


Figure 2.20 Model-based inquiry cycle, using practical work.

b. Research questions in this case study

The aim of this research is to study the effect of an intervention and of teachers' knowledge on their professional development and, as a consequence, on their classroom practice. This aim coincides with the objective of the TRACES project, which seeks to analyse research-based activities in order to determine the extent to which they may have a transformative influence in the classroom. In this particular case study, which analyses the teacher education interventon being carried out in the Amilcar School in Barcelona, the primary research question is as follows:

> *To what extent this professional development initiative based on design, implementation and reflection of Science lessons fosters teachers' professional development taking into account the theoretical frameworks of professional development and professional learning communities?*

In addition to this general question we also pose a more specific research questions about the teacher education program and the professional development of the teachers, namely:

1.4. ***What aspects of the professional development*** *of Amilcar primary school teachers have evolved and how during a teacher education intervention based on design, implementation and reflection of Science lessons?*

1.5. ***Which aspects of the teacher education model*** *-based on design, implementation and reflection of Science lessons - have more incidence on the professional development of the participant teachers?*

In order to address these specific research questions the present case study will analyse which aspects of professional development of teachers have evolved and how, and to which extent the teacher

education intervention proposed has had an incidence in this evolution and in the formation of learning communities according to the criteria set out above when describing the theoretical framework.

2.4.3. Research methodology

This case study concerns a group of teachers from the same school in which a school year teacher education initiative based on design, implementation and reflection of Science lessons was begun in the 2011-12 academic year. The interpretative qualitative approach taken by the study is consistent with the purpose and design of the initiative, and enables us to characterize the professional development of the teachers across different points of the intervention.

a. Data gathering strategy

The data collection instruments are built into the training programme and were developed in accordance with its objectives. In order to respond to the proposed research questions and to increase the reliability of the data a number of different instruments were used, thereby enabling us to triangulate the information sources and check their convergence. All the instruments were designed in conjunction with the teacher educator and were validated by the group of researchers from the TRACES project in Spain (see Table 2.10).

Presentation
At the beginning of the school year 2011-2012, an initial presentation of the intervention was made to all the School teachers together. An initial questionnaire was administered with the aim of providing a baseline (data called “initial questionnaire”. See Appendix 7). This session was also recorded in audio for later data analysis (data called “Audio recording 0”).

Training sessions 1
A total of 4 training session were done, one with each cycle (kindergarten, initial, intermediate and high) during the months of October and November 2011. In these training sessions, ideas for a first design of a unit lesson were raised and discussed. Each training session was audio recorded (data called “Audio recordings training session 1”). After the first training session, teachers completed the training diary online, with the aim of gathering their impressions about the training session (their opinion on what was helpful and what was missing in the training session) (data called “Training session Diary”. See Appendix 8).

Designs 1
After the first training session, teachers started working on their first design of a unit lesson on different scientific contents (see table 2.13). Via e-mail, teachers shared their designs (data called “designs 1”) with the teachers’ educator team. The teachers’ educator team revised them and gave feedback of the design 1 document (data called “revision of the designs 1”). This process included from 1 to 3 versions of the design 1. The comments associated in the e-mails were also gathered as supplementary data to the designs and its revisions (data called “e-mails associated 1”).

Implementation 1
As long as teachers finished their designs, they started implementing the unit lessons in the classroom, each teacher in a different moment through the following months (November-December-January). Teachers completed the implementation diary online, with the aim of gathering their impressions about the sessions in which they implemented their designs 1 (a general description of the session, easy and

difficult things when implementing the session and positive and negative evaluation of the session) (data called "Implementation session Diary". See Appendix 9). A video recording of the implementation sessions was optional for the teachers and only two of them accepted to be video recorded when implementing their first designs in the classroom (data called "video recording 1").

Training sessions 2

Meanwhile, between November and December 2011, a second training session was done with each cycle, in which different things were done depending on the teachers' progress in the design and implementation of the lessons. In some cases (teachers who hadn't finished their designs), the session was focused on finishing the design 1, while in other cases (teachers who had finished their designs and had implemented them), the training session was focused on reflecting about the first implementation classes. Training session 2 was audio recorded (data called "Audio recordings training session 2") and teachers filled up the same online training diary as in training 1 (data called "Training session Diary"). After the second training session, teachers kept working on their first design or their first implementation (depending on the teacher). New versions of the design 1 were sent to the teachers' educator team (data called "designs 1"), with their respective feedback (data called "revision of the designs 1") and e-mails associated (data called "e-mails associated 1"). Teachers kept completing the implementation session diary as soon as they had implemented their first design in their classes (data called "Implementation session Diary").

Training sessions 3

During the months of January and February 2012, one more training session was done in each cycle. In these sessions, some teachers reflected on their first implementation and others started working on their second design. These training sessions were again audio recorded (data called "Audio recordings training session 3") and teachers filled up the same online training diary as in training 1 and 2 (data called "Training session Diary").

Implementation 1 and Design 2

After the third training session, teachers finished their first implementation sessions and started working on their second design (depending on the teacher). Teachers kept completing the implementation session diary as soon as they had implemented their first design in their classes. Some versions of the design 2 were sent to the teachers' educator team (data called "designs 2"), with their respective feedback (data called "revision of the designs 2") and e-mails associated (data called "e-mails associated 2").

Training session 4

A last training session was done with each level between March and April 2012. In these sessions, some teachers kept working on their design 2 while others reflected on their implementation 2. These training sessions were audio recorded (data called "Audio recordings training session 4") and teachers filled up the same online training diary as in the other training sessions (data called "Training session Diary").

Design 2 and implementation 2

During the lasts months of the School year, teachers finished their second designs (data called "designs 2", "revision of the designs 2" and "e-mails associated 2") and started their second implementation sessions. Again, video recording was optional for teachers. Only one session of the 2nd implementation was video recorded. In this case, the implementation was a model class session, in which a teacher educator made the intervention (with the help of the two class teachers) (Data called "video recording 2") and a later common reflection of the intervention was done with the two class teachers and the

teacher educator (Data called “audio recording Implementation 2”). As with the first implementation, teachers completed the implementation session diary as soon as they had implemented their second design in their classes (data called “Implementation session Diary”).

Dates	Intervention	Description of intervention	Data collection	Codification
06/10/2011	**PRESENTATION**	Global presentation of the training and objectives for the School year (all teachers together)	Initial questionnaire Audio recording 0	1-pre_amc.docx A-0_amc.MP3
13/10/2011 to 14/11/2011	**Training sessions 1**	By cycle, teachers and educators discuss about design 1.	4 Audio recordings Session 1	A-F1_*cycle*_amc.MP3
		Teachers reflect on the training session 1 completing the training session diary online	Training session Diary	2-DF_amc.xls
10/2011 to 11/2011	**Design 1**	Teachers design their 1st sequence and educators give feedback about the design	Designs 1 Revision of the designs 1 E-mails associated 1	4-Ds1_*cycle*_*grade*_amc.docx 5-RDs1_*cycle*_*grade*_amc.docx Correu_RDs1_*cycle*_*grade*_amc.doc
15/11/2011 to 01/12/2011	**Training sessions 2**	By cycle, teachers and educators discuss about **design 1** or **implementation 1** (depending on the teachers)	4 Audio recordings Session 2	A-F2_*cycle*_amc.MP3
		Teachers reflect on the training session 2 completing the training session diary online	Training session Diary	2-DF_amc.xls
11/2011 to 12/2012	**Implementation 1**	Teachers implement their design 1 in their classroom	2 Video recordings 1	V-F1_*cycle*_*grade*_*name*_amc.wmv
		Teachers reflect on the implementation filling in the implementation diary online	Implementation diaries	3-DI_amc.xls
12/01/2012 to 09/02/2012	**Training sessions 3**	By cycle, teachers and educators discuss about **implementation 1** or **design 2** (depending on the teachers)	4 Audio recordings Session 3	A-F3_*cycle*_amc.MP3
		Teachers reflect on the training session 3 completing the training session diary online	Training session Diary	2-DF_amc.xls
01/2012 to 03/2012	**Design 2**	Teachers design their 2nd sequence and educators give feedback about the design	Designs 2 Revision of the designs 2 E-mails associated 2	4-Ds2_*cycle*_*grade*_amc.docx 5-RDs2_*cycle*_*grade*_amc.docx Correu_RDs2_*cycle*_*grade*_amc.doc
08/03/2012 to 29/03/2012	**Training sessions 4**	By cycle, teachers and educators discuss about the **design 2** or **implementation 2** (depending on the teachers)	4 Audio recordings Session 4	A-F3_*cycle*_amc.MP3
		Teachers reflect on the training session 3 filling in the training session diary online	Training session Diary	2-DF_amc.xls
03/2012 to 05/2012	**Implementation 2**	Teachers implement their design 2 in their classroom	1 Video recording 2 1 audio recording Implem. 2	V-F2_*cycle*_*grade*_*name*_amc.wmv A-I2_*cycle*_*grade*_amc.MP3
		Teachers reflect on the implementation filling in the implementation diary online	Implementation diaries	3-DI_amc.xls

Table 2.13: Intervention process of Case Study 4 (Amilcar School), data collection and codification.

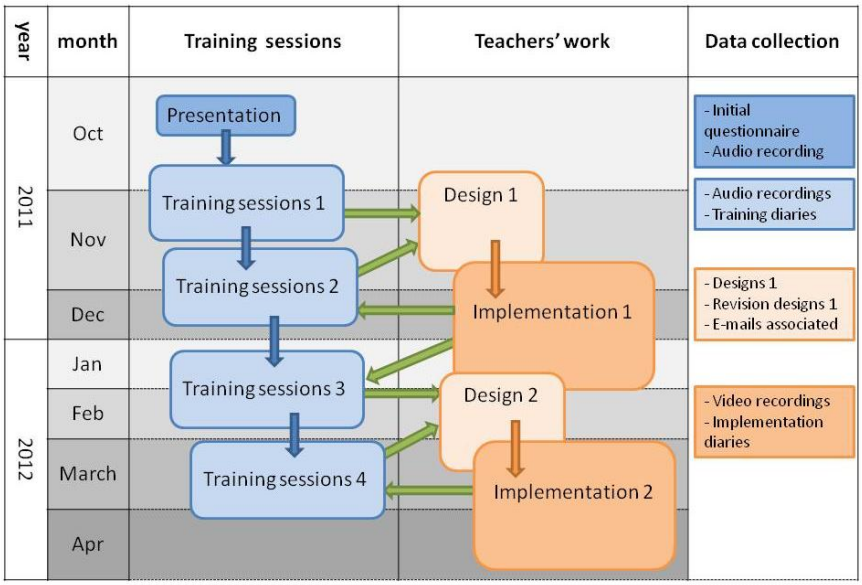


Figure 2.21: Diagram of the intervention process of Case Study 4 with the data collection associated

b. Data analysis strategy

In order to detect evidence of professional development among the teachers who have participated in the training programme based on design, implementation and reflection of Science lessons, and with the aim of identifying which aspects of this training model have an influence on the professional development of these teachers, we defined a series of professional development indicators that were based on the proposed theoretical framework.

The idea is to use these indicators to explore how teachers develop over time as a result of the training programme. The professional development indicators are as follows:

a. Mastering the scientific content

b. Positioning in a continuum

c. Recognition of external contribution (from Science Education Research)

d. Reflection about the practice

e. Building School structure/participation in the community

In order to facilitate the analysis, some subindicators were proposed within each of the indicators. Evidences to assess the degree of achievement of each of these subindicators were sought in the data obtained through the abovementioned instruments.

The procedure for referencing the data was as follows: we include the citation and then added in brackets the code corresponding to the teacher in question (see table 2.32). In the case of audio or video data file, the time of the oral intervention appears in hours (in the case of a long record) minutes and seconds. Then we noted the code corresponding to the instrument used to collect the data in question (see Table 2.14). As in the example: "*I liked that the word 'hypothesis' came out, so that they see that there is a scientific vocabulary*" (T2.4) (17'30'') (A-I1_2on_jni_amc.MP3)

Cycle	Grade	years	Teachers code
High	6th	11-12	T4.5, T4.6
	5th	10-11	T4.1, T4.2
Intermediate	Sp (PE)*		T3.6
	Sp (read)*		T3.5
	4th	9-10	T3.3, T3.4
	3rd	8-9	T3.1, T3.2
Initial	Sp (read)*		T2.6
	Sp (Engl)*		T2.5
	2nd	7-8	T2.3, T2.4
	1st	6-7	T2.1, T2.2
Kinder	Sp (Engl)*		T1.9
	Sp (read)*		T1.8
	Sp (Relig)*		T1.7
	P5	5-6	T1.5, T1.6
	P4	4-5	T1.3, T1.4
	P3	3-4	T1.1, T1.2

**Sp = Specialist. PE=Physical Education. Read=Reading. Engl=English. Relig=Religion.*

Table 2.14: Teachers' codes used in the data analysis.

2.4.4. Results

a. Mastering the scientific content

One of the most important concerns identified within the teachers has been the lack of scientific knowledge that results on an important insecurity when trying to teach some scientific concepts. Teachers recognized openly not to have a clear idea of important scientific contents and their willingness to learn in order to improve their science lessons.

> Teachers from kindergarten commented at the beginning of the school year: *"yes, but this [referring to the content] we don't know it either… I'm afraid" (T1.2) (32'45'') (A-F1_inf_amc)*

> At the initial questionnaire, one of the teachers stated: *"I would like not to have fears and doubts when starting a science lesson"* (1-pre_amc.doc)

Facing this situation, many teachers have been pushed to use in a non critical or reflective way the textbook as the content provider, and also as an easy way to have management control of the class. When teachers were proposed to use a different way of teaching that implies some modifications on the learning sequence or the content to be taught, they found it hard to leave the book apart or not to follow it rigorously.

> Initial cycle teachers commented on the training diary after their first formative session: *"The training session was missing going deeper, but taking into account that some of our classes have 27 or 28 students and that we are tight to the school books" (T2.6) "What we missed [from the training session] is trying to keep the reality of the book with the experimental work" (T2.1)*

However, some cycle teachers have reflected and questioned the scientific contents included in the textbook, showing an understanding of the critical content to be taught (basic models) and the learning cycle rational.

> Intermediate cycle teacher reflected after the 3rd training session: *"We have to foresee a summary at a class-group level in order to facilitate the presence of what they learn [main concepts], because until now we (students and teachers) have been very much used to assume the information from the book as correct, and we have to change the referent." (T3.3) (2-DF_amc.xls)*

In general, there has been a lot of work on understanding and learning the main scientific content (basic models), and a need for discussing scientific ideas more than once.

> Teacher educator told kindergarten teachers regarding their first design (living beings): "*We still need to specify a little more the idea or scientific content to work, because living beings is very wide and in order to do a design we have to specify more… I know this is the most difficult part, as we commented in the training session. To help you, I have included 3 scientific ideas that can be worked in the lesson of living beings*" (teacher educator 1) (Correu_RDs1_inf_P4_amc_v1.docx)
>
> Kindergarten teacher, when doing their first design on the life beings (chestnuts): *"Really when you [in general] start working on the paper you see the difficulty on specifying what you have to do. The other day it seemed that we had it quite clear the little idea we wanted to work, and now it happens to be still very wide" (T1.3) (Correu_RDs1_inf_P4_amc_v1.docx)*
>
> Initial cycle teachers at the end of the second design (The water cycle), they expressed: *"Just now we start sharpening and doing a fair-copy of the activities that we hope we will send them to you soon. It has been more work this time [than the first design of the 5 senses]. May be it's because there is more than one concept to work on [...] We hope you are happy... we put our biggest effort" (T2.1 and T2.2) (Correu_RDs2_ini_amc_v2.doc)*

Although this great initial difficulty, teachers have achieved to understand the important scientific ideas to be taught, especially those related to the lesson units they have designed. Despite teachers have shown different levels of mastery and success in mastering scientific and didactical content, most of them have appreciated the teachers' educator team activities and help, and they have stated that by participating in them they have realized about their need to reflect, become informed and learn about content (didactical more than scientific content) to become a better teacher.

> Kindergarten teachers in the second design (Astronomy) when making up a story for the children: *"We think that little by little we have understood what you want us to think about [the main scientific idea]" (T1.3 and T1.4) (Correu_RDs2_inf_P4_amc_v3.doc)*
>
> Intermediate cycle teachers when reflecting about the design of the "physical vs. chemical change" lesson: *"We have to thank the patience you show [the teachers educators] by repeating the ideas that distinguish and make us get confused about the topic. May be it is because we have it written down and we have read it more than once, or because we are adjusting more and more to the idea that we have to limit the expectative to specific topics... but now we are a little bit closer to the idea" (T3.3 and T3.4) (Correu_Ds1_mit_4rt_amc_v2.doc)*

b. Positioning oneself on a continuum

One of the central things when teaching science with a competence approach is the idea that we work in basic scientific idea (models) that can be taught in a continuum by increasing the complexity along the

different grades. The starting point of teachers regarding curriculum continuity was that of a fragmented curriculum where topics where taught in a certain grade or level and repetition was avoided. The view of continuity was not present at all, and teachers showed difficulties in understanding that there is a learning progression along the primary school. Teachers had also some reticence regarding this view, as if this repetition of ideas implies a lack of progression of students.

> In the 2nd training session, initial cycle teachers commented (when proposing them to work on the water cycle and states of matter for their second design: "*But we* [2nd grade teachers] *are not going to do the same topic as them* [1st grade teachers*], because then, students, I don't know, will repeat it next year...*" (T2.4) (48'33'') (A-F2_ini_amc.MP3)

In this sense, although the existence of some reticence at the beginning of the training, some teachers seem to have understood that there is a learning progression along the primary school and there is no problem in repeating topics/contents, but increasing level of reasoning or activity in each grade.

> In training session 4 (A-F4_inf_amc_part 1.MP3), kindergarten teachers express their idea about the distribution of the second design, deciding that each grade/level teachers (P3, P4, P5 and specialists) would design a part of the same lesson, and all kindergarten students would do the same lesson with different levels of achievement:
> *"What we said is that they [P3 teachers] would do the three levels [P3, P4, P5]"(T1.9) "So when you design, you design for the three levels?"* (teacher educator1) *"yes, and we all could do the same thing, and the results will be different, but it doesn't matter [...]" (T1.6) "we can do the same activities [...]" (T1.2) "And it's simply where the kids achieve"* (teacher educator1) *(28'00'')*

However, some teachers still have difficulties in accepting that the same topic can be taught in different levels or grades, or in using materials or ideas from other teachers that have already worked on the same topic/lesson.

> When starting their 2nd design, teacher educator wrote to high cycle teachers: *"Remember that you can ask 4th grade teachers for the materials they already designed. They did a Power Point with some very good photos of physical and chemical changes in the kitchen that you can also use*" (teacher educator 2) (correu_RDs2_sup_amc_v1.doc)

c. Recognition of external contribution (from Science Education Research)

Do teachers appreciate/recognize external contribution?

In general, there is much more recognition of the importance of the interaction with the teacher educator team more than the contribution of research papers. In general, there has been a lack of demand and use of research literature. However, some uses of literature are envisage as important, especially dissemination papers or those very concrete to their topic.

> Initial cycle teacher commented, referring to a research paper that teachers' educator team had sent to them about the idea of cycle in science education: "*I have liked the idea of cycle in general. There are concepts that are worth spending time in the classroom*" (T2.1) (Correu_Ds2_ini_1er_amc_v1.doc)

Teachers give special importance to teacher education materials, examples of lesson units, etc. Some of them have asked for specific materials related to the topic of the lesson unit they are designing

> Intermediate cycle teachers, before starting their second design (the flight of birds) wrote: "*It would be good for us to know any kind of handcraft or experience that relates the type of flight with the shapes of the body or the aim of the flight*" (T3.3 and T3.4) (Correu_Ds1_mit_4rt_amc_v2.doc)

There have been moments of reflection on the type of training teachers see as useful or effective. In general, it is said that not all teacher education programmes or materials are helpful in changing practice for being too theoretical or unconnected with their actual classroom. There has to be a specificity/adaptation of teacher education initiatives to the teachers' agenda, curriculum, etc.

> *"Do you know what? We are tired of filling up objectives and things like that [...] and at the end, the interesting issue is what you do in the class" (T4.1) (1h25'50'')*

Teachers have shown a progression in the appreciation of the help or support that the teachers' education team/researchers can make to help improve their everyday work, which is important taking into account that for these teachers the participation in this training effort was compulsory and added to an enormous list of other externally demanded teaching or organizational tasks.

> In the training diary, teachers have commented: "*As in all sessions, this training has opened our eyes to ideas that we are not used to work on*" (T1.3 and T1.4) "*It was helpful that you* [teachers educator team] *gave us some ideas so that later we will be able to create a couple of productive questions*" (T2.3 and T2.4) (2-DF_amc.xls)

Development of trust on the teachers' educator team has been a very important part to get a positive attitude of teachers' towards the training programme. There have been comments to the teachers' education team about teachers' own practice, worries and concerns, as well as about problems or constraints regarding the school structure or the administration team decisions. Teacher educators have got involved in teachers' problems, by giving their personal support to teachers and by having an active role as mediators between teachers and school administration, in aspects as the lack of free time to accomplish all the demands of the training program.

> In the 2nd training session, when talking about their reticence towards the training programme, initial cycle teacher commented:" *I am not saying that I don't want to do it because of you* [referring to teacher educator 1], *but you know, we are obligated to do this and then parents ask us, you know?* […] *Yes, I know…well, she* [referring to teacher educator 1] *has faced the problem* [referring to the conversation the teacher educator had with the management board regarding the lack of time]*, she has been there when we needed it, so this is the important thing for me… now I will do whatever is needed*" (T2.2) (A-F2_ini_amc.MP3)

What do teachers appreciate/recognize of the teachers' educator team?

Teachers recognize the expertise of the teachers' educator team in:

- The knowledge domain (didactical content knowledge): There have been moments of deep worry when not understanding the main idea in a specific science topic. In this sense, teachers have appreciated the help given by the teachers' educator team and they have evolved in recognizing what are the important ideas of science in each topic (science models).

> In an e-mail, the teachers designing the physical and chemical change lesson (intermediate cycle) were worried about not understanding the main idea of the science topic: *"Well, it seems that we still don't have it all clear how to solve the easiest way to distinguish the two type of changes. We understand that dissolution must be a physical change. However, when checking online [...] For sure we have distorted the main purpose of our work and that due to a lack of scientific knowledge we are complicating everything. Please, could you help us in this point?" (T3.3 and T3.4) (Correu_Ds1_mit_4rt_amc_v1.doc)*

During the training session 4 (A-F4_inf_amc_part 1.MP3), when talking about the main ideas regarding astronomy, kindergarten teachers said: *"But do you know where I see the problem? In that you master all this a lot [scientific content], but I don't" (T1.2) "But that's why we do these sessions" (teacher educator 1) "Now I see you and I think: you should always come, because for me, every project I start, I don't know how to take it [...] I lack... I don't what I lack!" (T1.3) (49'12'')*

- Planning the sessions: In general, teachers have experienced the need of planning and they have appreciated the use of a planification tool or method in order to do so (as the learning cycle, the setting of the objectives in each unit, etc.). Intermediate cycle teachers wrote at their implementation diary:

"Looking back we see that our initial idea was very confusing but that we have been designing the project with your help [teachers' educator team] until we have got a clear design" (T3.3 and T3.4) (3-DI_amc.xls)

But some still consider planning not so important because they it is useless when they have to adapt to specific conditions of the classroom and students.

Kindergarten teacher commented in the 2nd training session: *"Well, we go on the way, because with these kids… you always have to adapt, and if you plan something and they go another way, then you have to change and do what the kids need*" (T1.2) (23'44'') (A-F2_inf_amc.MP3)

Some planification tools, as the table of the design (see Annex XX), haven't been quite useful for teachers when trying to plan or start the design of a lesson. Most of them haven't used them, and the teachers who did it had difficulties in filling up the grid. In training session 4 (A-F4_sup_amc.MP3), high cycle teachers express, when talking about their second design:

"to send you our designs, what do we do? Fill up the grid?... because we have a dilemma: we don't know very well where do we have to put each thing in the grid... we don't know if we did it right last time" (T4.3) "well, this grid is only to help you with the design" (teacher educator 2) "yes, but, for example, what we have talked now, where in the grid do we put it?" (T4.1) "this grid helps at the beginning of the design [...] right now, you can do something like 'session 1: we will watch a movie...' [...] and then explain how do you think you want to do this session, and which questions will you ask, and which contents will you work on [...]" (teacher educator 2) (1h16'55''). Later in the conversation, the conversation continues: "so do you want us to tell you each objective for each class, following the structure [of the grid], or directly in the activities we write: 'objective...'" (T4.1) "no, we want what it works for you [...] something useful for you [...] if not, it doesn't have any sense" (teacher educator 2) (1h25'50'')

- Sequencing (learning cycle) as a sequence that helps students building ideas step by step. Most of the teachers have had an evolution in the recognition of doing something different, and they have recognized the importance of following a coherent learning progression along the sessions, which includes using important questions that problematise, building a learning sequence based on the construction of knowledge, and finding good examples of contextualized situations to work on the scientific content. These initial cycle teachers express this idea in terms of "a different way" of teaching when writing about the positive aspects of the implementation:

"The satisfaction as teachers of noticing that we can transmit content in a different way". (T2.3 and T2.4) (3-DI_amc.xls)

A high cycle teacher commented in the training diary: *"In the session we have also commented that to prepare good questions is basic in oder to arrive to the proposed objectives. We have said*

that it is needed to find an ecosystem that is close to students in order to later understand others that are more unknown for them" (T4.4) *(2-DF_amc.xls)*

There is a positive appreciation of the work done in the training sessions regarding sequencing, as well as recognition that designing and teaching in this innovative way wasn't as difficult as they had thought at the beginning. After the first formative session of initial cycle, the reading specialist said:

"Applying this method [referring to the design of the sequence] in the reading classes is not as complicated as I thought" (T2.6) (2-DF_amc.xls)

- Inquiry: Teachers have had moments of recognition of the importance of inquiry, relation with the phenomena and experimental work, as well as the reflection on the content associated to the experience as an effective way for the construction of knowledge. After the model lesson on the "treatment plant" experiment (in the water cycle design of 2nd grade) a teacher (T2.4) said:

"I liked a lot the question type 'why do you think that…?' you have said this one many times and I think it makes them reflect" (13'20''). Later, they emphasize the importance of the use of scientific vocabulary: *"I liked that the word 'hypothesis' came out, so that they see that there is a scientific vocabulary" (T2.4) (17'30'') (A-I1_2on_jni_amc.MP3)*

d. Reflection about the practice

Do teachers really reflect about their own practice?

In general, teachers have had difficulties in recognizing the importance of critical reflection on their own activity in the classroom. Very few teachers (only 2 out of 25) have accepted to be video recorded while teaching. Two more teachers accepted the teacher educator to do one model lesson (with both groups together) and to record that class. However, all four teachers have demanded comments and feedback from the teachers' educator team to improve their classroom activity.

Figure 2.22: shot of the video recording of a kindergarten lesson in the 1st implementation (life beings- chestnuts)

There has been an evolution in the recognition of the importance of doing reflective learning in order to develop professionally and change practice. From the beginning of the training, teachers' reflections showed that they were aware of doing something different. However, teachers mostly reflected in terms of what had worked in the classroom, evaluating the success of the method proposed in a quite technical way. These initial reflections, although being a first step in the reflective practice, lacked a deeper and more critical evaluation of teachers' own practice with the aim of learning and improving

their work. Kindergarten teachers, when reflecting on their first implementation (life beings-snails and turtles):

> *"In these more experiential sessions, even children who are not normally aware, show interest to note what the animal did, although they still don't focus on what we try to" (T1.1 and T1.2) (3-DI_amc.xls)*

Reflections at the end of the school year have been more specific and critical with the own teaching practice, recognizing their own strengths and weaknesses as professionals, which shows that teachers have understood that the real objective of the reflection is to improve their own practice. An intermediate cycle teacher reflected after the 3rd training session:

> *"We, 4th grade teachers, have to jump ahead, literally, and put in practice the material that we have. Until now, we have spent a lot of time developing activity sheets that haven't been feasible and we must do an effort in looking for materials that are useful enough for our lesson topic" (T3.3) (2-DF_amc.xls)*

Nevertheless, some teachers don't seem to be able to do critical reflection it by themselves. External guidance from teachers' educators – who are considered the experts – is needed for validation of their designs or implementations. After finishing the implementation of physical vs. chemical change lesson, teachers from intermediate cycle wrote:

> *"At the implementation diary we have compiled the observations about this week's session. We hope that you tell us what is needed to improve for next experience [referring to next design]". (T3.3 and T3.4) (Correu_Ds1_mit_4rt_amc_v2.doc)*

> Kindergarten teachers when sending via email their ideas about the design 2 (astronomy-shadows and lights), commented: *"You can tell us if we are on track or if we lack anything so we can correct it" (T1.1 and T1.2) (4-Ds2_inf_P3_amc.doc)*

What type of reflection tools do teachers use?

There has been a reduced use of teachers' diaries as a reflection tool, probably due to format limitations (difficulties to access the website, etc). Other types of tools, such as emails in an open format (without questions) have happened to be more used by teachers. Kindergarten teachers in the training session 4 (A-F4_inf_amc_part 1.MP3), said:

> *"What we did is: where it says 'implementation diary' 'whatever diary…', there is place where it says: 'Session 0' or something like that. We went in there and we started completing: session 0, next session, etc […] when we had a lot written, another day I tried to go back and I didn't find it" (T1.2) (1h 28'25'')*

> Kindergarten teachers wrote this at the beginning of an e-mail that included the design 1 (life beings-snails and turtles): *"We haven't been able to move throughout TRACES [referring to the website] and we don't know if we have to send it [the design 1] there or through your e-mail, so we do it from here [e-mail]" (T1.1 and T1.2) (4-Ds1_inf_P3_amc_v1.docx)*

Nevertheless, we should take into account that teachers were not used to reflect on their practice before the intervention and therefore any kind of reflective tool may be difficult to use at the beginning. Actually, most teachers who started using the diaries have continued doing it along the school year (see table 2.15).

	Training diaries				Implementation diaries	
	Session1	**Session 2**	**Session 3**	**Session 4**	**1st implem**	**2nd implem**
Kindergarten						
T1.1	1			1	21-28	
T1.7	1		4	1	21-28	
T1.6	1, (8, 9, 13)	1		1	1, 4	
T1.5	1, (8, 9, 13)	1		1	1, 4	
T1.8	1			1		
T1.9	1			1		
T1.2	1			1		
T1.3	1	2	2	1	17-19	1
T1.4	1	2	2	1	17-19	1
Initial cycle						
T2.3	7				1	
T2.4	7				1	
T2.5						
T2.2	4		3,10		3, 6-8, 12, 13	
T2.1	3		9		9, 10, 13-16	
T2.6	5		1		5, 11	
Intermediate cycle						
T3.1	12					
T3.3	10		5,6			
T3.5						
T3.2						
T3.4	11		7			
T3.6						
High cycle						
T4.1						
T4.4	14		8			
T4.3						
T4.2						

Table 2.15: Use of the training and implementation diaries by each of the teachers. Each number in each column represents one entrance in the diary for that session (when the same number is repeated in different teachers, it means that all those teachers made the same diary entrance)

As can be seen in table 2.15, some teachers have done individual entrances in the diaries (see teacher T2.2), which means they have done a personal reflection about the training or the implementation session. Some other teachers, specially at kindergarden cycle, have done one only entrance for the whole group of teachers (see entrance 1 in training session 1 and 4), which indicates that there is a lack of individual reflection as probably only one or two teachers wrote the diaries entrances in name of the others.

Training sessions have been useful as a common space for reflection about the teaching practice, as well as an exchange of knowledge and expertise. There have been important moments of critical reflection during the training sessions and teachers have shared their opinions regarding the teaching methods used and their effectiveness in the classroom, as well as their worries, ideas and doubts. Teachers have also thought on possible new strategies that may work in the classroom based on this common reflection. However, the personal level of reflection has been less used than a joined one, which has its limitations. Intermediate cycle teacher commented after the training session 3:

"Listening to the results of the 3rd grade activity, which is almost finished [implementation] has been positive for rethinking again the design that we still have to implement in 4th grade" (T3.3) (2-DF_amc.xls)

How teachers evaluate their own interventions / the new way of teaching science?

They evaluate the success of an implementation of their efforts mostly in terms of students' outcomes, usually much more in terms of motivation/interest rather than learning outcomes.

In the implementation diary (3-DI_amc.xls): "*It's amazing how they enjoyed watching what they were able to experience." (T1.3 and T1.4) "The illusion the kids show is what we value the most*" (T1.5 and T1.6) "*The best thing is the implication and motivation of students*" (T2.3 and T2.4) "*It has been comfortable how the students worked. Because I have seen them motivated*" (T2.6)

The reading specialist at initial cycle commented the need of repeating ideas with the children when implementing the 5 senses project: *"Although it may seem a repetitive work, it wasn't. Students were quite comfortable and happy" (T2.6) (3-DI_amc.xls)*

However, some teachers realize motivation is not enough for evaluating the success of an activity and they have to go deeper and evaluate their interventions in terms of students' real learning. They appreciate that now students are more aware of the lesson objective and they learn effectively. When referring to the implementation (3-DI_amc.xls) teachers said:

"Our reflection is that students have learned from the activity and the knowledge related with what we had proposed. It means, the work done has given the output it could give. The evaluation of the effort is totally satisfactory" (T3.3 an T3.4) "The participation, motivation and ideas that arise in the class, make us think about the level of knowledge that kids have on this topic." (T1.1 and T1.2) "Both sessions have been fantastic. Children have had fun and have learned a lot. I was surprised how they tried to guess what they touched, listened, smelled, etc." (T2.6) "Very good, better than what we expected. We highlight that students were able to easily reach the conclusion that we had set as an objective: How the animals relate with the environment?" (T2.3 and T2.4)

At the 3rd training session, a kindergarten teacher said that after working in the project of life beings (chestnut), and when introducing the human embrionary process, the student made content relations: *"the student saw the human embrionary process and said 'it's like the chestnut'… so they have related the concepts" (T1.5/6, 9'28'') (A-F3_inf_amc.MP3)*

Some teachers still see little difference between previous results and results after the new design and implementation. They state that the same class or students (specially those who usually have a low level of achievement) keep showing difficulties in following the class, although working in a different "way": When they have to say the worst thing regarding the first implementation (life beings - snails and turtles), kindergarten teachers say:

"There are always the same children who participate. There are some others that are not even aware" (T1.1 and T1.2). Initial cycle teachers, when talking about the implementation of their first design (The 5 senses lesson): "Not all of them have arrived [to the main idea] although we have given them many clues. I thought that the fact of doing it more experimental or leisure would give better results" (T2.2) (3-DI_amc.xls)

In training session 3 (A-F3_mit_amc.MP3), intermediate cycle teachers are asked about the possible change that weak students may have had*: "Have you seen any difference with the students that usually don't follow the class or not?" (teacher educator) "No, not really right now*

[…] those who don't understand… they are there, they want to participate, but don't do it" (T3.1) "For example, this girl in my class, who is very weak in everything [all subjects], I mean, she doesn't have any capacity, more or less she hasn't done this either" (T3.2) (23'30'')

Intermediate cycle teachers in the training session 3 (A-F3_mit_amc.MP3), when talking about the implementation of the their first desing 'states of matter'*: "there have been groups that have worked very well, who think a lot […] (14'45'') (T3.1) "some kids thought a lot, they were emotioned, and some of them said 'we seem scientists'" [...] "but this is a little part of the class… the rest were just mere observators, they just wanted to play... and my class is a good class" (15'50'') (T3.1)*

A kindergarten teacher reflected about what happened in the classroom when implementing the initial project about life being (snails): *"The participation was in touching or watching, but not in reasoning, thinking, connecting […] students just wanted to play" (T1.2, 23'25'') (A-F3_inf_amc.MP3)*

However, a few teachers consider that usually weak students that don't usually "shine" in the normal class can have an active role in the classroom by experimenting and building up a model: When reflecting on the model lesson within the water cycle design of 2nd grade ("the treatment plant" experiment) teachers said:

"M..[name of the student] very good, right?" (T2.3)"It's what you [refering to teachers'educator team] say, that depending on the thing we do… this kid doesn't shine in some type of situations, however in this kind of things [experimental work]... he does" (T2.4) (7'45'') (A-I1_2on_jni_amc.MP3)

Which topics do teachers reflect on?

Teachers have reflected on their previous teaching activity and have compared it to what they are doing now in relation to some aspects of the teaching model proposed.

Some teachers have reflected on their previous use of the textbook without problematising content or building a learning sequence. They do a positive appreciation of learning to leave the textbook and of teaching a learning sequence that has a 'logic order'. An initial cycle teacher commented, regarding the implementation of their first design (The 5 senses lesson):

"The most positive thing was working in a different way in the classroom, without the usual support of the book" (T2.1) (3-DI_amc.xls)

After the model lesson on the "treatment plant" experiment (in the water cycle design of 2nd grade) teachers said: *"All the work that we have done about the water [referring to the experiment done], that we hadn't worked that way before, I have liked it, well, we have liked it." (T2.3) "It has a logic order when working" (T2.4) "it follows a conducting line […] we have arrived where we wanted but following the steps […] before, I didn't do it, we did it with the book, following the book [...] Now, I have seen a more logic criteria" (T2.3) (18'20'') (A-I1_2on_jni_amc.MP3)*

In some cases, teachers have seen the importance of knowing the critical content (or big models) in science education – and therefore designing a lesson with this objective. They seem to realize that it is better to work on a few important ideas than to work on too many concepts that are not connected or

internalized by students. In the third training session (A-F3_mit_amc.MP3), when talking about their first implementation (states of matter), a third grade teacher stated:

> *"the lesson [referring to the previous year lesson] was very dense because we took a part of yours [4th grade teachers' content], we talked about oxidation, combustion..., all in the same lesson! of course, may be... obviously, they didn't internalize anything" (T3.2), [...] "I think that the lesson [referring to the previous years' designs], we won't even do it again, it's finished..." (T3.1) "no, no, no, I will reduce the content to this [referring to states of matter basic ideas]" (T3.2) (16'50'')*

Teachers have also reflected on the type of evaluation they do. Especially at the beginning of the training, some teachers were reluctant in changing the evaluation because they saw some difficulties associated with the new type of evaluation (type of demand was considered too high for students). After implementing the first desing [the 5 senses lesson], a initial cycle teacher commented:

> *"This type of assessment doesn't seem positive to me, as it was a great difficulty for students and it took a long time" (T2.1) (3-DI_amc.xls)*

However, many teachers have changed progressively from an initial traditional evaluation (based on memorization, definitions and descriptive questions) to other type of evaluation more based on competencies (questions that mobilize knowledge in order to apply it in contextualized situations and to solve real problems). When asking about their first implementation (states of matter) in the training session 3 (A-F3_mit_amc.MP3), intermediate cycle teachers said:

> *"They are very different [the previous assessment and the new one] because last year this lesson was very theoretical, and we asked […] 'what are the states of matter?'" (T3.2), "even there was a question in which they had to say if the materials were natural, artificial..." (T3.1) (16'50''). "Here we see the difference: 'What happens when ice, a solid matter, is changed into another container?' [reading a question of the new assessment aloud] and here: 'write which state of matter is: it has a fixed volume and a variable shape' [referring to last year's assessment question] [...] In this one [last year's assessment question] they [students] only have to put a word. On the other one [the new assessment question] they have to write what happens... well, it's a lot more demanding, right?" (teacher educator 1) (18'25'')*

Some teachers used to give excessive guidance and teach isolated and superficial ideas (instead of teaching the important scientific contents/models) due to the fact that students are considered too small/immature for conceptual work, argumentation, decision making and reflective thinking.

> *In the first training session (A-F1_ini_amc.MP3) teachers and teacher educator team had an important discussion regarding their 1st design (The 5 senses): "Until now, I haven't gone out of the sheet [textbook]. But we have said that I will bring something to experiment with" (T2.2) [...] "well, if you do this [referring to the ideas discussed], you are establishing the relationship function" (teacher educator 1) "ok, there is the relationship, but I don't want it to be programmed or guided" (T2.2) "well, you are working it..." (Teacher educator 1) "I want that if the experience takes us there, ok, but if not [...] I have my doubts that a child of 1st grade in this moment of the school year may be conscious or arrive there" (T2.2) (26'05'')*

However, some teachers have reflected on the positive aspects of doing reflective thinking and promoting "real" inquiry with their students, instead of a guided inquiry that doesn't promote decision making. They have seen that students are more able than what they thought in doing complex activities, making good decisions and building consistent argumentations. After the model lesson on the "treatment plant" experiment (in the water cycle design of 2nd grade) teachers talk about the methodology used by the teacher educator:

"I liked how you did it, I wouldn't have done it that way, I would have explained the function of each element filtered (it means, the stones don't let...) […]" (T2.4). "You wanted to give them a little bit the clue, but now you have seen that the clue has been found by them" (T2.3). "Yes, I say... they have been able to find the function of the stones [...] Of course, I didn't expect that from them" (T2.4) (3'35''). [...] "When we started up the experiment, and you [referring to teacher educator] asked them what they thought would be the order to put [materials] inside the treatment plant, and you let them do... instead, I would have said: 'this amount of cotton, this amount of stones...' because maybe this is a more structured way [...] however, it has worked out! Without having to tell them the exact amount of materials, it has worked out" (T2.4) (13'40'') (A-I1_2on_jni_amc.MP3)

In general, teachers have reflected on the lack of previous experimental work and the difficulties associated when incorporating experiments in the classroom. Before doing it, teachers felt insecure with the experiment procedures and methodologies, mostly because they considered the children too small to work properly and they thought that they would lose control of the class. After the experimental session, teachers have realized that it was not as difficult as they thought and have understood that both teachers and students have to get used to a new way of working when incorporating experiments in the classroom. Teachers are now less afraid of doing experiments in the classroom and they have a positive appreciation of experimental work, which is seen as a useful method to help students construct their knowledge and better learn the important scientific concepts. When talking about their first implementation (states of matter), in the third training session (A-F3_mit_amc.MP3), intermediate cycle teachers said:

"…I also think that, as this is the first time that we do experimentation and this, may be they [the students] also have to get used to work this way, and also, later on, they may be get used to and they will do a bigger effort and, I don't know, I think they will find it easier" (T3.1) (24'20'') "And you feel very insecure, specially with this type of things, you are afraid of saying something that you get lost" (T3.1) "Will you do it again next year?" (T3.3) "yes" (T3.2) "I think that yes [...] well, if we do more and we have this one clear...I think it will be easier" (T3.1) (26'15'')After the model lesson on the "treatment plant" experiment (in the water cycle design of 2nd grade) teachers said: "It has gone very well […] although they hadn't done that [experiments] before…" (T2.3) "and they are not used to work this way" (T2.4) "nooo […] "By experiencing, I think that they will remember it more than if they hadn't experimented […] because they have seen it, they have lived it" (T2.3) (12'40'') (A-I1_2on_jni_amc.MP3)

When they have to say the best thing regarding the implementation, kindergarten teachers highlight the experimental work with the snails and turtles:

"The fact that we can live the experience directly" (T1.1 and T1.2) (3-DI_amc.xls)

In some cycle levels, teachers already used experimental work before the intervention, but it was unrelated with the construction of knowledge. High cycle teacher commented after the third training session:

"Regarding ecosystems [their first design], we have worked some aspects of the content, but we should do one more step in order to deepen in some important contents and not remaining only in the experiments done." (T4.4) (2-DF_amc.xls)

Teachers mentioned some difficulties in accessing other spaces out of the classroom to do experimental work, especially common spaces that are used by other groups along the day. However, teachers have found ways to overcome these limitations.

When designing the astronomy lesson, kindergarten teachers discussed about the possibility of doing the class outside in order to see the sun moving through the different hours, but they said it was difficult to access the playground at any time because there is shadow for many hours and also other students occupy the playground. They discussed the idea and teachers gave alternatives and ways to overcome the limitation (1h 13'50'') (A-F3_inf_amc.MP3)

Primary school teachers have asked for free hours in the secondary school laboratory, something that was never done before (i.e. laboratory was previously used only by secondary school students). The willingness of overcoming the difficulties associated to the access to the laboratory has even changed the dynamics of the school laboratory use, and it represents clear evidence that experimental work has increased within some primary school grades. In training session3 (A-F3_sup_amc.MP3), the coordinator of the primary School said:

"When talking about using the secondary school laboratory, one of the teachers [he said the name] asked me to look for laboratory hours in order to go there" (T4.4) "wow this is new, isn't it?" (teacher educator 1) "yes, this is the first time that something like this happens in this School! [...] yes, they asked me 'you should find us a spot in the chemical laboratory' and I answered 'no problem, we will look for it, and if there isn't any, we will create it" (T4.4) (1h 19'55'')

e. Building School structure/participation in the community

In general, there has been an increase in collaboration between teachers. Work at cycle level has increased along the teacher training intervention, and there is now a positive appreciation of the collaborative work, as a way to help each other and reduce the amount of work. In some cycles, teachers have distributed their work of designing and even implementing.

Teachers at kindergarten cycle are a clear example of this collaboration that has grown throughout the school year. At the beginning of the School year, teachers did their first design (life beings) separately (by levels/grades).

In the second design (astronomy) they decided to distribute the work between teachers. A kindergarten teacher commented after the training session 2: *"We should start establishing common projects within the cycle [...] for not having an excessive volume of work" (T1.7) (2-DF_amc.xls)*

After training session 3, another kindergarten teacher specified the distribution of the work: *"We [all kindergarten teachers] have thought to prepare by levels the different aspects related to astronomy. So that: P3 has decided to work on shadows, P4 the movement of the sun throughout the day, P5 the day and night and Earth rotation. The English, music and reading specialists will work on the gravity force. All these aspects once they are prepared by each level, they will be presented to the other levels and each of us will adapt it to our group" (T1.6) (correu_Ds2_inf_amc.docx)*

Later in the school year, in training session 4 (A-F4_inf_amc_part 1.MP3), kindergarten teachers told us that they even wanted to share the teaching: *"What we said is that they [P3 teachers] would do the three levels"(T1.9) "So when you design, you design for the three levels?" (teacher educator1) [...] "Exactly... so this way it is easier that each of us prepares our part of the design and the kids can pass through each of us" (T1.3) (28'00'') [...] "So you will change classes, right?" (teacher educator1) "Yes, we will change kids" (T1.3) (28'45'')*

Other cycles have experienced a similar change in the work distribution at cycle level. A high cycle teacher wrote about the first design (ecosystems): *"At the second part of the lesson, we would like to work on ecosystems. In this part we have commented to work together 5th and 6th grades and build in some way a terrestrial and sea ecosystem" (T4.4) (Correu_Ds1_sup_amc_v1.docx)*

There has been an integration of teacher specialists' work in all cycles. Reading, PE, Music, English and Religion specialists of all cycle levels have designed lessons that go according to what class teachers are designing and implementing in their science lessons. In some cycles, they have gone further and specialists have participated in the design of the main lesson unit (when it has been distributed between teachers within the cycle level). There have been moments of common reflection about the benefits that integrating disciplines may have on students. Some teachers have realized that working on the same scientific ideas from the different subjects reinforces the scientific concepts from different approaches, which helps students to better understand and incorporate main scientific models. Other teachers appreciate the collaborative work with the specialist in the classroom for the help given in the class management.

Kindergarten English specialist reflects about working with the class teachers at cycle level: *"I have it clear that next year I will take out the book and go with them [referring to class teachers]. For example, if they work the snail, I do the snail too" (T1.9). Another teacher answers: "This is great" (T1.5) and a third teacher: "It would be better that way" (T1.3) (29'40''). After this conversation, the religion specialist says: "I have a doubt, what can I do from the religion subject?" (T1.7) and another teacher answers: "You can work values, for example, respect to animals and plants…" (T1.3/4) (30'55'') (A-F3_inf_amc.MP3)*

In training session 3 (A-F3_mit_amc.MP3) intermediate cycle teachers discuss with PE teacher about how to teach the same content (states of matter) in PE class: *"There are many games in which you can work this concepts and they live the experience as particles […] you can also do it with the space… and you start reducing the space, and they saw that when you reduce the space, they were more tight, and it was difficult to move" (T3.6) "If you do it again, you can tell them 'we are moving as if we were liquid...'" (T3.2) "That's what we have tried to do in all cycles, to go all together, when we do this type of difficult ideas, because if you go all together it's easier for the student to really get the idea" (teacher educator 1)(22'55'')*

In the implementation diary (3-DI_amc.xls), initial cycle teacher said about the implementation of the first design (The 5 senses): *"It [the implementation] went well thanks to the help of the reading teacher. This activity must be completed with two teachers in the classroom, in order to collect data and to carry it out without being too long for students and lose motivation." (T2.2)*

There have been specialist teachers who see some problems associated when doing collaborative work, as the lack of time for working on contents of their own specialization (reading, music, etc.)

The reading specialist at initial cycle expressed in the implementation diary (3-DI_amc.xls): *"Here I will point out the problem I have seen regarding my reading class. I have done these two implementations during my reading class, and as a consequence, I haven't been able to do reading during these two days" (T2.6)*

What has fostered or hindered the collaboration between teachers and with teacher educators?

From the beginning of the intervention, there has been a relaxation of school authorities' pressure on some issues, as in the possibility of not having to finish the curriculum, or not having to use the

textbook, etc. This shows a good predisposition of the management board towards the change of some aspects in order to promote teachers' development.

> At the initial presentation, there was a discussion with one of the teachers and the primary teachers' coordinator (T4.4) regarding the use of the textbook as a rule of the school: "*but as you know, we have do the book*" (T2.2) "*well, it is not that important... you can leave the book apart in this case*" (T4.4) "*but I don't understand, we cannot leave a part of it and don't finish it... it is like...*" (T2.2) "*I tell you that it is not necessary to finish it... this has already been decided, ok? don't worry*" (T4.4) (A-0_amc.MP3)

However, this commitment from the school administration was not detected on important issues such as the modification of schedules in order to allow teachers to meet and reflect by cycle or at school level. Most teachers mentioned the lack of compatible schedules or free time as a big constraint when trying to meet with their cycle colleagues. The little time they have together is devoted to other organizational activities at School level.

> Reflecting on the model lesson of the 2nd design (water cycle: the treatment plant experiment) in 2nd grade, teachers said: *"We have been short in time [with the experiment]. Now we have to finish, and do the work"(T2.4) "I don't know when I am going to do it.."(T2.3) [...] "this is teachers' reality. Now you [refereeing to the teacher educator] are seeing it, right? That we have the cool part, but we have to do other things, and where do we fit them?" (T2.4) (5'45'') (A-I1_2on_jni_amc.MP3)*

> Intermediate cycle teachers commented about the difficulties they had to meet for doing their 2nd design: *"We haven't had the occasion to start working" (T3.3) "We don't have hours in common"(T3.4) "and we haven't been able to meet, because we only have an hour [a week] and we have other visits [parents' meetings]..."(T3.3) (9'35'') (A-F3_mit_amc.MP3)*

> Kindergarten teachers talk about the difficulties for meeting again to continue designing the astronomy lessons: *"Now it's difficult to meet because there are some Wednesdays that we have other meetings" (T1.5) "and also carnival is coming and we have to organize it" (T1.6) "on the First of the month we have teachers general meeting […] we have thousands of things…" (T1.6) "and on the 15th we have 'pastoral work...'" (T1.1) (1h18'20'') (A-F3_inf_amc.MP3)*

2.4.5. Conclusions

The present case study analyzes an example of a long-term and school-based continuous professional development programme designed to promote the professional development of teachers. This initiative is one which requires high levels of involvement by teachers, the school and the facilitators of the CPD, in this case a research team in Science Education. The programme promotes and facilitates the design and implementation of innovative science teaching and learning materials followed by a common reflection upon their teaching practice among colleagues from the same educational level and with the educational researchers supporting the design, implementation and reflection effort. The goal is increasing the professional competence of teachers in the field of Science Education at early childhood and primary school level by allowing the development of trust and the sharing of knowledge and expertise with the aim to initiate creation of a professional learning community.

The initiative described has shown an influence on teachers' classroom practice, and an evolution in the professional development of teachers, when considering the five indicators of professional development we have decided to use according to our general theoretical framework.

1. Regarding the Knowledge domain:

Although the initial worries and insecurities regarding mastery of the scientific knowledge domain, there has been an increased confidence in mastering the content and a better understanding of the importance of the main scientific contents/models, especially those that teachers have already worked within their designs and implementations.

As we have seen, knowledge domain was a worry for all teachers, independently of their initial training as generalist of specialist, the teaching level (from kindergarden to 10-12 years old), or their teaching experience. Teachers recognized openly not to have a clear idea of important scientific contents and this pushed them to use in a non critical or reflective way the textbook as the content provider. The training effort has been organized around different activities addressed to help teachers not to master the scientific knowledge but the didactical knowledge (in the sense of didactical transposition) necessary for the students to show scientific competence. Theses taks have been reflection on the important ideas of science that should be mastered regarding every scientific topic, reduction and critical selection, from of all the contents present in the textbook, to those necessary for students to build these central ideas, critical sequencing of contents from those more close to the students ideas to those more difficult to be constructed, taking then advantage from students' standpoint in order to organize content progression and finally, definition of a coherent evaluation (one that addresses the important ideas and it is coherent with the learning process done in the classroom). Despite teachers have shown different levels of mastery and success in doing these tasks, most of them have stated that by participating in them they have realized the importance of content in organizing teaching and learning, and their need to reflect, become informed and learn about content (again, didactical more than scientific content) to become a better teacher.

2. Positioning on a continuum

The starting point of teachers regarding curriculum continuity was that of a fragmented curriculum where topics where taught in a certain grade or level and repetition was avoided. The view of continuity was not present at all, and teachers showed difficulties in understanding that there is a learning progression along the primary school and that the basic or more important scientific ideas or models can and should be common at all levels, despite taught with a greater level of complexity in each grade. Teachers had also some reticence regarding this view, as if this repetition of ideas implies a lack of progression of students. However, and related with the previous idea of starting to understand science teaching as the masterly of very complex, important and difficult to construct central ideas (instead of the learning of an enormous collection of unimportant details), along the CPD effort teachers started to show a better predisposition to devote time and effort to the teaching and learning of central ideas in all teaching levels, becoming more aware that there is no real repetition when the students' demand is different in every level. This idea has implications not only at the teaching and learning level, but mostly at the teacher cooperation and building of community level, as it implies sharing of knowledge, materials and experiences among teachers of different grades teaching similar or same central ideas. In some cases it has even had the effect to promote teachers planning together the design of teaching and learning materials for different grades, and could be the seed for a future organization of the curriculum at the whole school level around key ideas and topics that would be dealt with along the continuum of teaching from 3 to 12 years old.

3. Appreciation of external contribution / Importance given to Science Education research

Teachers have shown a progression in the appreciation of the help or support that theteachers' education team/researchers can make to help improve their everyday work, which is important taking into account that for these teachers the participation in this training effort was compulsory and added to an enormous list of other externally demanded teaching or organizational tasks.
This recognition has increased due to two important aspects: the recognition of the usefulness of the training programme and the development of trust with the teacher education team.
Regarding the recognition of the usefulness of the training programme, teacher' have explicitly signaled the difference between this training which has been "fitted to purpose" and practical (around the design, implementation and reflection of actual teaching practice) when compared with more traditional training courses they have been asked to participate, which have been described as too theoretical and unconnected to their real activity in the classroom. In this sense, and despite some teachers value research literature in the form of papers and mostly exemplary research-based classroom materials if they are related to the topic they are working on, their recognition of the important contribution of research knowledge is associated with the direct discussion and joined reflection with the science education researcher when discussing their practice (the particular topic they want to teach, how they teach it normally, what problems do they encounter, etc). Regarding the development of trust on the teachers' educator team, teachers have in some cases explicitly stated that this trust has been developed as a result of, on the one hand, the mediation done by the teacher educators between the school administration authorities (from principal to head of the primary school) so that the discourse used in the training was explicitly accepted by the school administration and community (including parents) and second, due to the adaptation of the training tasks and demands to the teachers' rhythm, supporting teachers in every small effort done and encouraging (instead of demanding) further implication in an step by step, progressive manner.
When analyzing what teachers appreciate from the teachers' educator team, they mostly talk in terms of expertise. They appreciate the teacher educator's knowledge domain of scientific basic concepts and science didactics associated, as their systemic use of the idea of the learning progression along the curriculum and an inquiry-based approach for the teaching and learning of science, which promotes scientific competence within the students. They have also had a more positive appreciation of the process of planning and the use of planification tools along the training effort, in particular regarding the sequencing of the teaching and learning along a learning cycle (starting from exploration of students ideas, including synthesis of ideas, etc) However, not all teachers have understood the importance of planning carefully the lessons, and some ideas regarding the sequencing have been differently addressed and mastered by different teachers. Further work on these concepts would be necessary in order for teachers to capture the structure of the learning cycle as the basic teaching and learning structure to follow both at the level of the teaching unit and the level of each lesson.

4. Reflection about their own practice

Reflection about their own practice has been one of the main objectives when designing the intervention in order to foster a sustainable professional development within the teachers group . At the beginning of the intervention, most teachers' reflections only evaluated the effectiveness of method proposed in a quite technical way, but they had more difficulty in evaluating their own interventions with the aim to improve their future practice, and most of them didn't allowed their classes to be video recorded. In spite of these initial difficulties, teachers have developed a more critical reflection of their own teaching activity, which is now started to being considered a useful way to improve their professional practice. However, external guidance from teachers' educators – who are considered the experts – is still demanded by teachers for validation of their designs or implementations. It can be said, thus, that although there has been reflection among teachers about their own practice, it is still needed the construction of an stable and sustainable learning community of critical reflection, without the

constant guidance of teachers' educator team. More work on development of teacher leadership should be done in order to accomplish this, which would be a further step in the development of PLC.

Teachers have done a reduced use of some of the reflection tools as the online diaries, probably due to format limitations (diaries were online and most teachers have difficulties with online access and tools). Communication with teacher educators via email has been commonly used by most of the teachers, and training sessions have become a useful setting for common reflection between teachers and with teacher educators. However, the personal level of reflection has been less used than a joined one, which has its limitations. It would be necessary to rethink the used tools or strategies for supporting personal reflection, as their non-extensive use show that they are not considered as useful by teachers as we would have liked it to be.

Teachers have reflected analyzing students' outcomes, sometimes in terms of motivation (usually related with the experimental work) but also in terms of effective learning and achievement of the lesson objective. In general, there is a positive valuation of students' effective learning, although some teachers still think there are things that haven't changed from previous interventions, such as that the same considered low-ability students are still not achieving the objective of the lesson. In this sense, how the new methods integrate all students should be an important goal for the future interventions of teachers.

When reflecting on teachers' previous work before the intervention and comparing it to the new way of teaching proposed, teachers have shown recognition of their own evolution in different aspects. Teachers have explicitly recognized that they now understand the importance of teaching the main scientific ideas/models and designing and implementing a learning sequence that helps building ideas step by step, instead of following the proposed sequence and contents from the textbook without questioning which of them where or not important regarding the topic studied. Most teachers have also changed the type of evaluation, from a more traditional memorizing assessment to an evaluation based on competencies, which is coherent with the learning process done. Some teachers have also seen the importance of promoting real inquiry in their classes and have realized that children are more capable of doing complex and inferential reasoning than what they thought. Regarding experimental work, most cycle levels hadn't done experimentation with their students before, because teachers were afraid of losing control of the class. Others were more used to do experiments but they were unrelated with scientific content. There has been an evolution in both cases: experimental work has increased at all levels and it is now more connected to the construction of models. Teachers have also overcome the difficulties they had in accessing spaces out of the classroom to do experimental work, and some of them are using the laboratory for the first time.

5. Building School structure

Teachers have changed their practice also in terms of collaborative work. Initially, teachers used to work individually or in the better cases with a single colleague teaching the same grade. After the teaching education intervention, we can say that teachers are now more used to work at cycle level, and that there is a positive appreciation of collaborative work as something that helps their individual practice. All cycle levels have integrated specialist teachers, working on the same content from different subject matter perspectives, which is seen to have a positive effect in students' learning and development of scientific competence and also as a way to integrate the different teaching teams in a joint enterprise. Although cycle level work has increased, work at School level is still not happening, which indicates that more work in building School structure still needs to be done.

It is also still to be seen if this collaborative work is sustainable in time without the external support of the teachers' educator team, as other tensions related with the school dynamics, structure and

organization have not been addressed and have an enormous influence in what teachers' considered it is expected from them.

In this sense, even though the initiative has been fostered by the school administration, teachers still miss some management board support in order to be able to carry out some of the requested changes in their practice. Being a school with quite strict rules and a hierarchical decision making, some relaxation has been identified during the intervention such as the fact that teachers were allowed to do not use the book if necessary. Nevertheless, this commitment from the school administration was not detected on important issues such as the modification of schedules in order to allow teachers to meet and reflect by cycle or at school level.

In general, it can be said that the proposed professional development programme has achieved some kind of evolution within teachers practices. By designing, implementing and reflecting about their own teaching activity, teachers have developed (in a different way) different tools and strategies to design and implement science lessons based on competencies, as using good questions that problematize, contextualizing, following a learning sequence that builds knowledge, working on some crucial contents or models and experimenting in an inquiry based approach. Common reflection about their own practice and a positive recognition of external contribution has increased along the intervention process.

As in the second case study, there are a number of questions that remain to be answered. The first is whether a training programme that requires such high-level input from a research team is really viable at national or international level (given that in addition to the full training days the initiative requires continuity over a number of years). This raises the question of how it might be implemented across several schools. A further issue is related to the continuity of the processes of reflection about the teaching activity, both at the individual level and among a school's teaching staff as a whole. Given the complexity of — and demands upon — the primary school timetable it has to be asked whether regular time can easily be set aside for group reflection on real and specific aspects of classroom practice.

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Appendix 1: Summary of the ICE's group meeting minutes

Grup Ciències Infantil i Primària

El Grup Ciències Infantil i Primària va iniciar-se el curs 2002-03 amb la coordinació de Montserrat Pedreira, a partir del curs 2003-04 la coordinadora ha estat Conxita Márquez

El grup es reuneix una vegada al mes, normalment el primer dilluns de cada mes. Està constituit per Mestres de Infantil i Primària.

A continuació copio el document inicial, d'on es poden desprendre els objectius del grup

Esborrany per a un document orientatiu per a la formació d'un grup de treball de ciències a l'ICE de l'UAB

Què pretenem

- Compartir experiències de treball a l'aula i de formació que enriqueixin els components del grup.
- Estar al cas de les innovacions i tendències en didàctica de les ciències a les etapes d'educació infantil i primària.
- Conèixer, crear, provar i analitzar experiències d'innovació.
- Marcar criteris d'acostament a les ciències que puguin ser útils als mestres.
- Destapar incoherències i mites com a eina de reflexió, plantejar interrogants sobre les maneres de fer.
- Trobar maneres de donar a conèixer les experiències, les reflexions i idees que puguin sorgir del grup de treball, ... Fer un esforç per a utilitzar un llenguatge senzill i entenedor i per buscar d'altres mitjans que ajudin a la comprensibilitat i expansió de les idees (vídeos, webs...), per tal de poder arribar a un gran nombre de mestres. La finalitat del grup no és crear un món propi d'"escollits" sinó intentar aportar un granet de sorra a la millora l'educació.

Quin tipus d'acostament a les ciències volem ?

Si haguéssim de buscar un concepte que definís de la manera més simple possible l'actitud bàsica per a afrontar l'ensenyament de les ciències a l'escola, ens podríem quedar amb la idea dels **respecte**, respecte als nens i nenes, i respecte a la naturalesa.

- **Escoltar els nens i nenes**: Una idea de nen com a persona capaç, competent, activa , amb idees, amb coneixements, que forma part d'un grup amb vida pròpia on cadascú aporta les pròpies iniciatives respectant les dels altres, per tal d'avançar conjuntament en la construcció del coneixement.

- **Dialogar amb la natura**: així com interpretem textos escrits o numèrics en l'aprenentatge de la lectoescriptura o les matemàtiques, en el coneixement del medi natural el nostre referent no pot ser altre que la mateixa realitat que ens envolta. Per a arribar a comprendre el

funcionament del món, hem d'aprendre a interpretar la naturalesa, a llegir els signes, a imaginar... i per això cal mirar, observar, manipular, inventar solucions, raonar, crear models...

De quin tipus de ciència parlem ?

- Una idea de ciència oberta, no definitiva, en evolució constant.
- Que parteixi dels models i concepcions dels nens i nenes i que els ajudi a fer-los cada cop més rics i evolucionats, a partir del contrast amb d'altres punts de vista (dels companys, la mestra, la realitat, un mateix...).
- Que valora les iniciatives de cadascú, la recerca d'estratègies pròpies i diferenciades per sobre del cenyir-se a maneres de fer donades.
- Basada en la recerca de relacions complexes entre conceptes, no pas en memoritzacions inconnexes.
- Que dóna molta importància a l'ús de diferents llenguatges (oral, plàstic, corporal...) com a mitjà de representació dels conceptes, com a vehicle de creació de coneixement, que permet compartir les idees amb els altres, que ajuda a estructurar els conceptes, a descentrar (del concret a l'abstracte) a desenvolupar el pensament.
- Sense restriccions, no limitada a una àrea - disciplina concreta, relacionada amb el món.
- Compromesa, que busca connectar els nenes i nenes en aquest nostre món, que pretén la comprensió alhora que valora també la intervenció activa.

Memòria curs 2003-2004

Animals

Què li entra i què li surt? Aquesta idea ha estat treballada en diferents animals i en diferents nivells: Elefants, cavalls, àligues, pingüins; Peixos; Grills; Insectes pal ; Tortugues ; Cargols

Cos humà

Algunes de les propostes de treball entorn del cos humà

Nosaltres per què mengem? Com passen a la sang les substàncies nutritives? Construcció de maquetes.

Canviem quan creixem?

De què depèn que "jo" existeixi?

La diabètis (Què deu tenir a dins una gota de sang? Què creieu que compta l'aparell? Què creieu què hi ha a l'entrepà que fa variar el número que marcal'aparell?

El cos humà és complex. Com es produeixen els canvis entre el què entra i el què surt?

Quant comença el nostre temps?

Què ens fa iguals i què diferents?

Construcció de maquetes: Com s'alimenta el fetus?

Altres éssers vius

Què li ha passat al bulb?

Bolets

Materials

Representació de sòlids, líquids i gasos. Per què quan posem sucre a l'aigua desapareix? Com deu ser l'aire perquè pugui passar per una xeringa i omplir un globus?

La descripció un primer pas per l'explicació

A partir d'una garota. Com ha de ser una descripció científica?

Descripció del cor. Després d'un guió d'observació o després de fer una observació lliure amb l'objectiu de contestar una pregunta?

Descripció del vol dels coloms

Sortida geològica. Observar/interpretar

Importància de les preguntes

Què és un ésser viu? / Com li explicaries a un extraterrestre què és un ésser viu?

Com és la Terra per dins?/ Què hi ha sota el pati de l'escola?

Dibuixa el cicle de l'aigua/ Dibuixa d'on ve l'aigua que surt de la font del pati.

Memòria curs 2004-2005

- A més de les reunions mensuals es va participar en: Aportacions del grup al Simposi de Tortosa
- Aportacions del grup a la pàgina d'intercanvi d'experiències del CEDECT
- Proposta de programa del curs a l'Escola d'Estiu de Rosa Sensat "Aprendre sobre els éssers vius i els materials a l'escola infantil i primària".

Memòria del curs 2005-2006

Calendari de les reunions i principals aspectes treballats a cada sessió

3 d'octubre. Planificació del curs. Recull de les produccions del curs 2004-2005. Propostes de temes a treballar. Activitats entorn de l'any de la física

19 octubre. Visita al Cosmocaixa centrada en el mur geològic i el taller: gènesi de les roques.

7 novembre. "Aprendre sobre la Terra a l'escola". Joan Bach i Conxita Márquez. Presentació d'una proposta de treball del model Sol- Terra.

12 desembre. Pacte nacional d'Educació. Teresa Pigrau. Els ocells al patí. Jesús Chivite.

9 gener. Com promoure la competència lectora a les classes de ciències. Conxita Márquez

6 febrer. Concreció d'activitats per promoure la lectura a la classe de ciències: Activitats de metareflexió- Teresa Pigrau- i activitats de lectura d'imatges (Victòria Carbó). Maneres de mirar des de la ciència (Victòria Carbó- Montserrat Padern- Teresa Calveras)

6 març. Intercanvi d'experiències: Sortida geològica al castell de l'Elamprunyà. Maria Manent; Els minerals ens envolten (Dolors Marlet); Les llavors (Carme Cuberes)

3 d'abril. Taller d'identificació i classificació de roques. Joan Bach

8 maig. Intercanvi de experiències: Els dofins (Carme Prats); El treball cooperatiu (Teresa Pigrau), El model sol-terra (Carme Cuberes)

12 juny: Intercanvi d'experiències: Com pot ser que puguem estar més temps sense menjar que sense beure?. Dolors Marlet; El bosc (Eulàlia Berbel)

Objectius del curs

- Continuar aprofundint en maneres innovadores de plantejar les ciències a l'etapa d'educació infantil i primària.
- Focalitzar l'atenció en el model Terra.
- Ser un punt de formació, trobada i intercanvi del que representa enseyar ciències a l'educació infantil i primària.

Metodologia del curs

Seguint la dinàmica iniciada en cursos anterior, hi ha dues parts diferenciades, una relacionada amb la formació i l'altre en l'elaboració, execució i intercanvi de experiències desenvolupades a l'aula.

Aquest curs la formació específica ha consistit en:

Una visita al mur geològic i la realització del taller de roques al Cosmocaixa.

Una xerrada titulada: "Aprendre sobre la Terra a l'escola" i una activitat pràctica entorn a una proposta de treball del model Sol- Terra per part de Joan Bach.

La realització d'un taller sobre roques al laboratori de didàctica de al ciències a la UAB.

A la resta de sessions hem seguit una mateixa metodologia consistent en l'exposició d'una experiència per part d'algun membre del grup i la posterior discussió.

Memòria del curs 2006-07

- *Calendari de les reunions i principals aspectes treballats a cada sessió*

9 d'octubre: Comentari de la memòria del curs 2005-.06. Planificació del curs. Propostes de temes a treballar.

Presentació del concurs de fotografia del CEDECT. Equip del CEDECT

Volem fer unes ulleres de sol. P5. Montse Padern.

http://www.xtec.es/cdec/intercanvi/ulleres/ulleres.htm

6 novembre: Minerals al super amb Eloisa Anglada

4 desembre: Model llum i ona. Josep Lluis Estaña

15 gener: Intercanvi d'experiències: Què estem fent a les classes de ciències?

12 febrer: Visita a l'Escola Estel. Maria Manent

- Organització del laboratori.

- Com treballar els minerals al super amb nois i noies de 6è.

http://www.xtec.es/cdec/intercanvi/minerals/minerals.htm

- Possibles activitats de lectura de textos de ciències: Lectura crítica, organització del procés lector (abans, durant i després de la lectura)

5 març: Seguim amb els intercanvis d'experiències: Què estem fent a les classes de ciències?

16 abril: Visita a l'Escoleta. Montse Padern i Tere Galindo

- Presentació de tres experiències:

L'aula de ciències a parvulari. *Experimentem?....Pensem*

Roques i minerals a 2n de Primària. En aquesta unitat didàctica s'utilitzen els sensors de temperatura per estudiar la variació de la temperatura a l'interior d'una mina. També es fa intercanvi d'informacions a través d'internet.

Terres i filtracions a P5. A partir de terres diferents es fan experiments. Amb la lupa s'aconsegueixen veure els forats minúsculs que té el paper.

14 maig:

Degustació de les galetes científiques. Montse Padern

La gelatina. Montse Pedreira

Pilotes que pesen diferent. Montse Pedreira i Conxa Colom

11 juny:

- Infusions. Eulàlia Berbel

- Las mongeta. Teresa Calveras

- El pot de buit. Conxita

Curs a l'Escola Estiu de Rosa Sensat.

Actualització didàctica de les ciències a Infantil i Primària i incorporació de les TIC.

Memòria del curs 2007-08

A destacar l'organització de les jornades "Conversar per comprendre" al cosmocaixa i un monogràfic de Perspectiva Escolar

1 d'octubre: *Calendari de les reunions* Comentari de la memòria del curs 2006-07. Planificació del curs. Proposta per part del David Vilalta d'organitzar les Jornades al Cosmocaixa i d'obrir un espai moodle.

4 novembre:

- El Roure i Materials i la màgia de les barreges. Neus Garriga

- El moodle. Jesús Chivite

3 desembre:

- Experimentem i aprenem amb els sentits. Mercè Crehueres. Escola Mare Nostrum

- Planificació de les jornades *Conversar per comprendre*

14 gener:

- Demanda de col·laboració de Perspectiva Escolar en relació amb el tema: "Experiències sobre Darwin i la teoria de l'evolució".

- Estat de les jornades "Conversar per comprendre"

- Converses sobre la densitat i l'electricitat. Albert Díez

- Els ungüents. Eulàlia Berbel

- Els boscos i el CO2

- Demanda de proposta per a l'Escola d'Estiu de Rosa Sensat.

4 febrer:

Visita a l'escola Dovella:

- La Dolors ens explica el treball que ha fet de la sal.
- La Carme Cuberes ens explica com ha utilitzat les peces de lego per representar la composició dels aliments.
- Estat de les jornades "Conversar per comprendre"

3 març:

- “Els fongs a la classe del mitjans”, una experiència d’aula de l’escola Rellinars presentada per la Maria Casanovas i la Carme Pablo.

- Estat de les jornades “Conversar per comprendre”

7 abril:

- Estat de les jornades “Conversar per comprendre”

- Discussió de temes d’evolució i herència amb Eduard Cruells

5 maig:

- Presentació dels diferents tallers i pòsters.

31 de maig.

Jornada: Conversar per comprendre

2 de juny:

- Valoració de les jornades. Fotos

- Presentació de al proposta del monogràfic de Perspectiva

- Sopar de final de curs

Memòria del curs 08-09

6 d’octubre

Calendari de les reunions Comentari de la memòria del curs 2007-08. Planificació del curs. Interrelacions entre el medi social i natural i relacions de les ciències amb altres disciplines. Es mostra un especial interès amb la relació amb l’Art. Es proposa que seria interessant posar-nos en contacte amb Montserrat Cortadellas

Reflexió entorn les competències.

- Anàlisi d’activitats des del punt de vista competencial per això es proposa l’eina dissenyada des del Creamat
- Criteris d’organització de la programació. Per on començar? Per les activitats d’avaluació, pels informes, ...

Activitats lectores a la classe de ciència

3 novembre 2008

Estat de la qüestió del monogràfic de Perspectiva.

Discussió del document PREGUNTES QUE PODEN SERVIR D’INDICADORS DE RIQUESA COMPETENCIAL D’UNA PROPOSTA O ACTIVITAT EDUCATIVA i aplicació a una activitat sobre els bolets. Es destaca la importància de la rellevància social.

1 desembre 2008

Taller d'experiments amb Montse Pedreira. El taller permet que els nens i nenes manipulin materials, reconeguin les seves propietats i puguin també reconèixer l''us social dels mateixos.

Monogràfic de Perspectiva.

2 de febrer de 2009

TREBALLAR PER MODELS, EN L'ENSENYAMENT DE LES CIÈNCIES

A INFANTIL I PRIMÀRIA . Els incendis forestals. Una pertorbació. Teresa Pigrau.

Celebració de l'any Darwin. Victòria Carbó. La Victòria ens va fer arribar una proposta en relació a la celebració del bicentenari del naixement de Darwin.

2 de març de 2009

La sessió es va dedicar a parlar de evolució. La Mariona Domenech va fer una explicació sobre els conceptes clau en evolució a partir d'un powerpoint molt clar i ric en idees. A la darrera part de la sessió varem fer una activitat per simular el procés de selecció natural i les seves conseqüències en les poblacions naturals.

30 de març

Presentació del material sobre com treballar l'evolució a Primària.

4 de maig de 2009

Aquesta sessió va estar a càrrec de Montserrat Cortadellas. Artista plàstica interessada des de fa més de 10 anys en temes d'educació.

8 de juny de 2009

Presentació de la maleta sobre evolució. Victòria Carbó

Tot el material de la maleta està a la pàgina del CEDET. **http://www.xtec.cat/cdec/portada.htm**

Activitat dels ratolins. Teresa Calveras

Com funcionen les nostres joguines? Neus Garriga

Propostes pel curs vinent

Per les diferents intervencions es va detectar una certa inquietud en relació amb la gestió del currículum. Del tipus:

Davant d'un currículum tan extens que cal assegurar a cada cicle?

Quines preguntes ens hem de fer davant les propostes dels llibres de text?

Com lligar els projectes amb el currículum?

Com seqüenciar els projectes? Per evitar parlar 3 cursos seguits d'energia i oblidar altres temes.

El tema dels projectes pot ser interessant. Sobretot aprofundir com es passa del estudi concret d'una temàtica a la generalització o model.

Altres temes:

Com avaluar la competència científica? O com avaluar la comunicació a la classe de ciències? Quins indicadors utilitzar per avaluar- regular la qualitat de les produccions dels alumnes

Memòria del curs 2009-10

Tinc un problema a amb la memoria del curs 2009-10. No trobo la carpeta.

Memòria del curs 2010-11

Els dies de reunió seran:

27 setembre, 8 novembre, 20 desembre, 10 gener, 7 febrer, 14 març, 4 abril, 2 maig, 6 juny

1- Proposta de treball pel curs actual

Es parla de les pissarres digitals. Es comenta que seria interessant saber quins avantatges representa el seu ús i quins recursos hi ha disponibles a la xarxa, per saber de quina manera utilitzar-la. Es parla de l'Escola Juncadella de Sant Vicens de l'Hort, com escola innovadora en aquest recurs.

En Jesús Chivite que ha fet la seva llicència sobre les TAC i les ciències ens podria fer una explicació general i també específica en l´ùs de la PDI. Es proposa que ho faci a la seva escola i així recuperaríem una antiga tradició i a més podríem veure les pissarres en el seu context.

Compartir experiències és un altre aspecte que es considera important de recuperar. La Conxa s'ofereix per explicar la experiència que va fer el curs passat a l'escola Mas Rampinyo a Montcada sobre l'hort, les llavors i la plantació amb els nens i nenes de P3 i P4.

La Roser també podria explicar un treball sobre els esquelets i els vertebrats a tercer.

L'any 2011 és l'any de la química i potser es podria agafar aquest com a tema central del curs.

L'article de la Mercè Izquierdo ha agradat molt i ha donat idees. La Roser resumeix molt bé les tres idees clau que serien:

- Tot canvi es degut a un desequilibri, per produir-se necessita una empenta que pot ser: temperatura, aigua, electricitat, cel.lular, etc....
- Les interaccions poden ser lleus, intermèdies o fortes.
- Els elements es conserven.

La Montser Padern explica una experiència que va fer amb paper de seda i lleixiu. Primer es va observar la interacció del lleixiu amb el paper de seda i després amb altres materials. També va estudiar els óssos i per investigar de què estaven fets sel's va fer interaccionar amb diferents materials, entre ells el lleixiu

La cuina es veu com un context interessant d'estudi de la química. Al Centre d'Art Santa Mònica es fa una exposició *Matèria condensada. Cuinar cuina* que convida a llegir cuina, gastronomia i alimentació amb ulls científics. Es fa fins el 5 de desembre. També es parla de al fundació ALICIA (Alimentació i ciència)

La Rosa M Tarin exposa que també li agradaria molt treballar contes populars des de la perspectiva de la química. Contes com els 3 ossos, els 3 porquets, Epaminondes, la sopa de pedres podríen servir com a context d'aprenentatge. Es podria fer un treball semblant a la mà de contes elaborat pel Creamat i Carme Aymerich. **http://www.unamadecontes.cat/web/blog/tema/151**

La Núria parla d'un altre recurs a la televisió alemanya on tres nens a l'estil de les tres bessones parlen sobre temes científics. Es va comprometrà a intentar trobar-ne algun i traduir-lo.

També recordem al Beakman i els seus programes i experiments. La Teresa Pigrau diu que els té tots enregistrats.

De part de la Mercè els comento que hi ha un llibre que es titula "Converses sobre química" de Jane Marcet. És un llibre de 1806 on una institutriu (La Sra Bryan) parla i experimenta sobre química amb dues alumnes, la caroline i l'Emily.

El llibre és en anglès però la Mercè Izquierdo proposa que si hi ha algú interessat es pot fer uan traducció i un petit guió teatral per poder-se'n fer alguna representació.

A l'acabar la sessió concretem el següent programa:

- 8 de novembre. La Roser i la Teresa ens faran l'experiència de l'aspirina efervescent i la interpretaran des de la perspectiva del canvi químic. La Roser també ens explicarà un treball que va fer amb el most el curs passat. També ens faran arribar un article de Cavall Fort on es fa una comparació entre la taula periòdica i l'abecedari o les peces de Lego.
- 20 desembre. Cadascú farà una proposta de treball amb les seus nens i nenes relacionada amb la química. A la segona part de la reunió la Victòria ens presentarà la lectura sobre biodiversitat.
- 10 gener. Anirem a l'escola del Josep on ens explicarà el treball de la seva llicència i veurem les pissarres digitals.
- 7 febrer. Convidarem a la Mercè per comentar les diferents experiències.

Reunió 8 de novembre de 2010

Tenim dues noves incorporacions de l'Escola Riera de Ribes, la Neus i la Marga

1- Experiència de l'aspirina efervescent- Teresa Calveras i Roser Ylla

Reunió 20 de desembre de 2010

Roda d'experiències per treballar la química

Es meu, això? Victòria Carbó

La Victòria ens explica com ha treballat aquest conte amb els nens i nenes de 1r. Destaca el paper dels contes com a mediadors didàctics. Quan tinguem el ppt l'adjuntarem.

Reunió del 10 de gener de 2011

La trobada és a l'escola l'**Escola Sant Josep - El Pi. Avda. Josep Tarradellas, 122**. On ens espera el Jesús amb una coca de pacharan i nous boníssima. A tots ens crida l'atenció que una escola al mig de l'Hospitalet tingui un jardi tan gran i amb tant ocells. Encara que ja és fosc sentim cantar una

merla. A més l'escola que és d'una línia fa molt goig, els espais són grans, endreçats i acollidors. Fem la sessió a l'aula d'anglès que és on hi ha una PDI.

El Jesús ens explica la seva llicència d'estudis **"Com les TAC faciliten el pensar, experimentar i parlar de ciències a primària"**. Ho fa utilitzant la PDI (Pissarra digital interactiva).

Reunió del 7 de febrer de 2011

Mercè Izquierdo comença la seva intervenció amb un títol suggerent: **La Química que encara no és química.**

Reunió 14 de març

Presentació de llibres útils a les clases de ciències (Es poden trovar al moodle)

Reunió del 2 de maig de 2011

Informacions vàries

La Montserrat Pedreira ens espera el dijous dia 2 de juny a 2/4 de 6 al Niu de ciència, a dintre el Museu Blau.

Després de fer les votacions corresponents decidim que el títol des curs que oferirem el curs vinent serà: **Fer ciències per comprendre i actuar en el món.**

La Núria Alsina ens informa del VI congrés "Els infants, protagonistes de la ciència" de la comarca del Garraf; organitzat pel Centre de Recursos Pedagògics CRP. La propera setmana estaran ja disponibles totes les ponències de les escoles - encara que ja hi han moltes de penjades-, i a partir de la següent setmana , es podran veure en diferit les exposicions orals dels nens i nenes. **http://congrescienciagarraf.info/**

També quedem que la propera sessió al ser la última anirem a sopar, com ja és tradicional.

1- **L'esferificació- Conxa Colom i Teresa Aparici- Escola Mas Rampinyo de Montcada i Reixac.**

2- **Com és que la closca de l'ou es torna tova. Carme Cuberes. 5è Primària. Escola Oriol Martorell**

3- Temes per la propera sessió:

   Rosa M Tarin i la Teresa Pigrau explicaran una proposta de treballar naturals i socials a través de les imatges.

   L'Eulàlia Berbel i la Roser ens explicaran com fer un compostador

   Explotarà, s'inflarà i s'enlairarà. P5. Escola Llebeig

2 de juny de 2011 Visita al Museu blau

Reunió del 6 de juny de 2011

Informacions vàries

Es comenta que la visita al Museu Blau va ser molt interessant. Especialment ens va agradar el Niu de ciència i el seu decàleg. La Victòria Carbó comenta que seria interessant saber els criteris d'ordenació de les vitrines, perquè vam sentir que el Pere Viladot ho comentava però no els recordem. Volem agraïr a la Montserrat Pedreira la invitació al museu i les seves explicacions.

1- Escola Tanit. Santa Coloma. Isabel Muñoz i Marta

En aquest bloc **http://segontanit.blogspot.com/p/fem-ciencia.html** trobareu tot el que ens va explicar la Marta, la mestra de la classe dels pastissers. L'escola Tanit és una comunitat d'aprentatge i la Isabel n'és voluntària. Treballa amb les mestres i els fa suport de ciències. Amb la Marta han treballat aspectes relacionats amb l'alimentació. A partir d'un ppt preparat per elles els nens i nenes van triar el nom de la classe: els pastissers.

Al bloc està clarament explicat tot el procés. La Marta comenta que quan va acabar el primer trimestre estava una mica intranquil.la en veure la quantitat de temps que havia dedicat al projecte. Però després es va tranquil.litzar en pensar que havia fet molts temes del llibre de coneixement del medi natural i social per amb molt més sentit que fer una lliçó darrera una altra: aliments, aparells digestiu, canvis en els materials, envasos. A més també va fer matemàtiques (pes net, pes brut, mesures....)

Va ser una exposició molt interessant ja que mostrava de manera molt endreçada i coherent moltes de les activitats que uns i altres heu anat fent en relació al cos humà.

2- 6è Congrés Els Infants protagonistes de la ciència. Vilanova i la Geltrú. Núria Alsina. Escola Arjau

http://congrescienciagarraf.info/index.php/ponencies?idPonencia=66

La Núria ens va explicar l'organització del congrés, la manera de preparar les intervencions orals dels grups, la manera de gestionar-ho, etc...

Ella va presentar la ponència del **cotó a la roba** feta amb els nenes i nenes de 2n de l'Escola Arjau. Primer ens va explicar el treball amb un ppt i després vam veure com els nens i nens ho explicaven al congrés (Heu d'anar a la part de la pàgina on diu Videos 6è congrés). Ens va portar una planta de cotó que han fet créixer a partir de llavors. És un treball molt interessant.

La Teresa Roger també ha participat amb els seus alumnes i a la primera sessió del curs vinnet ens explicarà la seva experiència, ja que aquest dia no va poder venir.

3- Calendari i programa del curs Fer ciències per comprendre i actuar en el món

Primerament vam fer el calendari de les reunions del grup pel curs vinent (aquest any anem més avançats que mai)

19 setembre, 3 octubre, 7 novembre, 12 desembre, 9 gener, 6 febrer, 5 març, 2 abril, 7 maig i 4 de juny.

Això ens va servir per determinar el calendari del curs que serà en dilluns i a partir del segon trimestre:

Calendari del curs: Fer ciències per comprendre i actuar en el món

Gener: 16, 30; Febrer: 13, 27; Març: 12, 28; Abril:16; Maig:14

Fer ciències per comprendre i actuar en el món

El nostre entorn està ple de realitats properes o llunyanes amb interés pels nens i nenes. Una observació, una lectura, una notícia pot estimular que ens plantegem preguntes i que volguem saber –ne més. L'objectiu del curs és pensar com aprofitar aquests contextos per ensenyar i aprendre ciències amb "sentit". Es farà una reflexió metodològica sobre l'aproximació escolar als continguts científics- la ciència dels materials, els éssers vius, l'energia, la dinàmica terrestre, el treball experimental- tot posant un èmfasi especial en la comunicació, la interacció i l'avaluació

Appendix 2. Teachers's interview

English translation

Field	Question	Sub-Question
0. General Information	a) How many years have you been participating in this innovative group?	
	b) How did you arrive to it?	
	c) Have you worked in the same school while you have been participating in the group?	
1. About the innovative group	a) How would you describe the group dynamics?	Is it centered in the design of mat reflections about classroom managemer science education in general, solution of ... Are the contents dealt in the group emer the schools, from the participant teach participants, from the group coordinator...
	b) Do you think that the objectives of the group agreed when the group was created are being achieved?	In the document that the coordinator ha with us, it can be read "to know, to creat and to analyze" innovative exp - How is this process of test and analysis?
	c) Regardind the innovative group, which aspect/s would you highlight for its/their influence in your teaching tasks?	
	d) Which characeristics do you think that make the group special (if you agree that it is special)?	Do you think that it would be possible to w similar group in your own school? Why?
	e) If you had to mention an essential idea of the work carried out by the group, which one would it be?	

	f) What do you think the contact with research has contributed to the group?	How do you think that this contact has order to be effective?
	g) Do you think that there is anything that should be changed or that is not working correctly?	Which? Why?
2. Knowledge transfer	a) How would you describe the transfer of the topics worked in the group to your classroom? And to your school?	
	b) Have you been able to implement in your classroom the materials designed or discussed with the group?	
	c) What do you think that should be improved regarding this transference?	
3. Influence on colleagues	Which influence do you think you have had in other colleages From the innovative group From your schoolDel teu centre From other schools or other groups From the teaching community in general	

Appendix 3. Teachers' questionnaire

Grup de treball de ciències d'infantil i primària de l'ICE de l'UAB

Informació sobre els participants

Benvolgut, Benvolguda,

Com la coordinadora del grup ja et deu haver informat, des del CRECIM (Centre de Recerca per a l'Educació Científica i Matemàtica) estem participant en el projecte TRACES que té com a objectiu analitzar els mecanismes que poden acostar la recerca en didàctica de les ciències a la pràctica educativa.

Una de les iniciatives que estem analitzant des d'aquest projecte és el grup de treball de ciències de l'ICE en el qual participeu. Per tal de poder caracteritzar millor el vostre grup, us l'agrairíem que responguessis aquest breu qüestionari sobre aspectes del teu perfil professional.

Moltes gràcies per la teva participació.

1. **La teva formació inicial com a mestre comptava amb una especialització/intensificació en ciències o matemàtiques?**

   ☐ Sí (Si us plau, detalla breument)

   ☐ No

2. **Si us plau, completa aquesta taula:**

Ets mestre/a de primària o d'infantil?	
Anys d'experiència com a mestre/a	
Anys participant en el grup de l'ICE	
Formes part de l'equip directiu del teu centre? En cas afirmatiu, si us plau, especifica en quin càrrec (director/a; cap d'estudis; ...)	

3. **On sorgeix el teu interès per participar en un grup de treball sobre ciències?**

4. **Com vas arribar al grup de treball?**

5. **Com definiries el perfil de la teva escola en relació a les ciències?** (es fan projectes de ciències específics, es disposa d'un espai/temps/materials exclusius per a fer ciències...)

En cas que el centre tingui o comenci a tenir un perfil específic pel que fa a les ciències, ja era així abans que entressis a formar part del grup de treball o és fruit de la teva influència com a mestre/a interessat en les ciències?

6. **Com valores el treball que es fa en el grup de treball sobre ciències?**
    a. **Quines activitats et semblen més enriquidores i perquè?**
    b. **Quines activitats que no es fan t'agradaria que es fessin i perquè?**

Moltes gràcies per la teva participació

Appendix 4. Coordinator's interview

Grup de treball de ciències d'infantil i primària de l'ICE de l'UAB

Informació sobre la coordinació del grup

Benvolguda

Com ja hem comentat, necessitem aclarir alguns aspectes que en l'entrevista personal no vam incidir prou i que ara necessitem per completar el nostre estudi.

Gràcies de nou per participar.

7. **Si haguessis de definir la filosofia que guia el grup quant a didàctica de les ciències, quins aspectes destacaries?** (modelització, argumentació...)

8. **Quins són, per a tu, les principals avantatges i desavantatges d'aquesta iniciativa (grup d'innovació)?**

9. **Quin dels aspectes que, per a tu, són efectius en la formació del professorat s'estan aplicant al grup i quins no s'estan podent aplicar?**
   Per què?

10. **Després de les entrevistes, hem vist que no és una tònica general en el grup el fet de dissenyar conjuntament materials, adaptar-los, implementar-los i reflexionar també conjuntament sobre aquesta implementació.**
    a. **Què podria aportar aquest tipus d'activitat al grup?**
    b. **Què dificulta que no es dugui a terme aquest tipus d'activitat pel grup?**

11. **Com d'actiu és el grup en l'espai virtual que s'ha dissenyat?**

12. **Podries explicar breument en què consistirà la formació que s'inicia aquest curs a càrrec del professorat del grup?**

Moltes gràcies per la teva participació.

Appendix 5. CDEC Teachers's interview

English translation

Field	Question	Sub-Question
0. General Information	a) How many years have you been participating in this innovative group?	
	b) How did you arrive to it?	
	c) Have you worked in the same school while you have been participating in the group?	
1. About the group	a) How would you describe the training that you have received/receive while participating with the CDEC's group?	Which contents are developed, who is in the training, how do you work with the c which are the outcomes…
	b) How would you describe the group dynamics?	Is it centered in the design of mat reflections about classroom managemer science education in general, solution of ... Are the contents dealt in the group emer the schools, from the participant teach participants, from the group coordinator...
	c) What would you highlight regarding the support received from the Adiminstration?	
	d) Regarding the group and the received training, which aspect/s would you highlight for its/their influence in your teaching tasks?	

		e) Which characteristics do you think that make the group special (if you agree that it is special)?	
		f) If you had to mention an essential idea of the work carried out by the group, which one would it be?	
		g) What do you think the contact with research has contributed to the group?	How do you think that this contact has order to be effective?
		h) Do you think that there is anything that should be changed or that is not working correctly?	Which? Why?
2. Knowledge transfer		a) How would you describe the transfer of the topics worked in the group to your classroom? And to your school? And to the schools were you have been giving training?	
		b) Have you been able to implement in your classroom and/or in the schools the materials designed or discussed with the group?	
		c) What do you think that should be improved regarding this transference?	
3. Influence on colleagues		Which influence do you think you have had in other colleagues From the CDEC's group From your school From other schools or other groups From the teaching community in general	

Appendix 6. Table for the design (Amilcar School)

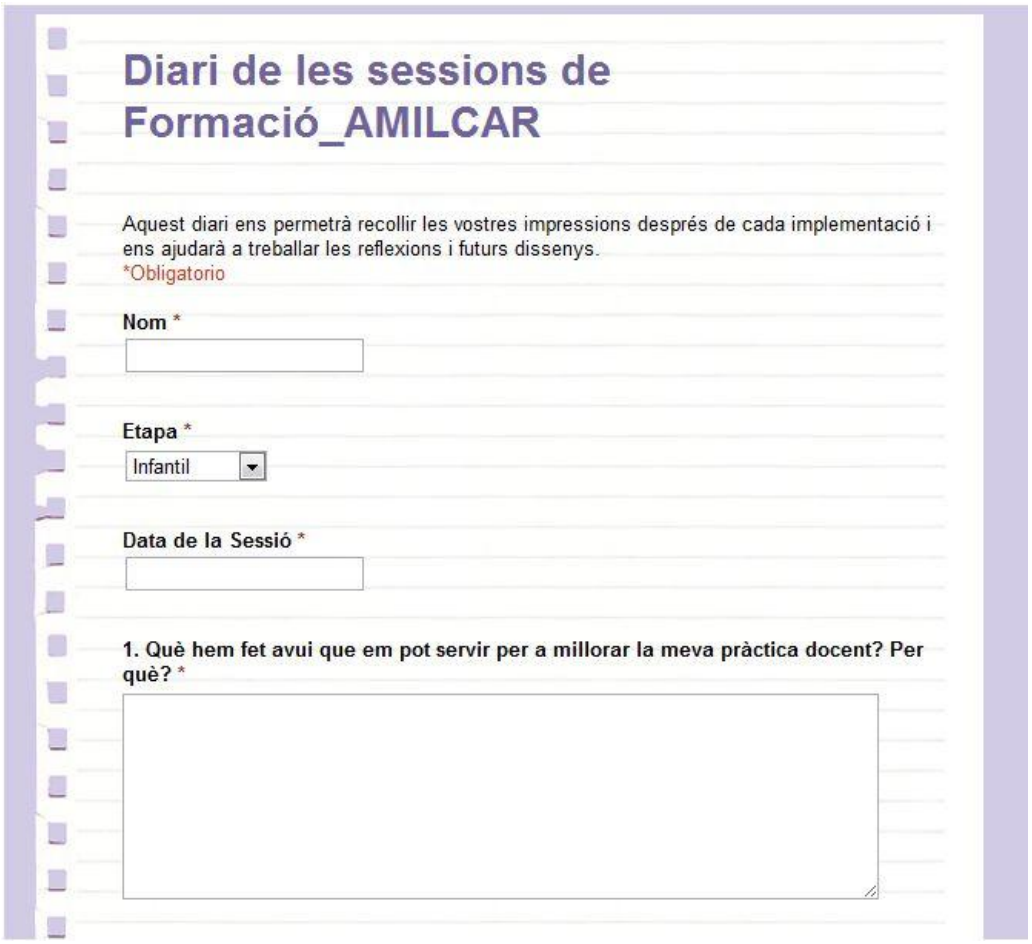
Problema a resoldre:	**Preguntes:**	**Continguts:**
Idees-accions:	**Activitats:**	**Objectius:**
Context:		

Appendix 7. Initial questionnaire (Amilcar School)

Què em va aportar la formació del curs passat, a mi com a mestre/a?	Què ens va aportar la formació del curs passat, a tots nosaltres com a claustre d'infantil i primària?

Què m'agradaria que m'aportés la formació d'enguany, a mi com a mestre/a?	Què m'agradaria que ens aportés la formació d'enguany, a tots nosaltres com a claustre d'infantil i primària?

Appendix 8. Training diary (Amilcar School)



Diari de les sessions de Formació_AMILCAR

Aquest diari ens permetrà recollir les vostres impressions després de cada implementació i ens ajudarà a treballar les reflexions i futurs dissenys.
*Obligatorio

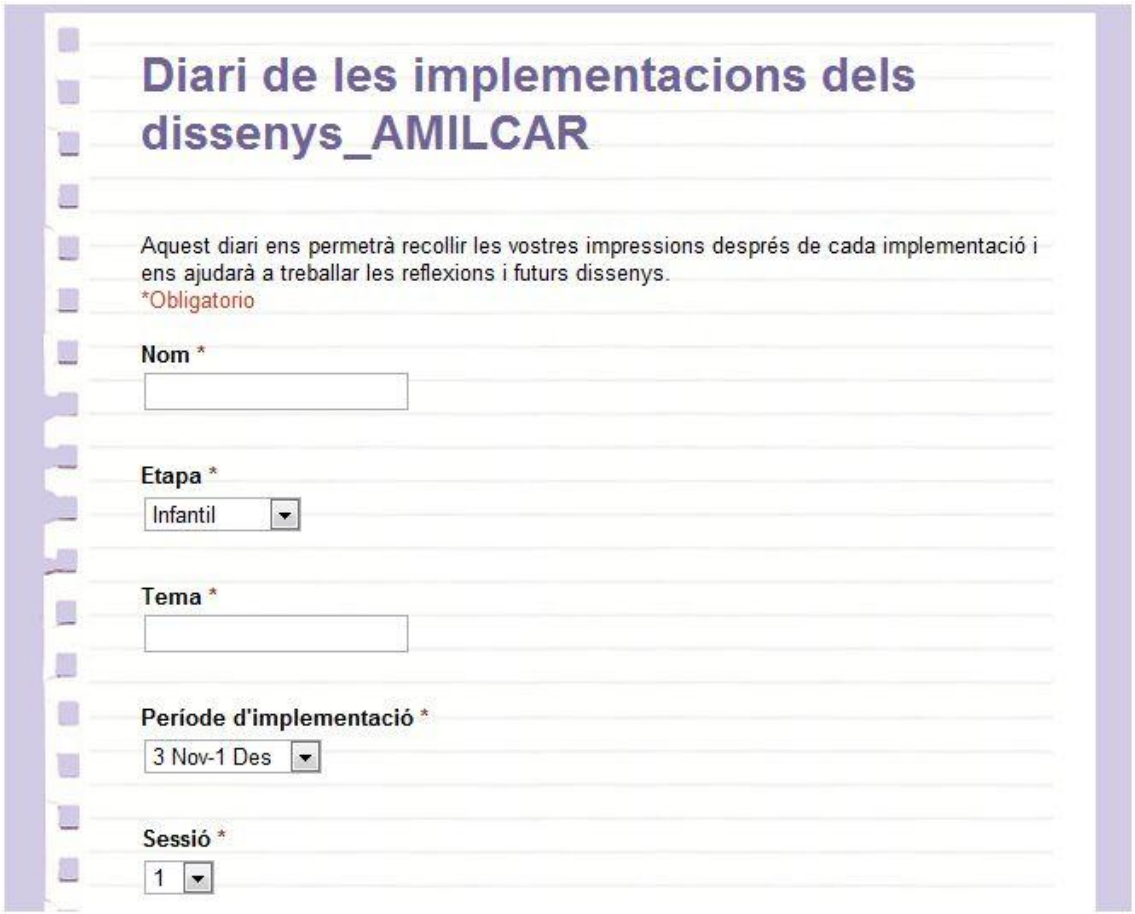
Nom *

Etapa *
Infantil

Data de la Sessió *

1. Què hem fet avui que em pot servir per a millorar la meva pràctica docent? Per què? *

Appendix 9. Implementation diary (Amilcar School)



Diari de les implementacions dels dissenys_AMILCAR

Aquest diari ens permetrà recollir les vostres impressions després de cada implementació i ens ajudarà a treballar les reflexions i futurs dissenys.
*Obligatorio

Nom *

Etapa *
Infantil

Tema *

Període d'implementació *
3 Nov-1 Des

Sessió *
1

Appendix 10. MDL training schedule

De acuerdo con la petición de los maestros del centro, la formadora, junto con la dirección del Colegio, estableció el siguiente plan de formación a tres años:

Curso académico	A petición de	Participantes	Contenido de la formación	Sustento económico
2010-11	Dirección	Maestros de Primaria	5 horas de formación sobre la matemática y el currículo competencial	Centro escolar
	Maestros del Ciclo Inicial de Primaria	Maestros del Ciclo Inicial de Primaria	Innovación en cálculo mental con el formato de formación de clases modelo y material de innovación	
2011-12	Maestros del Claustro	Profesores de Infantil y Primaria y Secundaria	10 horas de formación sobre el desarrollo del pensamiento numérico: cálculo mental y sobre resolución de problemas y heurísticas	El centro solicita una subvención al Centro de Recursos de Mataró (50%)
		Maestros del Ciclo Inicial y Medio de Primaria	Innovación en cálculo mental con el formato de formación de clases modelo, reflexión con el grupo de maestros y seguimiento de las innovaciones incorporadas en el aula	TRACES compra material didáctico para el desarrollo del pensamiento numérico (Multibases)
2012-13		Maestros de Primaria (los tres ciclos)	Innovación en cálculo mental con el formato de formación de clases modelo y material de innovación	Subvención del Centro de Recursos de Mataró (50%)

Appendix 11. MDL training schedule for the year, 2011-2012

a) Taller sobre el desarrollo del pensamiento numérico, en particular del cálculo mental.

DIA	HORES	CICLES	TEMA	CONTINGUTS
(07-09-11)	2	Infantil Inicial	Taller sobre desenvolupament del pensament numèric: càlcul mental.	Algoritmes i estratègies de càlcul mental (processos numèrics) Revisió del projecte de càlcul mental 2010/2011.
	3	Mitjà Superior		Algoritmes i estratègies de càlcul mental (processos numèrics) Presentació del Projecte de càlcul mental 2011/2012.
5 hores				

b) Taller de resolución de problemas y heurísticas

DIA	HORES	CICLES	CONTINGUTS
(08-09-11)	1	Infantil Inicial Mitjà Superior ESO	Marc general de la Resolució de problemes
	2		Taller de Resolució de problemes i heurístiques de resolució: contes, contextos, material manipulatiu i llapis i paper.
	2		Pràctica Reflexiva sobre la resolució de problemes.
5 hores			

c) Introducció i seguiment: projecte de càlcul mental i jocs de taula.

DIA	HORES 9:00-13:00	CONTINGUT	HORES 13:00-14:00	CONTINGUT
1 - (14-09-11)	1	Classe model primer A	1	Reflexió sobre la pràctica model Cicle inicial
	1	Classe model primer B		
	1	Classe model segon A		
	1	Classe model segon B		
2 - (15-09-11)	1	Classe model tercer A	1	Reflexió sobre la pràctica model Cicle mitjà
	1	Classe model tercer B		
	1	Classe model Quart A		

	1	Classe model Quart B		
3 - (11-01-12)	1	Classe model primer A	1	Reflexió sobre la pràctica model Cicle inicial
	1	Classe model primer B		
	1	Classe model segon A		
	1	Classe model segon B		
4 - (12-01-12)	1	Classe model tercer A	1	Reflexió sobre la pràctica model Cicle mitjà
	1	Classe model tercer B		
	1	Classe model Quart A		
	1	Classe model Quart B		
5 - (21-03-12)	1	Classe model primer A	1	Reflexió sobre la pràctica model Cicle inicial
	1	Classe model primer B		
	1	Classe model segon A		
	1	Classe model segon B		
6 - (22-03-12)	1	Classe model tercer A	1	Reflexió sobre la pràctica model Cicle mitjà
	1	Classe model tercer B		
	1	Classe model Quart A		
	1	Classe model Quart B		
24 hores			6 hores	
30 hores				

d) Seguiment d'innovacions a l'aula sobre resolució de problemes.

TRIMESTRE	HORES	CICLE	CONTINGUT
III - (10-04-2012)	2	INICIAL	Exposició de les innovacions implementades a l'aula durant el curs.
		MITJÀ	
		SUPERIOR	
		ESO	
2 hores			

e) Material i recursos:

- 8 jocs de multibase. Desenvolupament del pensament numèric.
- Material per elaborar els jocs de taula del projecte de càlcul mental: cartes, daus, fitxes, etc.
- Orientacions didàctiques pels mestres tutors del cicle inicial i mitjà.
- Quaderns de càlcul mental pels alumnes de primer a quart.

Appendix 12. Protocol sheet for the external observer

Observación de la primera sesión de formación. FECHA: _____

1. Aspectos motivacionales del profesorado (clima de intercambio en la sesión):

2. Participación del profesorado durante la sesión:

3. Foco de las intervenciones:

Conocimiento matemático	Aprendizaje de las matemáticas	Gestión del aula	Enseñanza de las matemáticas	Infraestructura	Otros

4. Creencias de los profesores sobre la influencia de la formación en generar cambios en su práctica:

5. Creencias de los profesores sobre la viabilidad de gestionar el proyecto de innovación y generar cambios en la escuela:

Observaciones:

Appendix 13. Initial questionnaire on community and classroom practice

NOM: _____ CICLE: _____

1. Amb una frase descriu quin paper creus que haurien de jugar en el teu creixement professional:
   a. Els companys de l'escola:

      _____
      _____

   b. L'Equip directiu:

      _____
      _____

   c. L'Administració educativa:

      _____
      _____

   d. Els alumnes:

      _____
      _____

   e. L'Entorn social:

      _____
      _____

   f. La recerca en didàctica de la matemàtica:

      _____
      _____

2. Com creus que hauria de ser un curs de formació per tal que t'ajudi a millorar les teves classes de matemàtiques?

3. Com valores les teves classes de matemàtiques:
   a. Quins aspectes destacaries positivament?

   b. Quins aspectes necessitarien millores?

4. En què et fitxes per saber que una classe de matemàtiques funciona correctament?

Gràcies per la teva col·laboració!

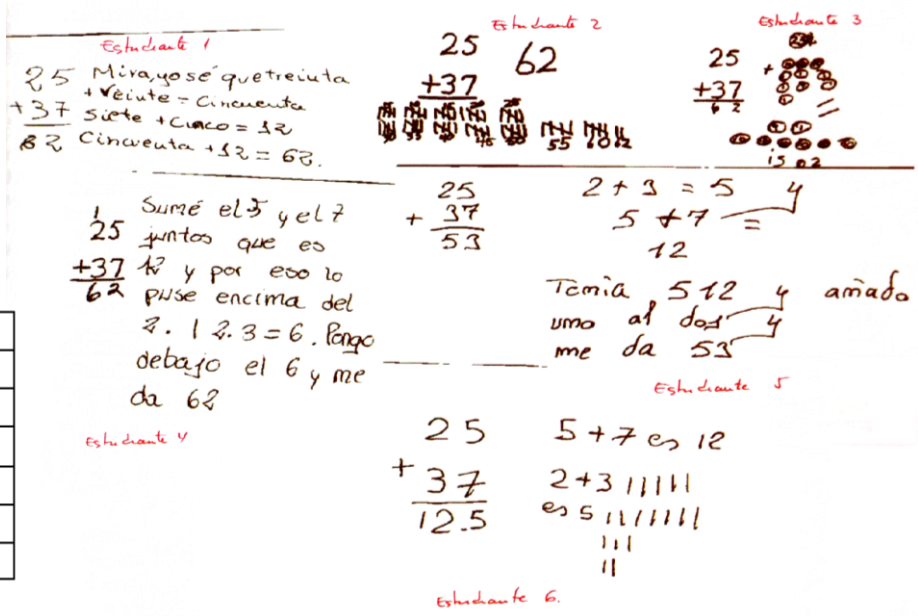
Appendix 14. Initial questionnaire on specialized mathematical knowledge about numerical thinking

NOM: _____ CICLE: _____

1. Valora de l'1 a 5, la importància que en l'actualitat doneu el professor del cicle a **l'ús habitual** a l'aula de matemàtica dels diferents tipus de càlculs: **1** totalment en desacord, **2** desacord, **3** indiferent, **4** d'acord, **5** totalment d'acord.

Tipus de càlcul	**1**	**2**	**3**	**4**	**5**
Càlcul escrit: treball sistemàtic dels algoritmes escrits de les operacions aritmètiques.					
Càlcul mental: és el càlcul de cap o de memòria (sense cap ajuda externa) i amb dades exactes.					
Càlcul estimat: es quan els nombres que s'operen són aproximacions subjectives per obtenir una resposta raonablement propera del resultat real.					
Càlcul abreviat: és l'escrit amb dades exactes però amb mètodes alternatius o adaptacions particulars dels algoritmes estàndards que estalvien o simplifiquen tasques.					
Càlcul aproximat: es quan els nombres que s'operen són aproximacions objectives, per restriccions obligades o limitacions derivades d'una mesura o acotació.					

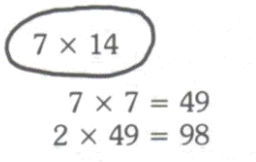
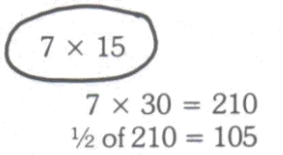
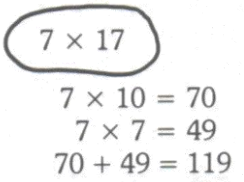
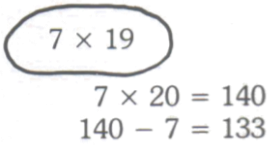
2. Valora de l'1 al 5 les resposta dels següents alumnes. I justifica com a mestre la teva valoració més alta i la valoració més baixa.



Tipus de càlcul	**1**	**2**	**3**	**4**	**5**
Estudiant 1					
Estudiant 2					
Estudiant 3					
Estudiant 4					
Estudiant 5					
Estudiant 6					

	Valoració més alta	**Valoració més baixa**
Per què?		

3. Observa els diferents mètodes de càlcul que han fet servir els alumnes per realitzar els següents productes. Podries descriure en què es basen els alumnes o quins coneixement de numeració fan servir implícitament?

	
Mètode 1:	Mètode 2:
	
Mètode 3:	Mètode 4:

4. Consideres que alguns dels mètodes anteriors són fàcils per explicar oralment, però difícil de escriure'ls? Quins i per què?

5. Consideres que alguns dels mètodes anteriors són fàcils d'escriure a la pissarra, però difícils d'explicar oralment? Quins i per què?

6. Creus que els nombres particulars seleccionats pels càlculs de la taula anterior poden influenciar l'ús de determinats mètodes de càlcul? Per què?

7. Analitza la resposta escrita d'alumnes de primària als següents algoritmes estàndards:

	CAS 1: $\begin{array}{r} 28 \\ +\,35 \\ \hline 513 \end{array}$	**CAS 2**: $\begin{array}{r} 54 \\ -\,28 \\ \hline 34 \end{array}$
Què li ha portat a aquest error?		
Com ha de respondre el professor?		
Com podem utilitzar les respostes dels per ajudar-los a millorar la seva comprensió ?		

8. Alguns alumnes ho fan d'una manera, i alguns d'altres maneres:

	$\begin{array}{r} 24 \\ \times\,17 \\ \hline 168 \\ 24 \\ \hline 408 \end{array}$	$\begin{array}{r} 24 \\ \times\,17 \\ \hline 168 \\ 240 \\ \hline 408 \end{array}$	$\begin{array}{r} 24 \\ \times\,17 \\ \hline 240 \\ 168 \\ \hline 408 \end{array}$
Comenta i explica que hi ha darrera de cada mètode?			
Creus que es pot usar una calculadora?			
Quina relació hi ha amb 7 x 8 = 3 x 8 + 4 x 8			

9. En quina de les dues situacions creus que els teus alumnes tindrien més dificultat per donar una resposta correcta? I per què?

Situació 1	**Situació 2**
$1 - 0.63$ $2 \div 0.01$	Quin canvi em donen a la pastisseria si pago 63 cèntims del pa amb una moneda d'1 euro? Quants cèntims tinc en 2 euro?

Gràcies per la teva col·laboració!

Appendix 15. Protocol sheet for reflection on the observed model class **T-1**

PROJECTE DE CÀLCUL MENTAL I ESTRATÈGIES DE RESOLUCIÓ

GUIÓ D'OBSERVACIÓ DE LES CLASSES MODEL

NOM: _____ CICLE:_____ CURS:_____

1. Què han fet els alumnes que pugui ser significatiu per al seu aprenentatge?

2. Per què ha passat?

PROJECTE DE CÀLCUL MENTAL I ESTRATÈGIES DE RESOLUCIÓ

GUIÓ DE REFLEXIÓ DE LES CLASSES MODEL

NOM: _____ CICLE:_____ CURS:_____

1. Anomena les diferents estratègies de resolució que utilitzen els alumnes durant la sessió?

2. De quina manera gestiona la professora l'aprenentatge dels alumnes a l'aula de matemàtica?

Appendix 16. Teacher's diary

PROJECTE DE CÀLCUL MENTAL I ESTRATÈGIES DE RESOLUCIÓ

DIARI DEL PROFESSORAT

NOM: _____ CICLE:_____ CURS:_____

- Què he après avui que em pot servir per a millorar la meva pràctica docent?

Appendix 17. Protocol sheet for reflection on the episodes chosen from the model class

Seminari de reflexió 2: Observem l'episodi 1 i reflexionen al voltant d'aquestes preguntes.

1. Què destacaries d'aquest episodi?	2. Què ressaltes com a important d'aquest episodi pel desenvolupament del pensament numèric dels teus alumnes?
3. Què canviaries de l'episodi i com es pot millorar?	4. Quines dificultats tindries tu com a mestre per gestionar aquest episodi i com consideres que les pots superar?

Seminari de reflexió 2: Observem l'episodi 2 i reflexionen al voltant d'aquestes preguntes.

1. Quines semblances trobes entre l'episodi 1 i el 2?	2. Quines diferències trobes entre l'episodi 1 i el 2?
3. Què t'aporta a tu com a mestre aquest tipus de discussions o reflexions per a millorar la teva pràctica a l'aula?	4. Què us aporta com a equip docent aquestes reflexions en les reunions de cicle o en la programació amb la teva paral·lela i quins problemes poden emergir?

Appendix 18. Outline of interview with two teachers of the MDL, 03/28/2012

Indicador	Pregunta	Subpreguntas
Reflexión sobre/para la práctica	Éste es un episodio de tu clase del otro día que me ha gustado especialmente, a) ¿Por qué crees que lo he escogido? b) ¿En qué te ayuda analizar este episodio para tu práctica en el aula? c) ¿Qué crees que les puede aportar a tus compañeros?	¿Estás de acuerdo con que se proyecte en la próxima sesión de reflexión? ¿Qué propones como guión que ayude a la reflexión del resto de maestros para la próxima sesión de manera? (qué destacarías)
Comprensión del contenido específico y de la metodología de aula que requiere	a) ¿Qué piensas de la forma de explicar las operaciones que propone el proyecto? b) ¿Qué otros aspectos de la forma de dar las clases de la formadora te llaman la atención? c) ¿Ves posibles aplicaciones para otros temas de matemáticas? d) ¿Ves diferencias en los alumnos/maestros con respecto a otros años / a medida que avanza el curso?	a/b1. ¿Hay algo en esta forma de explicar de la formadora que te gustaría incorporar (o que estás incorporando) a tus clases? a/b2. ¿Por qué te gusta / disgusta? c1. ¿Y de otras materias que no sean matemáticas? d1. ¿Argumentación, problemas en contexto, rapidez?
Posicionarse en un continuo	a) ¿Qué piensas de que se propongan estrategias que involucren conceptos de otros cursos? b) Hay ideas en matemáticas que pueden ser complicadas, como la división. ¿Cómo crees que influye el hecho de que se trabaje problemas de reparto en 1.º y 2.º?	a. (uso de paréntesis / propiedades de las operaciones / uso de los enteros) b. ¿Se te ocurren otros ejemplos de ideas complicadas de cursos superiores que se puedan trabajar en tu curso?
Reconocimiento del aporte externo (CMod / Ref.)	a) ¿Habías participado en otro tipo de formación permanente anteriormente? b) ¿Cómo definirías este programa de formación? c) ¿En qué crees que te puede ayudar a la hora de preparar y dar clase?	a1. ¿qué puntos te parecen positivos/negativos en comparación? b1. ¿Qué te aporta la observación de las clases de la formadora? b2. ¿Y la reflexión con los compañeros? b3. ¿Y visionar episodios seleccionados de clases? c1. ¿En qué momento te influye más la formación: planificación, gestión, evaluación?
Participación en la comunidad	Esta formación hace que los maestros del ciclo os planteéis cuestiones acerca de la manera de dar los contenidos en las clases, ¿Se hablaba antes de estos temas en vuestras reuniones de profesores? a) ¿Qué implicaciones en el aprendizaje de los alumnos crees que puede tener el hecho de que se hable de esto en el claustro? b) ¿Cómo crees que influye en la relación con los compañeros? c) ¿Y en relación con la escuela?	¿Qué crees que influye para que se den o no estos puntos que acabas de señalar?

Appendix 19. Protocol sheet for reflection on the episodes chosen from the teachers' classes

Seminari de reflexió 2: Observem l'episodi 1 i reflexionen al voltant d'aquestes preguntes.

1. Què destacaries d'aquest episodi?	2. Què ressaltes com a important d'aquest episodi pel desenvolupament del pensament numèric dels teus alumnes?
3. Què canviaries de l'episodi i com es pot millorar?	4. Quines dificultats tindries tu com a mestre per gestionar aquest episodi i com consideres que les pots superar?

Seminari de reflexió 2: Observem l'episodi 2 i reflexionen al voltant d'aquestes preguntes.

5. Què destacaries d'aquest episodi?	6. Què ressaltes com a important d'aquest episodi pel desenvolupament del pensament numèric dels teus alumnes?

7. Què canviaries de l'episodi i com es pot millorar?	8. Quines dificultats tindries tu com a mestre per gestionar aquest episodi i com consideres que les pots superar?
9. Al visualitzar per segon cop l'episodi 2, intenta reflexionar sobre els següents aspectes: 4.1. Relació entre l'enunciat verbal d'un problema i l'operació necessària per resoldre'l (Llenguatge quotidià vs. Llenguatge matemàtic) 4.2. Diferents significats del llenguatge matemàtic per a la resolució del problema: 4 + _____= 10 10 – 4 = _____ 10 – 6 = _____	10. Redacta un enunciat d'un problema per: 4 + _____= 10
11. Redacta un enunciat d'un problema per: 10 – 4 = _____	12. Redacta un enunciat d'un problema additiu per: 6

Appendix 20. Letter sent to families of students 3. º grade on the multiplication

UNA NOVA MANERA DE MULTIPLICAR EN COLUMNA

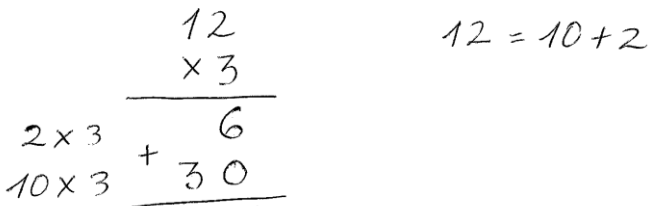
Usualmente en la escuela se enseñan los algoritmos tradicionales de las operaciones. Los algoritmos son "recetas" para calcular con dígitos. Los algoritmos son utilizados cuando se está trabajando con números naturales relativamente grandes y números con multi-dígitos decimales que son difíciles de calcular mentalmente de una manera simple y rápida.

Nuestra experiencia nos muestra que el trabajo sobre algoritmos NO ayuda necesariamente a los alumnos a comprender el significado de las operaciones. Por ello, como escuela hemos tomado la decisión de introducir el concepto de multiplicación a partir de un trabajo sistemático sobre el significado de la operación (suma repetida) y sobre el uso del valor posicional de los número con el objetivo de ayudar a los niños a una mayor comprensión del significado de esta operación.

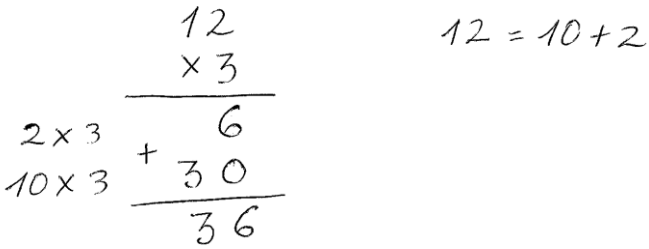
Los cálculos en columna están caracterizados no tanto por el método vertical de escribir el problema si no por la estrategia de descomposición de uno de los factores y el uso de los valores posicionales de los números cuando se calcula resultados intermedios. El método que aplicaremos consiste:

1. Utilizar la estrategia de descomponer el multiplicando (el primer número o factor) de mayor a menor: …centenas, decenas, unidades. El objetivo es trabajar el valor posicional de los números. Por ejemplo:

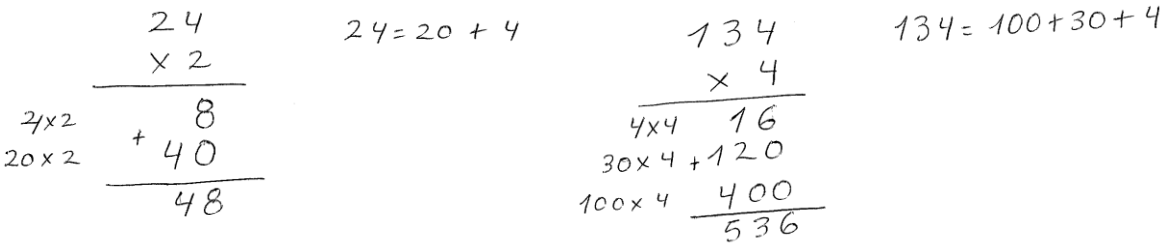
2. Aplicar la propiedad distributiva. Es decir, multiplicar cada uno de los números que forman cantidad total y se coloca el resultado de forma vertical.



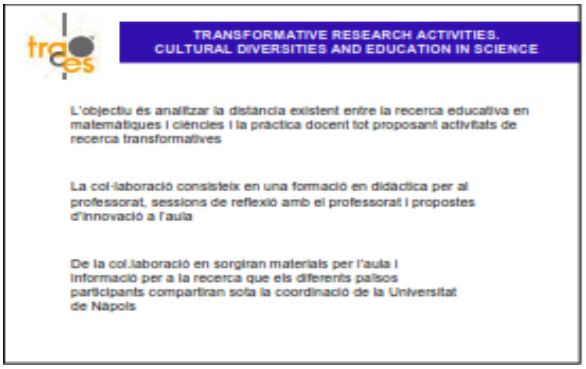
3. Sumar los resultados intermedios realizados y escribir el valor final.

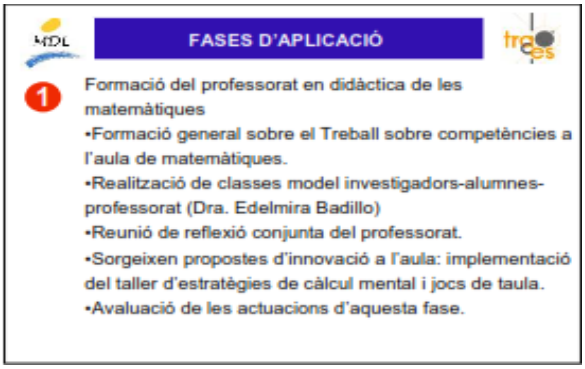


Otros ejemplos:



Appendix 21. Presentación al Ayuntamiento del proyecto de formación por parte de la Escuela





FASES D'APLICACIÓ

2 Aplicació a l'aula

Curs 2010-11. Cicle Inicial
Curs 2011-12. Cicle Inicial i Mitjà
Curs 2012-13. Cicle Inicial, Mitjà i Superior

Implementació del projecte d'Innovació en Càlcul mental i desenvolupament de competències matemàtiques.
•Desenvolupament del pensament numèric
•Foment d'estratègies de càlcul mental
•Resolució de problemes des de la pràctica reflexiva
•Utilització de jocs de taula

FASES D'APLICACIÓ

3 Anàlisi de resultats
•Observació a l'aula (professorat del Centre)
•Enregistrament en vídeo de les classes models de la **formadora/investigadora**
•Enregistrament en vídeo de les classes models de dues professores del centre (cicle inicial i mitjà)
•Enregistrament de les classes de matemàtiques de les tutores amb els alumnes del Centre

Figura 1: Fotograma, classe model (Tutora i mestre de suport observant a la formadora a l'aula)

FASES D'APLICACIÓ

3 Anàlisi de resultats
•Enregistrament en vídeo de la reunió de reflexió conjunta dels professors del cicle sobre la classe model observada

Figura 2: Fotograma, reflexió amb els mestres del cicle mitjà

FASES D'APLICACIÓ

3 Anàlisi de resultats
•Diari de reflexió del professor (on-line)

•Qüestionari als alumnes
•Resultats dels alumnes (av. continuada – llibrets de treball)

FASES D'APLICACIÓ

4 Gestió del projecte

Gestió administrativa de la formació
Gestió laboral-organitzativa del projecte TRACES

5 Comunicació - Informació

Carta presentació i reunió informativa a les famílies
Publicació al full informatiu "En xarxa" i al web
Presentació a l'entorn (Ciutat, Administració, Patronal)

FASES D'APLICACIÓ

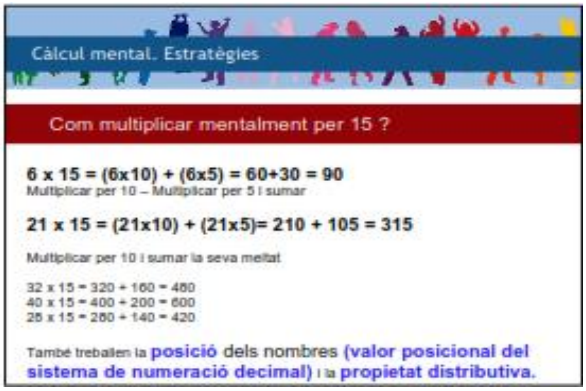
5 Comunicació - Informació

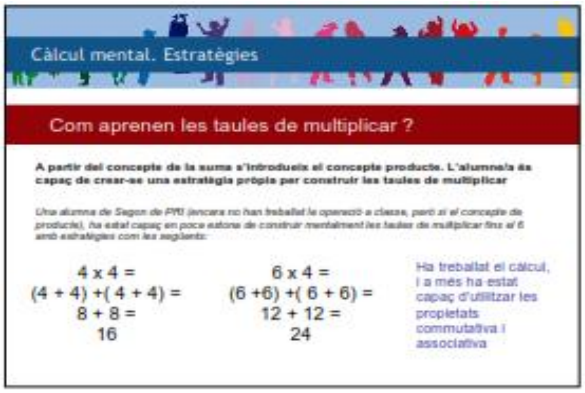
Carta presentació i reunió informativa a les famílies
Publicació al full informatiu "En xarxa" i al web
Presentació a l'entorn (Ciutat, Administració, Patronal)

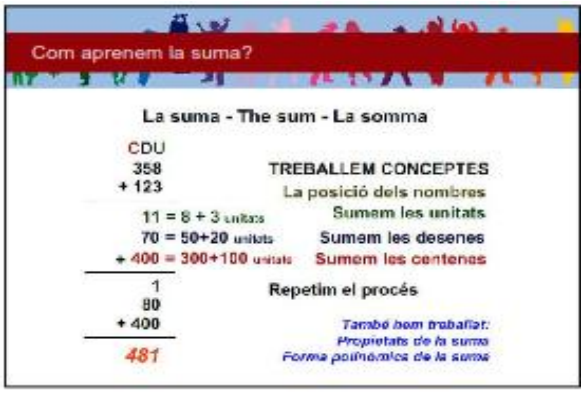

Competències bàsiques
ens agraden més les mates
inventen estratègies
tractament diversitat
constància
Alumnes
repetició
rapidesa
agilitat
augment autoestima
converteix les mates en un joc
comparteixen estratègies
valora més el què sap fer

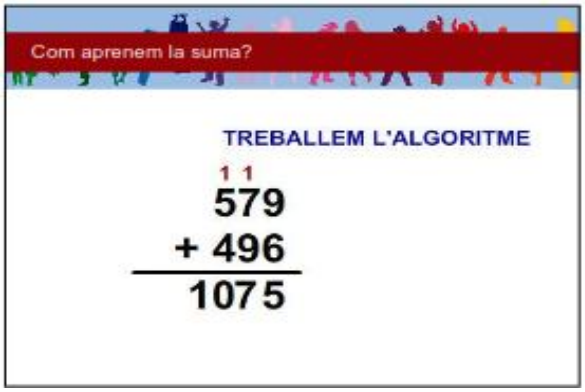

tractem la diversitat a l'alça
també aprenem
ens impliquem
atenem els alumnes amb dificultats
Competències bàsiques
Mestres
motivació
transversalitat
ús del llenguatge matemàtic
descobrim estratègies generades pels alumnes


Exemples

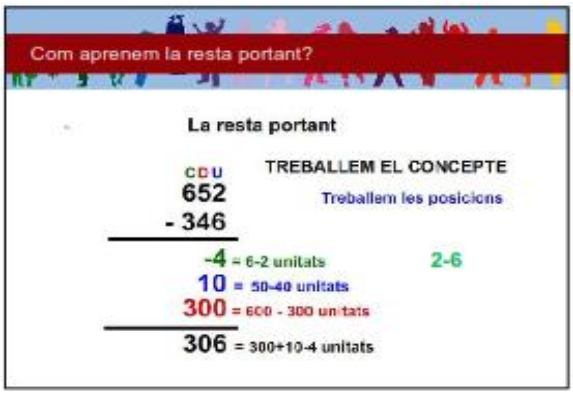

Càlcul mental. Estratègies
Com multiplicar mentalment per 15 ?
6 x 15 = (6x10) + (6x5) = 60+30 = 90
Multiplicar per 10 – Multiplicar per 5 i sumar
21 x 15 = (21x10) + (21x5)= 210 + 105 = 315
Multiplicar per 10 i sumar la seva meitat
32 x 15 = 320 + 160 = 480
40 x 15 = 400 + 200 = 600
28 x 15 = 280 + 140 = 420
També treballen la posició dels nombres (valor posicional del sistema de numeració decimal) i la propietat distributiva.

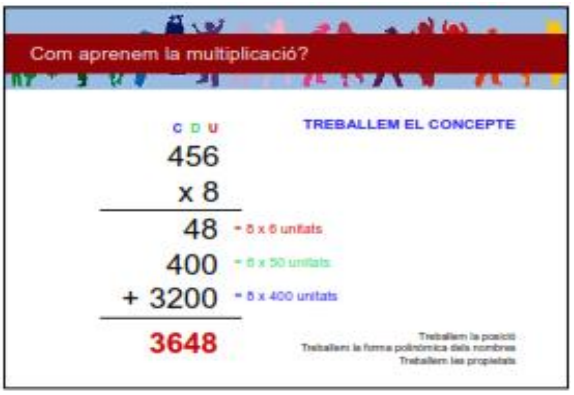

Càlcul mental. Estratègies
Com aprenen les taules de multiplicar ?
A partir del concepte de la suma s'introdueix el concepte producte. L'alumne/a és capaç de crear-se una estratègia pròpia per construir les taules de multiplicar
Una alumna de Segon de PRI (encara no han treballat la operació a classe, però sí el concepte de producte), ha estat capaç en poca estona de construir mentalment les taules de multiplicar fins el 6 amb estratègies com les següents:
4 x 4 =
(4 + 4) +(4 + 4) =
8 + 8 =
16
6 x 4 =
(6 +6) +(6 + 6) =
12 + 12 =
24
Ha treballat el càlcul, i a més ha estat capaç d'utilitzar les propietats commutativa i associativa

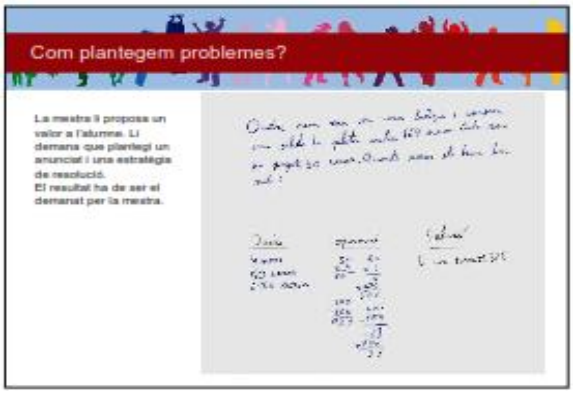

Com aprenem la suma?
La suma - The sum - La somma
CDU
358
+ 123
TREBALLEM CONCEPTES
La posició dels nombres
11 = 8 + 3 unitats
Sumem les unitats
70 = 50+20 unitats
Sumem les desenes
+ 400 = 300+100 unitats
Sumem les centenes
1
80
+ 400
481
Repetim el procés
També bem treballat:
Propietats de la suma
Forma polinòmica de la suma


Com aprenem la suma?
TREBALLEM L'ALGORITME
1 1
579
+ 496
1075


Com aprenem la resta?
La resta
CDU
987
- 444
TREBALLEM EL CONCEPTE
Treballem la posició
3 = 7-4 unitats
40 = 90- 40 unitats
+ 500 = 900- 400 unitats
543
També treballem:
La forma polinòmica dels nombres
La relació suma-resta


Com aprenem la resta portant?
La resta portant
C D U
652
- 346
TREBALLEM EL CONCEPTE
Treballem les posicions
-4 = 6-2 unitats
2-6
10 = 50-40 unitats
300 = 600 - 300 unitats
306 = 300+10-4 unitats


Com aprenem la multiplicació?
C D U
456
x 8
TREBALLEM EL CONCEPTE
48 = 8 x 6 unitats
400 = 8 x 50 unitats
+ 3200 = 8 x 400 unitats
3648
Treballem la posició
Treballem la forma polinòmica dels nombres
Treballem les propietats


Com plantegem problemes?
La mestra li proposa un valor a l'alumne. Li demana que plantegi un anunciat i una estratègia de resolució.
El resultat ha de ser el demanat per la mestra.


Destinació
NÀPOLS
Del 8 al 12 d'abril de 2012


TRANSFORMATIVE RESEARCH ACTIVITIES, CULTURAL DIVERSITIES AND EDUCATION IN SCIENCE
Representants de Catalunya al Congrés de Nàpols:
Investigadors de l'UAB
Un representant de l'ICE (formació de mestres)
Un representant de l'escola AMÍLCAR de Barcelona (Ciències)
Dos representants del Col.legi Mare de Déu de Lourdes (Matemàtiques)


És una satisfacció molt gran per el nostre centre poder representar la ciutat i el país.
Encara ens satisfà més observar que el treball realitzat per els nostres mestres i alumnes és valorat per "savis" de la matèria, i que és un instrument vàlid per l'aprenentatge dels nostres alumnes.