PROJECT FINAL REPORT

TRACES

TRANSFORMATIVE RESEARCH ACTIVITIES – CULTURAL DIFFERENCES AND EDUCATION IN SCIENCE

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EXECUTIVE SUMMARY

This report summarizes the outcomes and impact of TRACES, a two-year FP7 research project on the relationship between research and practice in Science education implemented in Argentina, Brazil, Colombia, Israel, Italy and Spain.

The TRACES research programme included desk research, national surveys based on large-scale questionnaires and in-depth interviews and focus groups, 24 four case studies involving schools of all grades, and an international workshop involving teachers, principals, administrators and researchers from the six partner countries.

The research developed produced a rich body of data and insights that go beyond the research focus of the project. This is consistent with the project's research approach, aimed at identifying the actual constraints that influence research-based practice in science education and the actions developed in order to promote it and to address the project's research questions in terms of the complex system of factors involved.

The main outcome of the project is a series on findings and recommendations for future action related to seven elements of the science education scenario which emerged as most relevant from the project's research programme.

The elements include:

- Cooperation among teachers
- Exploiting existing resources
- Cooperation between teachers and researchers
- Teacher training
- Relationship between local and central
- Long-term sustainability
- Relationship between school and society

The report provides summary descriptions of the project's context and objectives, the main scientific results and project's impact and dissemination activities. More detailed accounts thereof are available in the project's deliverable, all publicly accessible on the project's website at www.traces-project.eu.

CONCEPT AND OBJECTIVES

A number of findings from research in science education are well known and broadly accepted. They refer e.g. to inquiry based, learning by doing, social dimension of learning, active learning, diversity of learning styles, based on individual, cultural, gender-related factors.
While much research commitment has been put into looking at students learning, recently also in terms of neural, cognitive and psychological processes, in the effort of identifying effective methodologies for science education, little attention has been paid at barriers that oppose to a broad acceptance of research findings in everyday practice of science teaching in our schools. For researchers working side by side with school teachers, it is everyday experience to see how difficult it is to receive indications coming from research and transform them into teaching practice: there are cultural barriers, preparation barriers, time and resource constraints.
On the other hand, the research on education in sciences is going through a process of re-examination and reflection on the results obtained and on the problems still open. Compared to the remarkable amount of information about initial knowledge of the students there is a nearly total lack of information on the potentialities of development of scientific proficiency in effective conditions of instruction. The attention consequently has been moved, from a prevailing concern about spontaneous misconceptions, that may hinder the conceptual changes necessary to access accepted scientific knowledge, to the investigation on how to obtain an adequate and effective connection between the teaching proposals and the cognitive and cultural (individual and social) background of learners. It is also recognized that the improvement of effective decision making about education programmes requires systematic studies on the ways that programs themselves are implemented in different educational settings. Nevertheless the research that examines the interaction between efforts to enhance educational practices and the structural elements of school settings remain still “critical, underfunded, and underappreciated” (see e.g. [1,2,3,4]).
Through a close coordination between researchers and practitioners, TRACES wanted to pay attention to the complexity [5] of educational settings, regarding as its principal feature the values of stakeholders (i.e. their views about individual human potential, their hopes and expectations of what society can become, their ideas about how social problems can be alleviated), the variability of educational programmes (due to variability of policies), the organization of education (as a multi-layered system of poorly-connected levels, for example low versus high grade or school versus family context), diversity (linguistic and socio-cultural differences influence the learning processes).
Therefore, TRACES promoted transformative [6] research activities and investigated the factors that contribute to the research-practice gap, in order to identify innovative policies in science education that can contribute to fill that gap.
It did so through both desk and field research, in a cyclic process of analysis, action, reflection, looking for answers to questions such as: What can research in science education bring to school practice? What are the barriers opposing to this process? What changes are necessary in order to address the problem? The most relevant part of the research activity consisted in the development of field actions in each involved country.
In detail the main objectives of the project were to contribute to:

- identify in the involved countries the actual barriers to link teachers’ practice and indications coming from research in science education;
- define exemplar ways (models) to produce communities (made of students, teachers, parents, researchers, policy makers) allowing for an operative development of effective practices in science education;
- provide recommendations to overcome criticalities in science education practices;
- realize a web site as a resource centre where all project materials could be published, including surveys and state-of-the art reports, field action documentation, case studies and cross-national comparisons, external evaluation results and final recommendations to be used for future actions.

The final recommendations aim at informing teachers' work, principals' management, policy makers' decisions, and researchers' activities. At the same time, the other main project outcomes (e.g. case studies) aim at authorities, policy makers, funding institutions, people in charge for curriculum development, teachers' preparation and professional development. Secondary target groups are teachers and students (e.g. for what concerns educational materials produced throughout the project development in several school involved in the field actions).
The project was structured in four main stages:

Stage 1: A survey of teachers' (and other stakeholders') perceptions about science teaching conducted in all the six partner countries;
Stage 2: Implementation in each partner country of field actions involving hundreds of teachers in the design, carrying out and analysis of educational activities in classrooms and in a process of critical reflection on their practice;
Stage 3: Production of several case studies in each partner countries, analysing the process of implementation of the field actions and the lesson learnt during their development;
Stage 4: Elaboration of the project final recommendations based on the surveys' results and on findings from case studies.

The research methodology was based on a mixed qualitative-quantitative evaluation strategy based on a common evaluation framework previously shared at the consortium level. Field actions was documented using audio and video recordings and logbooks kept by teachers and researchers. Questionnaires, interviews and focus groups were used to look at both teachers and pupils beliefs, interests, goals, understandings, and learning. The materials produced by teachers and pupils throughout the activities were also be collected and analysed.
Although the project has continually been informed by all the well-known extensive international surveys on science education already available (TALIS, TIMMS, OECD-Pisa), we decided to start TRACES with a specifically designed survey for three main reasons:

- having a chance to investigate more specifically the stakeholders' perception about the reasons for the actual distance between schools and the other actors involved in science education;
- posing the basis for the subsequent steps of the project, starting to directly involve teachers (and other relevant actors) in the participative process of development of the TRACES activities;
- gaining a deeper understanding of the actual educational contexts in which the field actions had to be implemented.

After having accomplished the survey phase during the first six months of the project (the related analysis is reported in the deliverables D2.1-2.6), the TRACES consortium used hints coming from a compared analysis of the national surveys in order to design a general framework for the implementation of the national field actions (deliverable D3.1).
Then TRACES researchers spent over a year working side by side with teachers at the development of educational activities on the field.
Based on a common rationale and action-research strategy, in each partner country, we created a team of researchers, teachers and principals who worked on shared objectives and met periodically to plan, analyse, reflect on the progress toward the project objectives.
In the process, we looked at teachers' difficulties and strengths in facing the challenge of revising their activities in progress taking pupils' diversities into account and linking to the curriculum and resources limitations. This also gave us insights on the adequateness of teachers' preparation and professional development and help us identify recommendations for future practice.
The findings emerging from these experiences were collected in the case study reports (deliverables D4.1-4.6).
Although the main focus of the field actions was the investigation of the research-to-practice gap, the strongly participative nature of the activities resulted in a huge variety of directions undertaken in order to fulfil local needs and expectations.

The consortium made a further compared analysis of the case study findings in order to come out with a draft of the TRACES final recommendations that was discussed with representatives of all the involved stakeholders during the project final conference (deliverables D5.1 and D6.1). Due to the richness of emerged elements, the final recommendations are not exclusively focused on the gap, but also on a number of related issues such as the exploitation of internal resources in schools or the relationship of schools with the socio-cultural context in which they are based.

The TRACES recommendations are aimed at all the stakeholders in the science education area: teachers, researchers, educators, school administrators, principals, policy makers. In fact, the findings that emerged from case studies suggested the tension between research and practice have to be mitigated alongside with other tensions and gaps involving the relationships of schools with educational authorities, other educational institutions, local communities. The recommendations are aimed at sharing the lessons learnt during the two years of the project and at giving recommendations on actual initiatives to be undertaken in order to exploit already existing resources at their best and favour the establishment of communities involving different stakeholders in order to improve the way science is taught in schools.

MAIN SCIENTIFIC RESULTS

Surveys

TRACES surveys (WP2) included both a Desk Research part and a Field Investigation part. The Field Investigation aimed at researching into structural difficulties to accept and translate in actual practices research results and institutional indications on science education and the perceptions of the social role of science and function of science education for a particular target group.

The Desk Research aimed at giving a picture of the scenario of science education in the school system of each partner country, with a special focus on the relevant national initiatives devoted to improve science education during a defined period.

Criteria for the Desk Research included: a period of approximately 10 years as a reasonable time window in which to look at national initiatives and reform programmes; a list of eligible existing documents on the school system scenario. Partner countries developed local plans for the Desk Research as appropriate to corresponding national peculiarities.

In each partner country, researchers looked at the significant reforms and initiatives related to (science) education and the way these have shifted pedagogical and didactic paradigms, the foci of science education, the methodologies fostered.

Desk Research in each survey accounted for aspects of the school system addressed in the large-scale teacher questionnaire and other relevant themes including: national curricula (for science); number of years of compulsory school; how science teaching is arranged at the various grades (e.g. one common science subject or different subjects like physics, chemistry, biology, etc.); pre- and in-service teacher training; teacher selection; assessment of learning; interaction among teachers; availability of laboratories and other experimental resources; relationship to research; funding of research and development programmes.

The main objective of the national surveys was to inform the design of the following field actions, whose analysis was developed in form of case studies. Therefore, what we expected to obtain from the Field Investigation was a deeper understanding of the educational contexts in which the field actions will have been implemented. On the one side, this means understanding if our basic research assumptions seemed reasonable and if we was missing some relevant aspects of the way the school system functions. On the other side, we wanted to investigate stakeholders' strategies, beliefs, experiences, difficulties, perceptions and analyse qualitatively their correlation with specific cultural contexts.

The Field Investigation was conducted *on a large scale* by means of questionnaires administered to teachers (mainly); *on the small scale* by means of interviews with teachers, principals, local schools authorities, policy makers, researchers by means of focus groups with other involved stakeholders.

The discussion among the researchers in the consortium coagulated in a common questionnaire to be administered to teachers in all partner countries, with small changes related to national peculiarities and translation. Questionnaires were piloted with a small number of teacher and fine-tuned before being administered (see appendix A in deliverable D3.1 for the English version of the common questionnaire).

The themes addressed included: beliefs about founding ideas (theories) of science teaching and their connection to practice; aims and social role of science and/or science education; interaction with colleagues; perception of national initiatives and official indications on science education; perception of pre- and in-service training; barriers to effective practice; sources of materials/ideas for teaching; role of assessment procedures; sources vision of effective science teaching; role of external actors in school practice; gender related issues in teaching/learning.

In each partner country, the same themes were inquired in greater depth conducting personal interviews and focus groups with smaller sample populations. Besides teachers, other actors involved in the system of education were included: school principals, local and national administrators and policy makers, researchers in science education and teacher trainers.

Whereas personal interviews provided qualitative data in order to gain deeper insight into individual perspectives, focus groups allowed for elements to emerge from debate among different individuals both in the same category (teachers, principals etc.) and from different categories in mixed groups.
As a consequence of their more context-dependent nature and the necessity of being based the preliminary results of the national surveys, interviews and focus groups had their protocols designed locally in each partner countries (see annexes to deliverables D2.1-D2.6). All protocols were nevertheless shared within the consortium prior to their implementation. The interviews and the focus groups provided a deeper understanding of topics connected with the research focus. Teachers, principals, policy makers, researchers in science education were interviewed or involved in focus groups. The topics to be treated referred to the general themes reported for the Filed Investigation.

Stratification of the samples

Coherently with the abovementioned objectives, we were not aiming at a statistically representative sampling, but to a sampling which was stratified enough to be significant for a qualitative data analysis, which means it included a reasonable variety in terms of some aspects that we identified as peculiar of the specific national contexts. The identification of relevant stratification criteria was therefore the most important point in the definition of the national samples.
A section of the questionnaire was devoted to collect information about each teacher in the sample, in particular about gender, training and research experiences, school grade in which he/she teaches and other topics, which could be useful to characterize the teacher according to the stratification criteria. Any request for data allowing personal identification was excluded.
Among all partner countries 1900 completed questionnaires were collected and 165 people participated in interviews and focus groups. A detailed record per country is presented in Table 1.

	Argentina	Brazil	Colombia	Israel	Italy	Spain	Tot
Large scale	479	145	215	64	709 (+81)	207	1819 (+81)
Small scale	12	29	30	34	45	15	165
teachers	3	7	30	8	40	7	95
principals		8	-	3	(81)	5	16
researchers	4	9	-	10	4	1	28
pol. makers	1	5	-	6	1	2	15
t. trainers	3	-	-	7	-	-	10

Table 1 – Detailed large- and small-scale survey samples per country

Sample in each country

Italy. The survey was conducted at national level. Five criteria were identified for sample: *geographic area* (northern, central, southern); *social context* (big city-centre, big city-peripheral, medium city, small city); *school grade* (elementary, 1st and 2nd grade secondary); *presence of foreign students* (more or less than 20%). The total number of collected questionnaires was 790 (709 teachers and 81 principals). In addition, four focus groups were conducted with four different groups of teachers. Altogether, 32 teachers were involved in focus groups. Another 8 teachers, 4 researchers and 1 technical officer of the Ministry of Education were interviewed.

Argentina. The survey was conducted in the province of Salta. The large-scale sample was stratified along to the following dimensions: *social context; geographic area; school level* (kindergarten and primary school). The total number of collected questionnaires was 478. On the small scale, 12 individuals were involved in personal semi-structured interviews, including 4 Researchers in science education, 1 policy maker, 3 primary school teachers and 3 teacher trainers.

Brazil. The survey was conducted in the state of Rio Grande do Sul. The sample was stratified according to four dimensions: *geographic area* (centre, south and north); *type of school* (state, municipal and private); *school level* (secondary school and high school); *social context* (urban, suburban, and small town). The total completed questionnaires were 145. On the small scale, 29 individuals were involved in interviews and focus groups, including: 8 school principals, 5 policy makers, 9 researchers in science education and 7 teachers.

Colombia. Three Colombian regions were selected for the national survey: Andean, Orinoco and Caribbean. For the specific national context, the stratification criteria assumed were: *socio-economics context* (urban, rural, suburban); *administrative organization* (city, region); *kind of migration* (for work activities, for conflicts); *school level* (primary, secondary). In total, 215 complete questionnaires were collected and 30 teachers were involved in interviews and focus groups.

Israel. The Israeli survey was mainly conducted through a large number of in-depth interviews. In total, 65 completed questionnaires were collected. On the small scale, 34 in-depth interviews were carried out with a sample of stakeholders composed as follows: 10 science teaching researchers; 6 policy makers; 7 teacher educators; 3 school principals; 8 science teachers.

Spain. The Spanish survey was restricted to the Autonomous Community of Catalonia. The large-scale Spanish survey sample was designed in order to cover consistently three dimensions: *type of school* (public, private); *immigration rates in the geographical area* (high, low); *school level* (primary, secondary). The total completed questionnaires were 207. On the small scale the sample includes 5 school administrators and 7 teachers, 1 researcher and 2 policy makers.

Elements emerging from the national surveys

In this chapter we want to present a cross-comparison of the data coming from the field investigations in the TRACES national surveys (deliverables D2.1-D2.6), trying to connect stakeholders' perceptions with the scenario of the national contexts as emerging from the Desk Research part of the surveys. We want to present the main issues that emerged by cross-comparing the national surveys, using both quantitative data from the answers to the teacher questionnaire and qualitative data form interviews and focus groups with teachers, principals, researchers and policy makers.

As a general reference for the following discussion, in Figure 1 we present the answers to one of the core questions in the teachers questionnaire, the one concerning actions to improve science teaching. The graph gathers together the answers given by the overall sample of teachers obtained by aggregating the national samples. The total number of answers collected is approximately 1800 (different numbers of answers have been collected for each item).

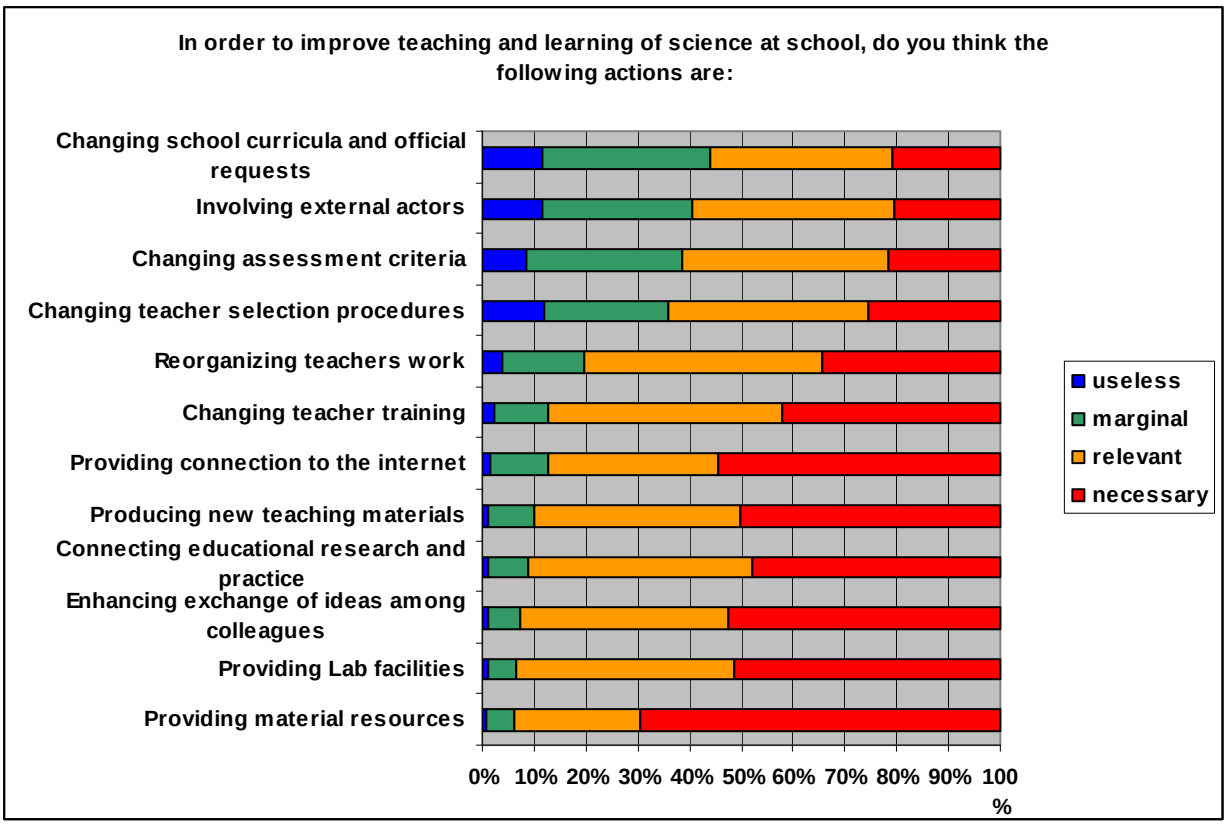

Figure 1 - Actions to improve science teaching – complete TRACES sample

Although the overall sample is biased by the different number of questionnaires collected in the partner countries (ranging from 64 in Israel to about 700 in Italy), some common trends emerge from the analysis of the answers to this question.

First of all, it is quite evident that the majority of the teachers perceives all the mentioned actions as at least relevant in order to improve science teaching, expressing therefore a strong need for structural changes in their actual practice. Nevertheless, a ranking in the importance attributed to the different actions by teachers is also quite evident: the need for more material resources (including laboratorial facilities and connection to the internet) is chiefly felt as strongly relevant, followed closely by the need for circulation of ideas and materials (exchanging ideas among colleagues, connecting educational research and practice, producing new teaching materials). Interventions on the general organization of their work (changing teacher training, reorganizing teachers work, changing selection procedures) are a bit less valued, while the interventions that are most poorly valued are the one regarding changes in the assessment criteria, involvement of external actors and changing curricula and official guidelines.

The picture emerging from this analysis is one of teachers who want to be provided with resources (material and not material) to sustain their work and don't believe they can profit of structural reforms or external intervention (including the interaction with researchers). In the rest of this section we will detail this general picture.

Impact of official guidelines on actual teaching practice

On the one hand, the desk research analysis carried out in each partner country highlights strong efforts towards the enactment of science curricula that are strongly rooted in up-to-date educational principles and goals and towards the implementation of initiatives for the improvement of science education that could enhance the actual impact of curricula and official guidelines on science teaching. On the other hand, the analysis of pre-existent research materials about the national school systems and of the data collected within the field research part of the TRACES national surveys show a wide separation between the aims of national policies and their impact on the actual work of science teachers in the classroom. The TRACES

surveys identified (or confirmed) a number of reasons for this separation as they are perceived by the different stakeholders in the school system. Most of these reasons are shared transversally although they emerge with nuances that are characteristic of the different national contexts. Among these reasons are the lack of involvement of different actors (researchers, teachers) in the design of policies, the weak connection between official guidelines and the actual teaching/learning contexts, the lack of knowledge of the guidelines by teachers also in connection with the lack of relevant teacher training initiatives and teachers' inertia with regard to didactical experimentation.

In all countries teachers expressed poor interest in changes in the official requests in order to improve science teaching. This is particularly evident in Italy and Colombia, where the majority of the teachers (59,5% and 51,1%, respectively) in the survey had a judgement of poor relevance for this item when answering to the question about action to improve science teaching (Question 8[1]). In other countries the answers to this same question were different (ranging from judgement of poor relevance expressed by 15,6% of the Israeli sample to a 38,4% in Brazil), but the item is everywhere one of the less valued when compared with the others. The hint coming from the answers to Question 8, is confirmed in the answers to Question 1 (sources of the important ideas for science teaching mentioned) and Question 9 (sources of ideas to improve teaching practice), where the item "official documents" is very poorly represented (by far the less mentioned item). This datum is more or less common to all partner countries as summarized in Table 2.

	Percentage of answers "official documents" in Question 1	Percentage of answers "official documents" in Question 9
Argentine	**11,7%**	**18,4%**
Brazil	**5%**	**18%**
Colombia	**not applicable[2]**	**not applicable**
Israel	**3%**	**6%**
Italy	**7,4%**	**9,9%**
Spain	**9%**	**11%**

Table 2 – Item "official documents" mentioned as source of ideas for science teaching in the teachers questionnaire

Choices of the other items in the answers to Question 1 and Question 9, show that the general trend is to value mainly one's own professional experience as a source of big ideas for science teaching, while resources available online, teacher training, colleagues and sometimes books and magazines are mentioned with difference strengths as sources of ideas to improve science teaching.

Let us summarize the reasons for the poor relevance (or bad perception) of official requests and documents as emerging from the national surveys.

A particular aspect in stakeholders' perceptions about the impact of official guidelines is connected with the introduction of standardized procedures for the assessment of learning, which is quite a topical issue in recent school reforms worldwide. There is almost general agreement in teachers' negative perception of this kind of tests as long as they expose to the risk of shifting the focus of teaching/learning towards the achievement of good results in the tests.

Teacher training

All the national surveys highlight teachers' general need for more specific training in order to be able to manage the contents of science curricula. The lack of specific training programmes developed in connection

[1] From now on, we follow the numbering of questions of the English version included in Appendix A of the deliverable D3.1.

[2] The item included in the Colombian questionnaire was modified to "documents", which has a different connotation.

with the latest science education reforms is also referred to in almost all partner countries. The perceived inadequacy of preparation often leads to a difficulty in acknowledging the official requests because they are badly understood and hardly translated into practice. Teachers often refer to their own professional experience as the main instrument allowing them to manage their work in the classroom. This scenario is well represented in the answers to the teachers questionnaire. For example, Table 3 summarizes the percentage of teachers mentioning "teacher training" and "professional experience" as sources of important ideas for science teaching they have learnt during their professional life: while professional experience is always mentioned by a large majority of the teachers, teacher training often falls below 50% of the answers. With the exception of Israel and Argentine (where the percentages are almost equal), professional experience is by far more strongly considered than teacher training. These data have to be read together with those contained in Table 2, connecting the poor relevance attributed to official guidelines documents to the lack of specific training. This connection is confirmed by the analysis of the interviews and focus groups.

	Percentage of answers "professional experience" in Question 1	Percentage of answers "teacher training" in Question 1
Argentine	**64%**	**64%**
Brazil	**73%**	**45%**
Colombia	**not applicable**[3]	**53%**
Israel	**62%**	**67%**
Italy	**88%**	**39%**
Spain	**81%**	**44%**

Table 3 – Items "professional experience" and "teacher training" mentioned as source of ideas for science teaching in Question 1 of the teachers questionnaire

Among the issues emerging from the analysis of the survey data, we want to underline the stronger need for specific training in science education expressed by primary school teachers when compared to secondary school ones. This last emerging issue is common to almost all countries.

Interaction among teachers

Collaboration among teachers and sharing of competencies and ideas are considered as a founding value and as an important resource by most of the teachers in the overall TRACES sample. Strong relevance is attributed to training among peers and more in general to the construction of networks of collaboration at different scales. At the same time, actual communication among teachers is often limited to issues related to the solution of organizational problems and institutional opportunities for dialogue usually do not foster a more significant interaction.

The results of our surveys show that teachers in the sample perceive interaction among colleagues as fundamental. In all countries, a large majority of the sample indicated the enhancement of the exchange of ideas among colleagues as a strongly relevant action to improve science teaching (Question 8), while colleagues are always mentioned as one of the most valuable sources of ideas for science teaching (Question 1 and 9). Nevertheless, interviews and focus groups showed that the actual situation of practicing collaboration is rather more complex. The attitude of everyone to question his/her own beliefs is considered as a necessary premise for a fruitful collaboration. Collaboration can be particularly effective when an interdisciplinary approach is used and, more in general, among colleagues who share the same concerns on students learning. One of the teachers interviewed in Italy identified a number of barriers towards an effective collaboration aimed at promoting innovations in science teaching: lack of esteem

[3] The item "professional experience" was not included in the Colombian questionnaire.

among colleagues and unwillingness of everyone to move from the balance reached after years of experience; lack of external motivation: no benefits (also economical) for the additional work to be done and poor interest by principals towards quality of educational activities; lack of training: without stimuli coming from training experience is even more difficult to be motivated to abandon well-established certainties.
In parallel with the appreciation of collaboration and networking as opportunities for a collective cultural growth, teachers in all countries notice that unfortunately most of the interaction among colleagues is generally devoted to organizational issues, such as students' misbehaviours, the management of conflicts or the accomplishment of bureaucratic duties, that are often the main priorities in teachers' work. Official modalities of interaction are often not mandatory and does not represent (at all school grades) a guarantee for actual cooperation and are on the contrary often perceived as very poorly constructive.

School organization
Another main issue emerging from the surveys is connected to structural barriers towards the improvement of science education that are characteristic of the national school organization. Among these barriers the more recurrent ones are the organization of teachers' work (mainly in terms of timetables) and the lack of materials resources. Interaction with school administrators is another point on which attention has to be focused, confronting teachers' perception about structural issue with the one expressed by principals. In fact, principals' main claim is shared with teachers and concerns the general perception of a strong lack of material resources, with special reference to the lack of lab-facilities addressed to the improvement of science teaching. In all countries, principals also claim the lack of teachers' adequate preparation in scientific contents and teaching methodologies, together with the lack of motivation among teachers, that makes it hard to implement innovation programmes. Teachers are seen as pursuing out-of-date teaching approaches, mainly based on the use of textbooks as the main resource. The structural need for a better selection of teachers is connected to the limitations in the role of the principal him/herself.

Socio-cultural issues
The possible differentiation among kind of schools or among school experiences (conceived for different students) seems to be an interesting topic coming out of the national surveys. The interest in this issue should lead us to deal with many themes, embracing problems we are not able to unravel exhaustively in the framework of our inquiry. Nevertheless, we would like to underline the link between this point and the wide reference to necessity of *contextualisation* in science education practice. According to the answers to open-ended questions the idea that science has to be contextualised to everyday and/or modern situations is recurrently highlighted. However, if we look at all the collected answers, we notice that *"sense"* is made explicit less than it is evoked. The question about what are the most adequate goals for science education is a very critical knot, which concerns the meaning itself and the articulated interpretation of "scientific literacy" and of its aims. Actually explicit teachers' beliefs reveal different ways to detail the usually-mentioned relationship between science education and everyday life, with the idea that scientific rigour could be "displaced" by interest in education for healthy living, balanced and well-being for all. On the other hand, there is a prominence of interest in developing of skills for individual life, in contrast to the interest in developing skills useful to belonging society. Obviously, a reflection about the aims of science education involve a parallel consideration of *motivational aspects*. In each survey it is outlined that teachers are mainly satisfied at the intellectual and the relational level, and in a lower measure at the social one (in the sense of social merit of their job). Main factors of professional satisfaction are success with students' achievements, respect from students and contact with them, students' motivation and engagement, working conditions, professional interest, development and renewal. It is important to outline that the *socio-cultural composition of classes* is one of the aspects that show a controversial profile according to teachers, being of none or bad influence for some teachers while having a positive one for others. Generally diversity of abilities in the classroom is problematic and relates with family situations and in some teachers' opinion it entail special strategies for the management of classroom. But it seems that teachers' think to deal with this theme without a link with outsider actors. In fact, *involvement of external actors* in the educational practice is a very few ranked option by most teachers, in particular those with

more experience and who participate in research. On the contrary, it is an important factor for primary school teachers. However, when asked to comment on bad or good administrative initiatives, none of the mentioned teachers' initiatives open the school to the society. A possible explanation for this lack of interest in involving external actors is teachers' (rather widespread) perception of the value society attributes to their work. The *linguistic skills* are priority and preparatory to science education, which appears referring to a well-said. In other cases, for example for what concerns the laboratory activities in second grade secondary school, the reference is also to a well-done, understood in a procedural meaning: skills in collecting and processing data, capacity to give a formally correct report. According to this perspective, many teachers mention the necessity to base science education activities on "practical work" and underline the importance to increase the material resources devoted to this kind of activity. Nevertheless, as a widespread attitude, laboratories are meant as a special context in which non-ordinary activities can be carried out. Moreover the typical description of lab activities given by teachers seems to present a naïve conception of laboratory activities, which is strongly based on pre-defined procedures and often lacks of the direct participation of the pupils.

Research vs. practice

A theme emerging from the answers to the questionnaire is connected to the judgement of poor relevance about the involvement of external actors expressed by the majority of the teachers in the sample. This perception is again in line with the strong relevance of professional experience as source of important idea expressed in the answers. Moreover, expressing their view about the factors that positively (or negatively) influence their teaching, teachers mostly mentioned their training, what appears students have learnt and their skill in managing scientific topics.

Putting all these consideration together it seems we can draw a picture of teachers expressing strong confidence in their teaching skills. This argument is reinforced by the strong relevance attributed to the connection between educational research and practice as opposed to poor relevance of the involvement of external actors. This could mean that teachers would like to perform an autonomous research work in their schools or alternatively that they would like to profit, but again autonomously, from educational resources produced elsewhere by research professionals. Generally, several factors (the same ones in all the involved countries) are considered as important regarding the success of teachers' participation in research and innovation. Teachers mainly think that research should be less theoretical in order to be more effective. In addition, teachers again pointed out to the necessity of time for participation in innovation and research. Moreover, teachers refer to the necessity of training to help their participation in the innovation.

However, there are many factors that make difficult an integrate work of teachers and university researchers: for same aspects, they seem to have divergent interests or constrains. In fact, from surveys it seems come out a teachers' view of academic researchers which does not encourage the possibility of an effective common work. The academic research in science education seems to be constrained by the limited recognition and power that educational research has in the academic arena and in its policies. It appears to be oriented by the professional education of researchers and extremely focused on specific components of the teaching/learning process (being very selective about the variables to control). The peculiarity of its methodological approach tends to make them blind to other features which are instead very significant within a class. Moreover, it is apparently unable to fulfil the expectations of the school system concerning the possible "discovery" of theories that may enable to predict learning outcomes from the application of practical algorithms in education field. Several point revealing a broad difficulty in the mutual comprehension. One of the main and most widespread critical knots in the relationships between these two sides of the education system relies in the teachers' opinion about the lack of awareness of school context by academic researchers, who are often considered as only interested to data collection in school, without giving any feedback. Therefore, in teachers' perception the interaction with academic researchers is seen as a special and potentially fruitful partnership. At the same time teachers depict researchers as lacking in the capacity to actually manage the work in the classroom, in terms of mediation strategies and awareness of contextual matters and related constraints.

While the idea of school as the place where mainly the research in science education has to be carried out come out from several directions (paying attention to several implications). At the same time, criticisms come from academic researchers to teachers.

Gender related issues

As evidenced by a wide literature, gender difference does play a role in individual and societal attitudes towards science and science teaching/learning. TRACES' surveys addressed the problem with three specific questions included in the teacher questionnaire in all partner countries. We asked teachers if they experience differences of interests in boys and girls towards different scientific themes (Question 13) or engagement in different types of activities (Question 14). We know, for example, from research that girls are more sensitive to those aspects of science that are related to societal issues, such as the preservation of ecosystems or health care. We also know that girls are usually more engaged by activities that involve communication and interaction with peers. We have also asked our sample teacher populations if they take any difference into account when they plan their activities in the classroom or if they revise their practice according to emerging differences (Question 12).

As we expected, a general result is that the issue is generally underestimated by the majority of teachers questioned. Most of respondents say that they don't notice difference among their male and female students and their comments suggest that taking difference into account is perceived as a kind of discrimination. The attitude perceived as "correct" seems to be treating all students as they were the same, the classroom as a whole, as if this would preserve equity.

On the other hand however, there is a significant number of comments, in which respondents do note that "I actually didn't think about this issue in this terms" and claim they should do more so.

Another interesting result is that, although the general trend is common to all partner countries, there are significant differences in proportions among them. In Italy, we found the largest percentages of respondents claiming that they don't notice differences between their male and female students for what regards science learning. The percentages of teachers answering negatively are all well above 80%.

When confronting these findings with those in the other partner countries one sees that the sensibility the highest sensibility to the subject is found in Israel and Brazil while Colombian results are somewhere in between.

Resonating with research literature, we also found that teacher mention a number of subjects such as sexual education or environmental issues as more popular among the girls and astronomy or electricity more popular among boys. Many teachers also mention communication as an activity in which the girls engage more willingly than boys do.

Teachers' beliefs with regards to gender related issues as emerging from TRACES surveys seem to represent another element of distance between research and practice.

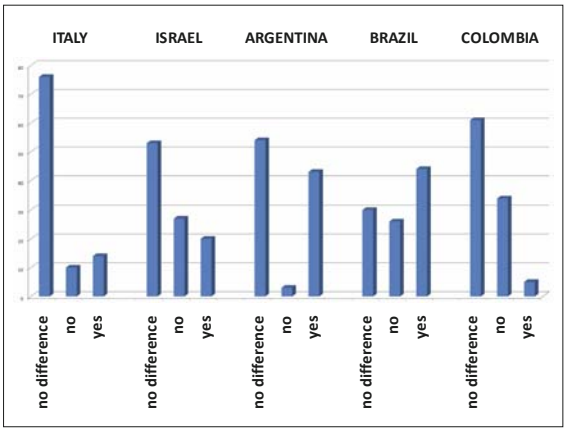

Figure 2 – Comparison of answers to Question 12

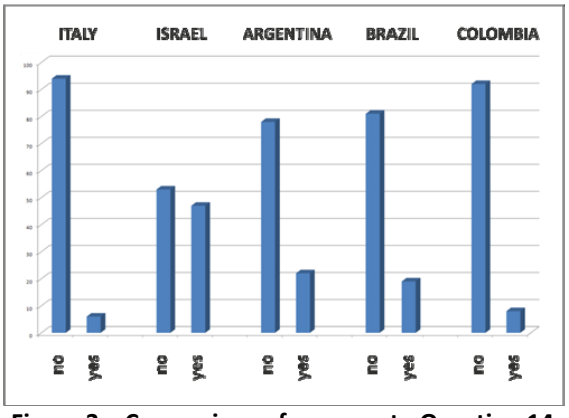

Figure 3 – Comparison of answers to Question 14

Case studies

TRACES field actions (WP5) were carried out over a period of 15 months, form January 2011 until March 2012. following a timetable composed of four main stages. The analysis of the documentation and evaluation materials collected during the actions was devoted to produce case studies describing the entire design and carrying out process. The design and implementation of the field actions were informed by the general criteria coming from the cross-comparison of the national survey: distance between official guidelines and actual teaching practice; relationship between school teachers and external actors; impact of assessment methods on science teaching; teaching practice as a research work; interactions among teachers; role of experimental activities in science teaching; teachers' self-perception of the adequateness of own preparation (training); gender related issues; impact of structural constraints on science teaching; role of the contextual dimension in science teaching.

Structure

Based on these insights, the TRACES coordination team produced common indications for the upcoming field actions (see deliverable D3.1). The wide degree of freedom agreed about the nature of the field actions gave rise to a reach variety of kind of interventions in schools including small or large groups of teachers, single schools or groups of schools, different dynamics of interaction (classroom activities entirely designed together with teachers or adaptation of proposal coming from science education research), strongly varied socio-cultural contexts. The Steering Committee (as scientific board) worked in order to define a common structure for the case studies: on the one hand, the structure had to be flexible enough in order to favour a narrative description of what happened more than a schematic reconstruction; on the other hand, a common set of analysis categories allowing comparisons among widely different contexts had to be provided. The process towards the definition of the final template for the case studies was therefore long and complex but the end the consortium succeeded in defining a suitable structure leaving room for both a qualitative interpretative description of the development of the field action and on a more focused analysis of six main research issues (meta-analysis questions) included: what role teacher education plays (official training; colleagues / community); what role educational authorities plays (official curriculum and official indications; supervisors / inspectors; external assessment; incentives / teacher career); what role the school structure plays (teachers' culture / tradition; administrative staff; students' culture; time available; school duties); what role educational resources play (access to ICT structures; available laboratories; adequate classrooms); what role the social community plays (parents; civil structures / social-economic context; economic activity / industrial context); what role research in science education plays (researchers; teachers´ access to research results; teachers´ perception of research; research findings).

Field actions were developed in a large number of schools in all partner countries. The choice of the schools to be involved tried to follow the same stratification criteria used during the national surveys and exploited the contacts established during the surveys themselves. The general vision of the field actions shared at the consortium level implied a collaborative research approach involving both teachers and university researchers in stable project workgroups designing and refocusing the actions during devoted periodic meetings. Based on field actions, several case studies were produced in each partner country (3 in Argentina, 3 in Brazil, 4 in Colombia, 3 in Israel, 8 in Italy, 3 in Spain). In the following section the main findings are reported, coming out from a cross-comparison of national case studies (deliverables D4.1 – D4.6).

Findings

Findings and recommendations presented in this report are based on a meta-analysis of case studies produced in each partner country.

In a first step of the analysis, a preliminary set of categories was produced, which could effectively organize the emerging issues. The categories produced by each researcher were then compared in terms of the related issues and a final set of seven categories (referred to as *themes* in what follows) was selected.

On the basis of the selected categories, a second-step review of the materials was carried out. This process, which again was conducted, by means of a set of preliminary findings coded in terms of the seven selected categories. Based on these preliminary findings we drafted a first version of recommendations.

Introduction to themes

Research carried out in the framework of the TRACES activities over a period of almost two years in six countries provides a vast richness of insights that often go well beyond the research focus of the project, i.e. the relationship between research and practice in science education.

This is consistent with the project's research approach, aimed at identifying the actual constraints that influence research-based practice in science education and the actions developed in order to promote it and to address the project's research questions in terms of the complex system of factors involved. This applies in particular to the case studies, which constitute the core of the TRACES research programme.

Working with teachers in the framework of actions aimed at promoting research-based science teaching implied addressing, along with the more strictly disciplinary and pedagogical issues, equally fundamental questions such as those related to teacher pre- and in-service training, those related to the relationships among teachers and with the principal in the school, those related to the local context in which the school operates, such as the relationship with the territory and the local community, those related to the broader (national or regional) context such as the relationship with administrative and supervising institutions, the education policies, the official curriculum and summative assessment procedures.

These elements play an important role in teachers' work and have to be taken into account when designing transformative actions, that is, actions aimed at changing practice.

Change implies questioning consolidated practice and involvement in the broader debate on science education in a process of continuous reflection and professional development.

This process is promoted by interaction with colleagues in the same school and with external actors such as researchers in science education or teachers from other schools or educators from the informal sector.

TRACES research shows that teachers can largely benefit from increased opportunities of sharing their experiences and reflections in a group that works together identifying common issues and strategies.

Such groups include discipline related groups such as science departments of different kinds according to the school cycle, cross-disciplinary groups, cross-grade groups in the same cycle, cross-cycle groups in comprehensive institute etc.

Our findings support the growing consensus (see [7] for a recent review) that developing professional learning communities promotes change in teaching by supporting reflective practice and professional development.

In the schools where teachers are used to work in groups with colleagues from the same school or in networks with nearby schools, TRACES field actions found a richer soil for common growth and effective exchange among teachers and with the researchers involved.

Issues which are recognized as shared by the group are more effectively addressed because self-confidence and motivation are strengthened. This also enhances teachers' attitude towards a perturbation to the ordinary work such as the one related to the interaction with the researcher. Moreover, a group of teachers who are able to establish common interests, needs, objectives are more likely to play an active role in creating or selecting targeted opportunities of professional development both in terms of structure and content. Such a bottom-up approach to the definition of specific professional development paths for different groups of teachers seems indeed promising in addressing the lack of coherence and systematicity which research identifies as one of the main issues in traditional professional development programmes (see e.g. [8, 9]).

Another element emerging as crucial to the impact of research on practice is teachers' perceived relevance of research results to their everyday practice. Relevance emerges as a key factor in teachers' relationship to research-based stimuli aimed at promoting change as they may receive through official indications and curricula, research literature, training or other professional development programmes.

As any other research sector, research in science education is specialized in its language and norms, which are established and recognized by its reference community. In order to set up an effective dialogue with the different communities of practitioners, mediation is needed in terms of what content is identified as most relevant and what language is more appropriate.

In most of TRACES field actions, researchers worked in schools with small groups of teachers trying to establish a participatory approach to the common work, in which researchers and teachers, notwithstanding the specificity of their competencies and roles, would cooperate as peers. This implied

involvement in the decision making process regarding both structure and content of the action and co-responsibility in the implementation and evaluation of the programme.
In agreement with earlier studies (see e.g. [10]) our findings suggest that if participants develop a sense of ownership of programme, the programme is better received and more likely to have an impact on practice.
Analysis of TRACES field actions suggests that teachers' sense of relevance of the actions' content is strongly corroborated if researchers and teachers interact in concrete settings such as classroom activities with students. Shared classroom work strengthens teachers' trust in the researcher and the educational approaches the actions aim at promoting and demonstrates their relevance to everyday practice in that they are confronted with real-world constraints. The classroom is perceived as the most reliable testing ground where the reflections developed at the researcher (or trainer)-teacher level can be evaluated in terms of soundness and applicability. By conducting activities side by side with the researcher teachers are also more likely to develop as sense of confidence with regards to the promoted pedagogy and the necessary autonomy for incorporating related stimuli in their practice in the long term. Our findings suggest that this applies both to training programmes and to more general professional development programmes such as teaching experimentations or action-research programmes. As a broad corpus of research suggests (see e.g. [11, 12]), 'authenticity' promotes long-term learning and teacher learning should indeed make no exception.
The ideas of co-responsibility, ownership and relevance also emerged as key features in another structural element in a systemic view of school and teaching.
While some of TRACES case studies were specifically focussed on issues related to the interaction between school the community and the local socioeconomic and cultural specificities, also in other case studies and the dedicated workshops conducted during the final conference these proved to play an important role in the way science is taught at school.
Teachers involved in our research programme seemed support the idea that the school should be seen as a collective construction in which teachers, pupils' families and other members of the community should be involved.
The idea of ownership and co-responsibility correspond on one side to seeing the school as an integral part of the community. An effective school is flexible to the needs and culture of the community in which it operates and is to which it belongs to the community and with which a mutual recognition of norms, values, visions is needed. On the other side, the community should be seen as an integral part of the learning process of the pupils and it should take responsibility in what happens at school.
Teachers' work is most likely to have an impact on the students if the learning process is supported by the families and more in general by the local community and if the role of the school in the community is recognized and valued.
The support of the community appears even more decisive when the school is committed to experimenting innovative pedagogical approaches. In the framework of TRACES field actions, teachers explored a number of different strategies aimed at involving the community while implementing research-based approaches to science education. Teachers' choices in terms of content also proved to be most effective when the content was recognized as relevant by the families and the local communities. For example, in rural communities in Argentina and Colombia, teachers involved in TRACES field actions focused their work on content related to local needs such as running water or devices powered through solar energy.
Taking the local needs and interests and the cultural specificities of the community in which the school operates into account requires that the school's choices in terms of content and pedagogy enjoy a certain degree of freedom. In other words, that external constraints such as the national (or regional, according to the country's educational system) curriculum and assessment prescriptions are flexible to a certain degree.
A flexible national science curriculum requires that fundamental learning goals are identified, around which a more specific content can be selected at the school or class level according to emerging needs. Although there is growing research commitment at level aimed at identifying scientific core ideas and related learning progressions through the grades (see e.g. [13]) further effort seems to be needed in this direction. Impact on the educational policies, science curricula and teacher training appears very limited.

Theme 1: Cooperation among teachers

Even if teachers spend most of their working time alone with their students, the relationship with colleagues plays an important role in their everyday practice. Along with the tasks institutionally appointed to collegial organs such as the school or class council, the science department etc., teachers share their experience, beliefs, perceptions in many formal and informal situations. In smaller or larger groups, teachers take decisions about curriculum, pedagogy, assessment, in-service training and work organization that are then reflected in their classroom practice.

A large majority of the teachers involved in the TRACES large-scale national surveys referred to better opportunities of cooperation and exchange with colleagues as one of the most relevant factors for improving science teaching in their schools. When asked about sources of conceptual stimuli about teaching and factors that influence their practice, teachers in our sample mentioned interaction with their colleagues among the most important elements.

In TRACES field actions, researchers from each partner team involved groups of teachers from schools of all grades in activities focusing on research-based approaches to science teaching. In some cases the groups shared a history of cooperation and professional development, in other cases, the group involved teachers who were not used to work together on a deep level of reflection.

Analysis of our case studies suggests that the impact of the activities was influenced by the extent to which participants were able to share needs and visions and work together as a group.

In Italy's CS1 and CS2, two groups of teachers with comparable levels of experience in both practice and professional development were involved in similarly designed programmes. In both cases, decisions about both content and structure of the programme were taken collegially. While teachers in CS2, who were able to identify common interests and objectives and take decisions accordingly, expressed general satisfaction for the programme, those in CS1, who clearly were less used to shared reflection, found it hard to agree on suitable programme content and finally lamented the scarce relevance and limited effectiveness of the programme. Notably, the second group included teachers from two formerly distinct schools just recently united in a comprehensive institute.

Involvement in a professional development programme in interaction with external actors such as researchers or teacher educators or expert colleagues is – together with specific pre-service training – the most relevant opportunity for teachers to be exposed to educational research.

Teachers who are used to cooperate with colleagues and able to establish common interests, needs, objectives are more likely to play an active role in creating or selecting targeted opportunities of professional development both in terms of structure and content. Such a bottom-up approach to the definition of specific professional development paths for different groups of teachers seems indeed promising in addressing the lack of coherence and systematicity which research identifies as one of the main issues in traditional professional development programmes.

As some teachers also highlighted, however, given the limited opportunities for professional development and more specifically in-service training activities, sometimes very few or even a single teacher in an entire school will be able to take part in such activities. This also partly depends on teachers' willingness to travel to another city or to invest part of their free time.

Also in this case, a group of teachers that make reflection and discussion an ordinary part of their work will be more likely to be able to take advantage of professional development experiences of single colleagues when they are shared within the group.

In any case, a practice of science teaching which is open to reflection and innovation based on stimuli coming – *inter alia* – from research results implies questioning ordinary work in light of an external stimulus that may – or may not – provide more effective approaches to teaching. In this regard, teachers in one of the final TRACES workshops interestingly referred to a 'perturbation' of an existing equilibrium.

TRACES research suggests that accepting such a perturbation requires strong motivation and confidence and that being part of a consolidated group of colleagues promotes both motivation and confidence. Sharing issues within the group implies opportunities for mutual support and for the exchange of competencies and experiences that may enrich and ease the work of all colleagues.

In many of TRACES case studies the presence of an external actor represented a catalyst in teachers' group dynamics, facilitating processes, producing commitment, creating a virtual space for interaction to take

place, or situations in which even existing structures (for example the science department in the school involved in Italy's CS7) were not effectively exploited.

Teachers identified lack of time and appropriate organizational structures as the main barrier to cooperation with their colleagues. The opportunities for working together, for example conducting activities in the classroom or exchanging roles of conductor and observer, and for meetings in the broader group are limited and scarcely acknowledged. Notably, institutional pre- and in-service training programmes usually do not include cooperative work activities.

Teachers in Spain's CS1 (see e.g. p. 65) referred to ordinary work organization as a 'trap' that forces committed teachers to make up time to devote to shared reflection by renouncing to personal needs.

In Italy's eight case studies, researchers provided involved teacher with online community tools through the TRACES website with the aim of promoting exchange of insights and materials. The tools included discussion groups, a repository of files aimed at the exchange of materials, and a blog tool to post comments about the development of the work, activities in the classroom, emerging issues etc. Although there was in fact very limited use of the tools, many teachers remarked their usefulness and suggested that resistance may be ascribed to the novelty of the medium and be easily overcome if the tools become integral part of the ordinary work.

Some teachers highlighted that the kind of work we were carrying out in the framework of the TRACES activities (see e.g. CS2) was indeed demonstrating the relevance of online tools such as repositories of materials and discussion forums to their teaching practice. It was also evident, though, that a key success factor was the fact that the materials collected and the discussions were strongly contextualized in that they were part of a wider programme including meetings in person, activities in the classes etc.

In the absence of preparation and awareness, even existing opportunities for teachers to meet and share reflection, such as the science department or the inter-class meetings often turn into service duties devoted to the accomplishment of bureaucratic tasks. Teachers in Italy's CS2 described a situation in which interaction tends to crystallize around tasks perceived as bureaucratic requirements such as the yearly programme development and there is indeed no real dialogue on deeper elements relevant to the teaching practice.

Prospective science teachers involved in pre-service training in Brazil's CS3 emphasized the relevance of cooperating in communities of practice and reflection groups and suggested that students accessing the courses should be selected according to their interest and availability to share experiences and reflection with colleagues.

Many teachers pointed out that for the interaction to be effective the level of the discussion should address fundamental questions such as visions of education and of science education in particular. Teachers in Spain's CS1 considered the opportunity to share reflections on science teaching in a research approach that involves deep analysis and evaluation of classroom activities with the aim of informing practice. The process seemed to be promoted by collaborative design of classroom activities, which provides a concrete common ground on which to share reflection on both disciplinary and pedagogical aspects.

The possibility of structuring the curriculum according to specific school or classroom needs and more generally of emerged was particularly valued by teachers involved in TRACES research. This was for example the case in Brazil's CS2 (see e.g. p. 89), in which official indications granted sufficient flexibility for mixing classes in larger groups of students and working with a team of teachers. Colombian (see e.g. CS2, p. 111) and Argentine teachers emphasized the need for national curricula to be general and flexible enough to adapt to local cultural and socioeconomic specificities with regards to the local community or the single class (see also THEMES 5 and 7).

Discussion on fundamental aspects such as the vision of teaching, the structure of the planned and implemented curriculum and students' assessment emerge as particularly relevant when teachers from different cycles interact. While official indications often emphasize the importance of continuity along cycles (verticality), school systems often display fractures in approaches related to different teacher preparation and selection, curricular structure, assessment procedures etc. Opportunities for teachers from different cycles to meet are also very limited. In Italy, recent reform is promoting the formation of comprehensive institutes including kindergarten, primary and lower secondary cycles.

For teachers in newly formed comprehensive institutes (see e.g. Italy's CS1), involvement in cross-cycle boards such as the science department represent both a challenge and an opportunity for sharing reflection about verticality issues and exploiting one another's specific competencies. In Italy's CS8, differences related to the vision of the role of the teacher and his/her responsibility with regards to students' learning seemed to represent a serious barrier in understanding how work in a higher cycle may build upon development in the lower cycle.

Sharing reflection and discussing within a group implies sharing doubts, difficulties, limits, and exposing one's own practice to public criticism. This is a demanding process and requires favourable conditions to be promoted. In particular, mutual observation of classroom practice, which many teachers referred to as effective peer-to-peer exchange activities with their colleagues (see also THEME4), may represent a demanding commitment for some. In Italy's CS8, teachers showed widespread resistance to being observed while teaching and more generally there were few cases in which teachers agreed to be observed when simply asked to do so. When mutual observation was instead explicitly supported and established as an integral part of the programme (as for example in Brazil-CS2, Colombia-CS3, Spain-CS2) teachers expressed great enthusiasm for the process.

Some teachers also pointed out that sometimes consolidated groups sharing common visions of education, along with practices of communication and interaction, might as well be subject to stagnation because inclusion of external stimuli is limited. In Spain's CS1 (see e.g. p. 68), a group of teachers from different schools with a long history of cooperation and common reflection on issues emerging from their everyday classroom practice emphasized how sharing a common approach to teaching and a consolidated relationship with academic research in education may represent a barrier to including other colleagues in the group.

Theme 2: Exploiting existing resources

The question of limited resources available to schools, in terms of personnel, materials, opportunities for in-service training etc. is perceived as paramount by most teachers involved in TRACES research. In the large-scale national surveys, teachers referred in particular to a higher provision of material resources, laboratorial facilities, connection to the internet as the most relevant factors for improving science education. TRACES research suggests that relevant resources exist in the school system which it is sometimes difficult to identify, acknowledge and effectively exploit.

Many teachers and groups of teachers develop rich professional knowledge through practice and in-service training. Many teachers have consolidated competencies in specific areas such as laboratorial activities, disciplinary content, pedagogical approaches, interaction with the informal sector, involvement in school- or university-based research programmes and may play the role of experts and support their colleagues' practice and professional development with limited impact on schools' budgets.

TRACES researchers found that expert teachers may contribute significantly to the development of the entire school when they take on roles of leadership in specific areas (Spain's CS1, see e.g. p. 67) or when their working time is organized in such a way as to enable them to support their colleagues, for example by advising about the design and implementation of laboratorial activities (Italy's CS7). In Italy's CS5, the entire development of a peer-to-peer training programme was put at risk when the leading teachers were forced to discontinue their commitment due to personal problems.

In Brazil's CS2, researchers found that the teachers in the school involved took up the role of leading actors in promoting innovation by making the best of the latest policy reform allowing for greater freedom in organizing classes and work around more cross-disciplinary conceptual nodes.

A relevant insight emerging from TRACES case studies involves the issue of how teachers may capitalize on their experience in classroom practice and professional development so that the experience of each individual can serve as a resource for himself and the teaching staff as a whole (see also THEME 1).

In particular, the problem of how to document experience and produce materials which are 'usable' by other colleagues and how to share these materials is very complex. According to the discussions in Italy's CS2, teachers identified the two fundamental elements for sharing and fruitful exchange of experiences in the documentation of practice and production of usable materials, and the meetings in person in which one gets the real feeling of what people need and why certain materials might be useful to one's practice.

Cooperation among teachers from different cycles seem to be particularly effective since competencies are often complementary. For example, teachers from the primary cycle are usually more competent on issues related to pedagogy and classroom management while teachers from the secondary cycles are competent in disciplinary content. TRACES researchers found that teachers practice can effectively benefit from cooperative activities such as shared planning and reflection (see e.g. Italy's CS7). In the comprehensive institute involved in Spain's CS1 (see e.g. p. 148), researchers encouraged teachers from the primary cycle to exploit the science laboratory facilities in their institute, formerly only available to secondary cycle students. The process resulted in a permanent change of the internal regulation for accessing the laboratory.
On the other hand, the opportunities available to teachers in comprehensive institutes may be missed when teachers tend to consider their students' learning along the different cycles as separated in self-consistent blocks, rather than a consistent, coherent long-term path (see e.g. Italy's CS8, p.204) or when cannot develop a shared vision about founding questions, such as whether the school curriculum should or should not refer to methodology besides contents (see Italy's CS1, p. 43)

Theme 3: Cooperation between teachers and researchers
Teachers very broadly expressed great appreciation for their interaction with academic researchers. In particular they remarked in several circumstances and in different contexts the advisability of setting up stable communities of practice formed by teachers and researchers cooperating as peers so that each member, by the means of active participation, provides meaningful contribution for the each other's job. Some teachers (Spain, CS1, p. 152) suggested this kind of interaction should be compulsory and regular.
In several contexts the interaction between teachers and researchers seemed particularly effective when it involved direct participation of researchers to teachers' activities and, above all, to the work with classes. This occurrence allowed actual exchange between the two groups, moving from a shared practice that played the role of common ground, which people could build meanings within. The interaction between teachers and researchers appeared less effective (Italy, CS1, p. 49) when these participative modes could not be established.
In many cases the researchers' presence played a strong role of catalyst, making easier reflection and sharing within the groups of teachers. In some situations, the researchers' action supported the development of potentialities which were already present in schools.
Several results from research in science education would be considered hardly understandable by the side of teachers, because they too weakly refer to real situations. At the same time those results could be considered useless, because they reformulate taken-for-granted ideas in a more complex language. Actually, some teachers (Italy, CS7, p. 187; Spain, CS3, p. 138) expressed little interest in results from research, the way they are ordinarily published because they turn out scantily accessible and usable. Anyway in other cases (Spain, CS3), teachers appreciated the possibility of accessing literature in the field of science education through the researchers' mediation.
Some teachers expressed a strong confidence in the way they work and in the implicit assumptions, which underlie their choices. Otherwise, almost all teachers, both those who feel strongly self-confident and those that do not, referred to the necessity of building large theoretical frameworks, characterized by strong key-ideas, to be used as reference for planning and conducting the work with classes. These frameworks could be either autonomously outlined by groups of teachers in a school (Italy, CS7, p.183; Brazil, CS3, p.104) or elaborated by groups of teachers collaborating with researchers (Spain, CS3, p.145; Italy, CS2). According to a widespread idea, the production of such a framework should entail a rethinking of the structures of scientific disciplines in a didactic perspective.

Theme 4: Teacher training
The direct and participative involvement of teachers in training programmes seemed to play a very relevant role in TRACES field actions. Actually, teachers in different contexts acknowledged a great usefulness of training activities in which they were involved in an participative form. Training sessions were particularly appreciated when they were centred on dynamics that typically develop in the ordinary processes of

science teaching and learning. These activities were considered effective and motivating, being able to support the teachers' commitment in the development of innovative paths in science teaching.
In several contexts emerged that an imposed training programme could be little meaningful and badly received by teachers. Generally, groups of teachers expressed the need for autonomously deciding forms, ways and contents of in-service training activities.
The possibility of setting up training contexts based on peer-to-peer interaction was broadly acknowledged as relevant.
A certain difficulty was pointed out in planning and conducting activities in science education, which were structured in a flexible enough way in order to allow a free explorative practice and a meaningful production of discourses, moving from ordinary pupils' knowledge. This difficulty was mainly expressed by teachers of primary school level (Italy, CS2, p.69). According to the teachers' opinion, this difficulty is due to their incapacity to easily manage disciplinary contents (Italy, CS4, p. 119; cs8, p.210). This lack was put down to an inadequate training, both in- and pre-service.
Some teachers expressed a considerable difficulty in managing the divergent ways pupils can adopt when they approach matters emerging during activities of science education. Therefore, teachers explicitly asked that some training activities be devoted to support and develop their capability to manage this kind of situations, in order to allow for a significant inclusion of different contributions which pupils could bring to the work sessions at school.
Groups of teachers assigned a great relevance to the training programmes which enable them to elaborate an autonomous pedagogical view which worked as a frame for science education activities (Colombia, CS1, p. 77). Training situations seemed to be more effective when teachers were able debate and re-elaborate the contents of curricula and possible materials designed to be used in educational activities (Israel, CS1, p.22).
It seemed that useful training programmes should include elements concerning the ability of understanding the connections between what happens at school and the ways people live, understand and learn. A need for training programmes including insights coming from social and anthropological studies emerged in several contexts both explicitly (Colombia, CS1; Argentina, CS2) and implicitly (Italy, CS7, p. 192). A need also emerged for training on elements related to cognitive issues, as well as reflections about the relationship among mathematical, scientific and linguistic knowledge. For example, teachers in Spain's CS2 (see e.g. p.104) emphasized the value of introducing a specialist language along with the use of the related concepts in classroom activities. Other teachers (Brazil, CS1, p. 66) considered the relevance for students to autonomously produce scripts in order to reorganize inquiry-based activities. This task also seemed to improve students' linguistic skills, as it was remarked pointed out by teachers teaching classes with significant numbers of students with migration background (e.g. Italy, CS3, p. 102).
In different contexts the opinion emerged that in-service training should move from the actual teachers' needs. Therefore, the training experiences should be designed weighing and integrating in an equilibrated manner both theoretical and practical aspects (Israel, CS2, p.60), so that teachers can recognize the possibility to use, in the ordinary practice, what has been developed within the training activities (Spain, CS1, p.64). At the same time, teachers should be allowed to compare contents and forms of training experiences with their personal beliefs (Brazil, CS2, p.97) for what concerns science education. Moreover, it seemed that the actual possibility of assigning a sense to training activities lies in the fact that teachers can recognize (Italia, CS2, p.73) the opportunity to explore point of views that are wider than those they usually consider, but tracing back to already consolidated knowledge and experience.
Significant training activities addressed to science teachers should have the same structure of effective activities undertaken at school in the field of science education. This opinion came from both groups of teachers involved in the development of field actions and different actors that took part in workshops within the final conference. In particular, great relevance was assigned to the fact that training activities actually encompassed a practical and laboratory work. This goes for in-service training (Spain, CS3, p. 147), because those activities are useful to provide teachers with confidence in managing the work with pupils. At the same time, they are useful for pre-service training (Brazil, CS3, p.121), because the trained people are allowed to imagine themselves as teachers, projecting themselves in actual situations.

Mutual observation and analysis of classroom episodes seemed to be effective tools for teacher training. They enabled groups of teachers to assume a deeper awareness about their pupils' long-term improvements, in spite of the impression – on short terms – that the teaching action was ineffective (Spain, CS3, p. 103). Also the observation of classroom sessions undertaken by experienced teachers appeared to be useful, because it enabled trainees to become aware of effective ways to carry out a work with pupils (Israel, CS1). Another relevant element for the training activities seemed to be the sharing among people as development of discourses, which enables trainees to have the opportunity of re-constructing in a meaningful manner their pupils' experiences, situating their teaching in an enlarged frame (Colombia, CS1, p. 80).
In several cases teachers assigned a considerable relevance to possible forms of acknowledgment, not necessarily in terms of wage, of participation to experiences devoted to in-service training. A strong sense of self-effectiveness, developed by teachers that took part in training activities, seemed (Spain, CS1, p.63) to be related to the fact that those teachers were working with the aim to subsequently play the role of trainers for other colleagues.

Theme 5: Relationship between local and central

The need largely emerged for involving several stakeholders, at the local level, in open debates about pedagogical issues concerning science education and related specific actions, which should be undertaken. This position appeared to stand out against initiatives imposed from on high, which are not able to take into account local needs.
In several contexts the relevance of socio-cultural issues is so strong that it heavily address the teachers' pedagogical choices, as well as those ones of entire schools, for what concerns both the way learning experiences are managed and the choice of the contents that are developed with classes. This happened both in European urban contexts, with a large part of population being low-income (Italy, CS7; cs8), and in Latin-American countries, in situations where population had poor access to resources (Argentina, CS2) or had need for contrasting conditions of environmental degradation (Colombia, CS3).
It was very broadly requested that the structure of curricula and evaluation criteria had a low grade of standardization and were alternatively designed in order to be adaptable enough to local needs. In details, in some cases teachers expressed the idea (Italy, CS7, p. 182) that possible standardized tests had only the function of furnishing a picture of the global situation of a school, or of a school system, rather than being used for students' assessment. Furthermore, according to the opinion of groups of teachers (Israel, CS2, p. 60), the introduction of standardized tests forces to increase the pace of the work with classes, in an inadequate way in respect to the students' needs, because of the worry about treating all the contents included in the official curricula.
In some cases, evident tensions and divergences were recognized between teachers, interested in building of competences and sensibilities useful to the exercise of a responsible citizenship, and policy makers, interested in developing specific skills aimed at guaranteeing competitiveness of a country at several levels (Israel, CS3, p. 81). In the same way, tension were highlighted (Colombia, CS3, p. 165) between general ideas about science education, so as they also come from research and that policies translate in curricula and documents that bind the local work, and, on the opposite side, the needs noted by teachers.
In some contexts, students (of high schools) seemed too little involved in a debate concerning the social role played by science education. In this situations (Italy, CS5) students picked out only basic competences in mathematics and science, built at primary school, as relevant ones. At the same time, students resulted little interested in the learning in that area. On the contrary, situations where students were involved in that kind of debate (Colombia, CS4; Argentina, CS3) were also characterized by an active participation to school experiences.

Theme 6: Long-term sustainability

Initiatives promoting innovation and experimentation in science education are more likely to involve entire schools and large numbers of teachers when they are sustained by people responsible for educational policies, granting them a more structural nature (Israel, CS3, p.84). Whenever this support is lacking, the results obtained by this kind of initiatives often become discouraging.

Particularly favourable circumstances for the development of effective innovation initiatives emerged in those cases (Argentina, CS1, 2, 3) where educational authorities were committed to follow and coordinate the development of the actions through the work of supervisors having a school teaching background.
On the contrary, national initiatives perceived by teachers as unsuccessful are usually characterized (Spain, CS1, p.67; Italy, CS7, p.178 and cs8, p.203) by an initial enthusiastic impulse not followed by the needed institutional support towards the activated processes of cooperation among schools and other actors and educational experimentation.
In order to implement initiatives promoting innovation of science teaching in their schools, school principals claimed their need for adequate financial support and the actual possibility of suitably reorganizing teachers' timetables (Israel, CS2, p.60). In fact, significant experiences were developed in those cases where school administrators provided teachers with an actual recognition of the workload related to participation in special initiatives (Spain, CS1, p.51), granting a long-term basis in the implementation of the initiatives, comprising the innovation activities in teachers' ordinary work-plan and providing specific professional development courses connected to the proposed experimentations.
Producing documentation materials about the classroom activities was recognized by teachers, including those involved in training courses (Colombia, CS2, p.97), as a very useful way of setting up a shared reflection and evaluation of their work. Nevertheless, difficulties emerged concerning the access to materials produced and circulation of the related reflections made by colleagues, even in those cases where this practice seemed to be well-established among teachers (Italy, CS2, p.67).
In some cases (Spain, CS3, p.137), a difficulty emerged by the side of teachers in placing their work within a more general reference framework shared with their colleagues, going in the direction of defining a vertical curriculum covering their students' entire school career. Even in those cases (Italy, CS1 and cs8) where the construction of such a vertical curriculum (including grades from 1 to 8) is sustained by official indications, teachers expressed their difficulty in sharing a common framework with colleagues teaching in different school grades.
Some case studies suggest that when teachers recognize themselves as intellectuals having the full responsibility of choosing the cultural directions framing their teaching practice then they are more likely to set up significant educative experiences (Colombia, CS1, p.62). Such kind of teachers expressed the need to share with their colleagues the construction of a theoretical framework for their practice, claiming the need for a strong decisional freedom based on their awareness of the socio-cultural context in which they operate (Italy, CS7, p.138) and on their capacity to link the classroom activities with the knowledge built by their students outside school (Colombia, CS4, p.209).

Theme 7: Relationship between school and society

In a number of different cases, a lack of active involvement in the development of the learning experience by the side of students (especially those in higher grades) emerged. Students often perceive a lack of relevance in both the content of school topics and the way school activities are carried out. Discussing with Italian students in grade 12 (Italy, CS5, p.141) students seemed to express a quite naïve vision about the social function of science literacy, assigning actual relevance to elementary competences and skills only, while perceiving more complex disciplinary contents as part of a coherent (and self-referential) scholastic knowledge.
In this same direction, many teachers highlighted (Brazil, CS1, p.63) that the teaching/learning process strongly improves its effectiveness when the formulation of problems and questions moves from a teacher-centred to a student-centred approach, explicitly discussing with the students the relevance of the topics proposed as connected to the actual socio-cultural context they are part of. First of all, this approach seems to be relevant because it promotes the active involvement and the development of a stronger sense of ownership concerning scientific knowledge by the students' side. Furthermore, this approach seems to allow students (Colombia, CS4, p.20) to develop a sense of responsibility towards the development of their knowledge and to consequently recognize themselves as aware actors democratically participating in the life of their community. This kind of perception about school science is strongly contrasting with the ideas expressed by the abovementioned Italian students (Italy, CS5, p.141) claiming the elitist nature of scientific

knowledge and attributing it a function of social discrimination connected to the difficulty in accessing its specific language.
In some case studies (two in particular, focused on schools based in middle-class areas of European cities – Italy, CS6, p.159; Spain, CS3, p.120), students' families attention towards school activities was perceived by teachers as a way to interfere and put pressure on them. Teachers mentioned they sometimes feel obliged to make given educational choices in order to meet parents' expectations. In other cases, teachers mentioned that their will to keep an autonomous way of managing school activities can cause conflict with the parents. On the contrary, direct involvement of students' families in the educational experimentations made in the classes (Spain, CS2, p.115) seemed to produce a recognition of the teachers' work by the side of parents together with the enhanced awareness of the relevance of parents' involvement by the side of teachers. In this specific case, the relationship between teachers and parents was also enriched and mediated by the presence of external actors (university researchers) directly involved in the experimentation activities.
Teachers, principals and other people working in schools based in suburban areas (Italy, CS7, p.180, CS8, p.211) seemed to feel they have the responsibility to support what we might call social promotion of the local community so that the relationship with families is driven by this perspective. The staff of these schools assigned particular relevance to the involvement of families in supporting children in their learning experiences, regarding school and family as two interacting parts of the same system (Italy, CS7, p.185).
In a perspective in which school education – and science education in particular – is considered as a way to promote social transformation (Italy, CS7, p.178; Colombia, CS1, p.119), teachers seemed to feel they have to be strongly invested with the responsibility of their social function, capable of mediating among different needs (ranging from the pedagogical to the political ones), capable of actively participating to the life of their community.
The active involvement of the local community has been recognized as even more relevant in those contexts (Argentine, CS1, p.28 et seq.; Colombia cs1, p.113) in which the community strongly bears its own culture that is characterized by a considerable degree of otherness when compared with the culture on which school teaching is based. This is the case of communities belonging to indigenous populations in Latin American countries. In these cases, it resulted particularly relevant to design and develop science teaching/learning experiences, whose structure was compatible or otherwise interrelated with the cultural perspectives, the practices, the language of those communities. On the one hand, it resulted particularly important to recognize the way these communities consider people as an integral part of their environment; on the other hand, as long as these communities are not characterized by a strong differentiation of productive activities, it resulted that insisting on the differentiation of areas of knowledge makes little sense.
The experiences made in some Latin American countries (Argentine cs1, CS2 and cs3; Colombia, CS1) highlighted that an effective integration of the school with the local community takes place in those cases where the school is capable of interpreting the needs of the community itself. In some of these cases, science education experiences were structured around the fulfilling of local material needs such as the access to resources in order to meet energy requirements, the purification of water in order to make it drinkable, the protection of the environment, the way to structure a balanced diet. This approach to science education (Colombia, CS4, p.207) makes the teaching/learning experience particularly significant, allowing to solve practical problems that are relevant for the community and offering the opportunity to address several disciplinary issues (in physics, chemistry or biology) highlighting their correlation with the needs of the community.
Even in cases (Italy, CS7, p.181) in which the material needs of the local community are not so urgent, some teachers emphasized the relevance of linking the way the educational experience is structured with the socio-cultural context. Those teachers highlighted that scientific disciplines – with their peculiar interrelation between operative and explanatory aspects – offer a unique chance of personal development to those children who do not have access to relevant educational experiences due to their socio-cultural background.

Workshops

Researchers, teachers, principals and administrators, together with external experts in the field of science education and the project's external evaluators, were invited from all six partner countries to discuss three main themes emerging as paramount from a preliminary analysis of TRACES research findings. About one hundred people attended to the workshops. The three themes include: teacher education; teaching and school context/policies; teaching and the local community.
On each theme, four workshops, each one lasting about two hours, were held involving mixed groups including all different actors and participants from all six partner countries. A special role was of course played by teachers, who represented the largest part of the participants in each workshop.
All the discussions held within the workshops and the plenary session were audio-recorded. The following reports were produced basing on the related files.

Group A – Teacher education

The group A has been engaged in a discussion about the theme of science teacher preparation, which was one of the three topics for the workshops.
In the first place, a strong necessity is recognized, by the side of teachers, for feeling self-confident in the possibility of autonomously undertaking paths and experiences in science education, which are meaningful for both pupils and teachers – on the one hand – and which are also well structured at the disciplinary level.
The necessity of meaningfulness can be read in a double way. In fact, it was differently highlighted by several contributions, which recognized as central issue the possibility that science teachers give sense to their job and, at the same time, that their job consists in making sense.
Obviously, the matter of *giving sense* to the practice of science education is closely related to several aspects. Mainly, it depends on the beliefs of a teacher and on the actual possibility of developing school experiences, which fit with those beliefs.
It seems that the direct and participative *involvement* of teachers plays a fundamental role. In fact, a great relevance is assigned to the training contexts that are characterized as situations where teachers participate as active subjects, confronting with actual dynamics typical of teaching/learning processes and dealing with the specificity of science knowledge. From the discussion emerged that the direct involvement of teachers in training programmes sometimes results difficult. The main problem seems to concern the possibility to involve a large group of teachers in training activities.
The actual possibility of giving sense to (maybe we could say recognizing a sense for) science education activities and strategies, so as they are suggested by research in science education, lies in the grade of *proximity* of those suggestions to the way teachers intend their job, the way they carry out science education activities, as well as it depends on the proximity of those suggestions to teachers' knowledge and expertise (in terms of both disciplinary and pedagogical issues). So that training activities can be effective when they move from the point where teachers stay and offer an enlarged perspective on the matters, which are dealt with. In those cases teachers seem to recognize the usefulness and the feasibility of their engagement in the proposed practices.
Another key element, which seems to play a relevant role in order to create conditions allowing an attribution of sense to science education, is what was called the "nature" of science. The point is that teachers need a frame, which they can refer to in the design and developing of science education activities, as well as in the design and implementation of assessment strategies. The problem is that, in many cases, it seems that pre-service preparation doesn't support teachers in this necessity, which consists in the construction of awareness about that theme. The frame provided by ideas on the *nature of science* not only allows teachers to give sense to their job, but also concerns the matter of *making sense* in science education, being the science knowledge based on modelling and on construction of meaning. In fact, people in the group agreed on the fact that making science at school means keeping together discourses, factual aspects and interpretations. They actually shared the idea it is very relevant, in science education, pupils and teachers at the same time have an "image" of what is happening when they deal with some phenomenological aspects.
The necessity to make explicit what is the nature of science in training activities for science teachers appears to be closely related to the consideration that there is an actual distinction between the science as

product of some special practitioners (scientists) and the science that has to be taught at school. This fits with the idea, expressed in the general statements we started from, that *mediation* is required "between disciplinary contents and educational needs". The function of mediation played by researchers was also considered in terms of opportunity to "reshape" science knowledge for school teaching and learning, at the same time keeping the specificity of science knowledge. Therefore, a very relevant part in effective training programmes should be played by consideration of cognitive issues, as well as of dynamics that characterize the production of ideas.

Nevertheless the problem of mediation, mainly intended as didactic mediation (as continuous and dynamical issue), entails the character eminently reflexive of teaching practice and consequently the necessity to set up training contexts, which allow the development of skills, approaches, strategies that are actually informed by a *reflexive attitude*.

The construction of settings and generally situations for training, which actually met the teachers' needs, is therefore related to the possibility to receive a *support* (from researchers, experienced teachers, trainers) allowing the development of those skills and sensibilities. Opportunity of continuous preparation is considered very relevant. In-service training and pre-service preparation have to be developed in an intertwined way. The function of support for teachers has to be characterized, as we have already underlined, by the possibility to be directly involved in activities of science teaching leaded by experienced people, as well as by the possibility to dedicate to reflexive practice and to reflection on meta-cognitive aspects implicated in science education, and by the possibility to deepen knowledge on disciplinary contents (related to role they play in pupils' educational experiences). This is the kind of support requested by teachers to researchers in science education, in order to feel self-confident and sustained also at the emotional level.

At the same time, researchers are asked to be prone to a certain kind of *flexibility*, in order to adapt at different local situations (as well as teachers have to be flexible to the students' needs and conditions). On the other hand, another kind of flexibility, directly concerning teachers, seems to be necessary. In fact, one can notice there is a sort of opposition between general requests, for example national indications or curricula, with defined contents to be transmitted – by the one hand – and the necessity of autonomous management of class activities, by the side of the teachers (based on their beliefs).

Anyway, coming back to the role played by researchers, several requests come to them from people regularly engaged in science education activity at school, and this should get researchers in science education, as well as trainers in the same field, to a rethink, or an enlarged consideration on their role and their relationships with the other pieces of the educational system. Three main requests can be picked out, which are obviously interlaced. The first one concerns the necessity of *reshaping* science contents, according to the idea of a science-at-school, which has to be developed and made explicit. The second request concerns the necessity of teachers to be supported in the undertaking of a reflexive practice, being not enough the provision of didactic materials (as in the statements of drafted guidelines is reported), as well as of general ideas on the framework they should refer to; teachers rather need interlocutors, which they can confront with. But – and this is the third request – researchers are asked to be able to provide for this support, taking actively part in ordinary educational contexts, in a pliable way.

Otherwise, the support by researchers is just a part of the game. In fact, a strong relevance is given to the opportunity of establishing contexts for teacher training based on a *peer-to-peer* relationship, where teachers (and researchers) can actually meet in communities of practice, confronting on their experiences, undertaking a reflection on their job and deepening their knowledge an analysis of disciplinary contents.

Group B – Teaching and school/political context

The discussion group was focused on the structural constraints of the school system and how they can favour or hinder effective science teaching.

A first relevant aspects concerned the fact that national assessment test are made for language and mathematics and not for sciences. The situation is quite similar in all the other TRACES countries. It was agreed that science curricula should structurally create links among the different disciplines: reading science can be interesting for young children and could be a good tool for teaching language. In some

countries official indications already go in this direction but there is often a strong lack of coherence with the way supervisors judge school teaching and with the approach used in teacher training.
As one of the Brazilian teacher mentioned: supervisors are used to inquiry about what is being taught in mathematics and science separately and when they encounter a situation in which innovative approaches mixing disciplines are applied they find it difficult to understand which topics are taught and in the framework of which disciplines. It was agreed that boards made of teachers, researchers, school administrators and policy makers should be constituted in order to clarify these contradictions.
This point reached about curricula and official indications from the school authorities brought into the discussion the general idea of constructing learning communities made of different actors (not only teachers and researchers). As strongly pointed out by some of the people from South America, the relevance of these communities stands in their potential of bringing a deep transformation of the culture of teaching: moving from the idea of teachers as transmitters of knowledge towards that of teachers as producers of knowledge. In order to make the process of construction of such communities feasible (and sustainable), first of all structural barriers are to be removed in order to let teachers build their own communities and have time and space to reflect together on their practice. The lack of time is mainly due to the lack of money invested in the school: most of the experiences teachers made in building communities with their colleagues are based on their voluntary and misrecognised personal efforts. As it was agreed by several teachers, time devoted to reflection and planning makes a school working as a whole. This aim can be pursued also giving teachers the opportunity to share classes, working in parallel.
The discussion then moved towards the role of researchers in the construction of learning communities and the modalities of collaboration between teachers and researchers. It was agreed that to talk about barriers to be removed and resources to be exploited in order to construct communities the group has to share an idea of how this mixed communities are made: different ideas the interaction between teachers and research imply different measures to be undertaken in order to make the interaction work effectively.
It was agreed that the construction of workgroups is the way to be followed in order to build effective interactions. This idea brought into the discussion structural problem: as long as researchers cannot be in all schools all of the time, one as to find a way of making this idea sustainable. It was suggested that teacher training courses could be the missing link in the connection between schools and universities: governments are always investing a lot of money in pre-service teacher training and student teachers preparing their degree theses could act as mediators of the relationship between researchers and teachers. Nevertheless it was agreed that the first step in the construction of communities of learners is building workgroups of teachers within the schools (or involving some schools).
Summarising the elements emerging from the discussion, it was agreed that if the interaction between researcher and teachers is aimed at producing actual change in teaching practice, then it has to stay focused on some crucial points: producing professional development; starting from teachers own need towards change (overcoming their resistance); sharing with teachers indicators of change in their practice and in their students level of attainment; establishing an horizontal relationship between researchers and teachers.
We then moved to talk about other possible barriers (apart from the lack of time and money) that should be removed in order to make this kind of interaction work. A first possible measure to be undertaken in order to overcome teachers' was proposed: innovative contents and methodologies proposed by research have to be included in the national assessment test; researchers and policy makers have to agree on the contents to be inserted in the curriculum and develop assessment tests coherently, in a top-down approach to the production of teachers' motivation towards innovation. This idea produced a lively debate, with most of the teachers from other countries claiming that any top-down approach to motivation is fated to fail. Nevertheless, it was agreed that a coherence among curriculum, indications and assessment should be granted. But the main emerging idea was again the one already emerging at the beginning of the discussion group: coherence has to be piloted through the organisation of round tables and board of experts involving all the actors with the same level of legitimacy. About the assessment tests, most of the people in the discussion group also stated that they don't believe in the efficacy of standardised national tests: assessment should be integrated in the local teaching process, take into account local teaching/learning

needs, be coherent with the educational objectives. Assessment should be intended as a moment of production of knowledge, producing hints for the formative evaluation of educational paths.
The remarks about the importance of adapting assessment tests to local needs, brought into the discussion a more general concern: the question raised of what are the respective roles of teachers and researchers in the process of reflection that allows to connect the global level (idea of the world) to local level (what has to be taught in the class). In a researchers' point of view, the role of researchers is to keep things functioning at the global level (producing cognitive models) sharing reflections with teachers who (with the help of researchers) specify and apply them at the local level (producing reflection on curricular contents).
Several interventions reaffirmed the idea that polarisation of roles between researchers and teachers in the reflection at the global and local level are is one of the barriers to be removed in order to fill the gap between research and practice.
One last issue tackled by the group was about the role of educational and more in general written materials in the functioning of the interaction between teachers and researchers. Several participants agreed that the sharing of written materials is the core of the activities of a community such as the one we were talking about because they are the tools needed to reconstruct the relationship between the local and global level we were talking about before. Written materials are not going one-way from researchers to teachers, who have just to adapt research ideas coming from research to their local needs. Written materials produced by teachers have to be considered as research materials and innovation can come also from them and not only from the academic literature. Time and space are needed in order to make people share the materials produced by everybody. A good model for creating chances of sharing is that of a physical resource centre were different expertise (researchers, teachers) join together and develop prototypes of activities to develop science topics. As long as the production of documentation materials has a central role in the reflection on practice, teachers have to be trained in documenting their work.

Group C – Teaching and the local community
The group mainly focussed on two issues: the relationship between school and community and the relationship researchers-school. Generally, it was difficult to let the proposed link between the two issues emerge. What did emerge are some common characteristics participants identified as key factors in both relationships considered: namely aspects of ownership, relevance, involvement.
An element on which the group showed broad agreement is that the school should be seen as an integral part of the community, that it belongs to the community and that a mutual recognition is needed. On the other side, the group also pointed out that the community is an integral part of the learning process of the pupils and that it is necessary for the community to take responsibility in what happens at school. An expression which recurred in the discussion was that of *co-responsibility*.
Traces field actions included contexts as diverse as aboriginal communities with linguistic specificities, isolated villages, rural, suburban and urban areas. In each different context one would find different perceptions of what one calls community.
In some cases, for example aboriginal communities or isolated villages in Argentina, the community would have a strong awareness of itself as such and the school would be faced with the issue of relating to the community's culture in terms of both knowledge and values.
In some other cases, mostly in Europe, but also in urban contexts in South America, a sense of community seems to be lacking and it is sometimes the school itself who feels the need to promote the development of such in its catchment area.
The idea of community itself is context dependent and needs to be shared and negotiated at different levels: among the teaching staff, with the pupils' families, the neighbourhood, the city.
Generally, however, participants seemed to be supporting the idea that the school should be seen as a collective construction in which teachers, pupils' families and other members of the community should be involved.
A collective construction of the school implies that a vision of education is shared between the school and the community. Other elements also emerged as significant in the relationship school-community: the curriculum, the assessment methods, , the vision of education itself.

In many cases, participants remarked that for the school to make sense in its context it is necessary that values are shared between the school and the community.
Participants also pointed out that it's fundamental to promote a sense of continuity between the knowledge taught at school and the knowledge of the community and, more generally, between school and society.
Some concepts recurred in the way participants described an effective school-community relationship: co-responsibility, ownership, relevance.
Co-responsibility refers to the idea that the community should share with the school a responsibility in pupils' learning process.
Ownership refers to the idea that the school should be seen as belonging to the community. The school should promote this vision by taking the needs of the community into account and involving the community in its activities and the decision making process.
Relevance refers to the idea that knowledge taught in the school is not disconnected from pupils' and the community's everyday experience and culture and that this knowledge is usable, meaningful, *relevant* to the life of the community.
Of course, the latter two ideas are closely intertwined in that promoting a sense of relevance of what happens at school with regards to the community's everyday life also supports the development of the community's sense of ownership with regards to the school and the activities carried out therein.
Participants described a number of strategies which seem to be effective in promoting a sense of continuity between school and community and involving the community in school's activities.
In the last of the four workshops the group tried to identify the role the interaction with research might play in contributing to the school-community relationship. The discussion focus shifted however to the researchers-school interaction, particularly for what regards researchers' interventions in schools and teachers professional development.
Researchers' interventions in schools were described as a perturbation of an existing situation which may give rise to different reactions. Participants pointed out different factors influencing the way the intervention is received and its impact on the school. Again, the concepts of ownership and relevance emerged as key success elements.
An important factor relates to the process of decision making (*ownership)*. For the intervention to be well perceived, it should not be imposed on the teachers but it should be their decision to be involved. Preferably, the content and the structure of the intervention should also be rooted in teachers' needs and interests. Important is also that the intervention creates links with teachers' everyday practice (*relevance*). A crucial step in doing so is for the researchers to also enter the classrooms and in a way be exposed to all those elements which constraint teachers' real-world practice.

Recommendations

The analysis of the surveys, of the findings coming from case studies and of contents of discussions held during the workshops lead to formulate seven recommendation (one for each theme selected in the analysis of case studies), which are here synthetically reported (for a broader discussion about their meaning and implications see deliverable D5.2)

RECOMMENDATION 1

Cooperation and sharing represent fundamental components in teachers' practice and professional development. Systemic elements such as pre- and in-service training, organization of work time and spaces, documentation and communication tools should be so designed as to promote a culture of cooperation and sharing among teachers in each school.

RECOMMENDATION 2

A rich patrimony of experience and competencies related to science education exists in all schools and should be valued and exploited. Many teachers can be recognized as experts with specific competencies and can effectively contribute to their colleagues' practice and professional development as well as to

the broader science education research debate. In particular, cooperation and sharing among teachers from different school cycles and scientific disciplines should be promoted.

RECOMMENDATION 3
School is the most significant place where research on learning and teaching can be developed. In order to make the research activity sustainable and effective, teachers should have opportunities to meet and share ideas and practices with external actors, engaged in research in the field of science education. This kind of research should aim, on the one hand, at producing general frameworks of reference. On the other hand, it should aim at developing proposals feasible and compatible with forms and features of school practice.

RECOMMENDATION 4
Teacher training as a continuous process should largely involve peer-to-peer professional development and have a compulsory nature. Training programmes should include activities concerning the planning, the evaluation and the interpretation of teaching/learning dynamics as they actually develop in the classroom.

RECOMMENDATION 5
Curricula and evaluation strategies and tools should be designed that enable teachers take local specificities into account. Curricula should be flexible enough in to be adaptable to needs related to local educational contexts. Standardised tests should be aimed mainly at gathering data that allow schools to understand how their students' performance are related to the national standards and at refocusing general educational policies.

RECOMMENDATION 6
Schools should be able to autonomously develop educational experiences that are shared within the school itself in a community dimension, giving continuity to the educational choices made and making the school capable to consider and exploit the opportunities of support offered by the school system and the interaction with external actors.

RECOMMENDATION 7
Relevant actors within the social community should be involved in a debate about the aims of science education, allowing societal and local community issues to be considered and included in the educational work made in schools.

IMPACT AND DISSEMINATION ACTIVITIES

During its two-year development, TRACES directly and indirectly set in action a series of activities with a relevant impact on different elements within and beyond science education. One may categorize these elements in terms of four dimensions of impact: teacher training, school administration, schools, and research.

Teacher training
The progressive and final outcomes of the project have informed and will inform teacher training programmes in the universities involved in the project, which all play a significant role in the teacher training system in each partner country.

School administration
In many partner countries, TRACES teams have established relationships and agreements with local and national authorities and promoted agreements between the authorities and schools involved in the project, presented opportunities and raised awareness in a way that has informed and will inform future policy.

Schools
TRACES activities have involved relevant numbers of schools, teachers, principals in reflection, debate and common work with researchers in a way that has informed and will inform perceptions, beliefs and practice. Involvement in TRACES at various levels has questioned ordinary practice and experimented new approaches for what regards not only classroom teaching, but also the relationship with colleagues, researchers, families and the local community.

Research
Also for what regards researchers involved in the project's activities in all partner countries, TRACES has questioned consolidated practice and explored innovative approaches of ways of involving teachers and other stakeholders in actions aimed at improving science education. Especially with teachers, TRACES researchers have experimented in participative models of interaction aimed at promoting participant's motivation through an enhanced perception of ownership and relevance of the activities to their everyday practice. TRACES researchers have worked in a more teacher-centred approach and raised their awareness and understanding of the constraints that affect research-based practice. TRACES process and findings will inform the practice of the researchers involved in the project and therefore impact further research projects in which they are and will be involved. Dissemination of the TRACES outcomes through participation in conferences and academic publications provides for an impact on the broader research community.

OVERALL IMPACT
TRACES research programme implied a direct impact on a large number of stakeholders involved. Approximately 2000 teachers, principals, researchers and administrators were involved in the national surveys. On the large-scale, stakeholders were informed about the project's research issues and administered a questionnaire including related questions, both closed and open. On the small-scale, stakeholders were involved in in-depth personal interviews and focus groups stirring reflection and debate in the first phase of the project and in long-term (10-15 months) field actions in the second phase.

In order to collect to reach a relevant sample for the surveys, information about the project and an invitation to be involved in the surveys were sent to over one thousand schools in the six partner countries.

Involvement of stakeholders in the surveys also implied interaction and agreements with administrative structures of the local school systems at various levels and the construction or enhancement of relationships that can be exploited in future actions.

TRACES findings and preliminary recommendations were disseminated in each partner country through a number of channels including seminars, meetings and conferences.

The TRACES research has produced large-scale national surveys (see D2.1-6 and D3.1), 24 case studies (see D4.1-4.6), analysis of four workshops involving teachers (see D5.1), researchers, administrators and principals from all six partner countries, and finally overall findings and related recommendations for future practice (see D5.2).

This rich corpus of results represents a reference for different stakeholders – such as teachers, researchers, administrators and policy makers – in considering the different issues addressed by the research. It provides insights on both stakeholders' beliefs and perceptions and the issues related to the implementation of actions bringing educational research to school.

As well as through the official deliverables, the results have been made available through other channels which are more accessible to different stakeholders, such as the project's website, the final conference, seminars, presentations, talks and posters in national and international conferences.

Seminars and conferences have been organized in the partner countries involving larger groups of teachers than those directly involved in the project's field actions. Presentations have been organised involving whole schools or networks of schools. For example, at the end of the Italian field action programme, a presentation and debate was organised for science teachers from the a local network of primary and secondary schools related to the school directly involved in the Case Study 3, in a neighbourhood of the Northern Italian city of Treviso. The workshop involved around 50 teachers who were invited to participate through the communication channels of the local network of schools constructed within the national project LES (Laboratories for Science Education). This network is active since ten years and is committed with the development and dissemination of laboratorial paths for science education (http://95.228.132.92/sitoLES/index.htm).

The TRACES consortium conducted a symposium session in the **2011 ESERA Annual conference** in Lyon (5-9 September 2011). The results presented in this symposium represent an important milestone in the development of TRACES. They represent the conclusion of the first phase of the project – a survey on the research-practice gap focused on teachers – and set the ground for the second – afield study to look at the same issue in vivo. The symposium summarized and compared the surveys carried out by partner research groups in the TRACES consortium, focusing the attention on the findings that highlight some of the factors underlying the tensions existing between three key components of the formal science education scenario: research, policies, and practice. The symposium discussant, Dr. Katerina Plakitsi, is Assistant Professor of Science Education at the Department of Early Childhood Education of the University of Ioannina in Greece. Four papers reporting findings from TRACES surveys were published in the conference proceedings.

The TRACES coordination team participated in the **Scientix Conference** held in Brussels on May 6-8.Scientix is the community created to "facilitate regular dissemination and sharing of know-how and best practices in science education across the European Union" and managed by European Schoolnet on behalf of the European Commission. A TRACES poster was presented at the conference for the participants to view. The conference was attended by over 400 teachers, researchers and policy makers. Prior to the conference, a meeting was held with 14 other project coordinators in order to discuss future perspectives in EC funded research in science education and possible cooperations. TRACES is present on the Scientix portal with the devoted description pages since the very beginning of the project.

The TRACES coordination team is involved in the **Light and Sustainability Erasmus Intensive Programme**, coordinated by the University of Ioannina (Greece). Once a year, this international collaboration is committed with the organisation of a two-weeks intensive workshop aimed to enhance the professional knowledge and skills of science teachers by lifelong, didactically-innovative and pedagogically-rich, open and flexible learning approaches. For what concerns undergraduate courses, the project is aimed at helping

students to gain their job in both schools and museums without any gender or disability exceptions. The annual workshop involves around 100 participants (from 8 different EU countries), most of which are student-teachers attending their pre-service training. This programme is another opportunity to be exploited in order to disseminate the TRACES results and involve other relevant stakeholders (the participant student-teachers and the involved researchers) in the online debate on the final guidelines.

Members of the TRACES coordination team participated in the **8th International Conference of the ERNAPE**, European Research Network about Parents in Education on Home, School and Community: a partnership for a happy life? held in Milano on 29th June - 1st July 2011. The Conference was attended by over 300 researchers, teachers and parents. The team of the University of Naples presented a six-year experience: Science Laboratory Activities for Kids and Parents in Naples developed in a collaboration between schools, university, and the science museum in Naples.

The TRACES Project was presented by the Brazilian team and discussed at the **VI Encontro Ibero-americano de Coletivos Escolares e Redes de Professores que fazem investigação na Escola**. The event was held in Cordoba (Argentina) on July 17th to 22th, 2011 and involved about 1000 teachers from several Ibero-American countries. These teachers sought to improve their practices through the exchange of experiences. The aim of the dialogue was discussing new ways of pedagogical organization in order to achieve a more humanistic and contextualized education. During the event, the results of the first stage of the research developed in TRACES were presented. The discussion was inserted in the thematic axis Práticas Pedagógicas (Pedagogical Practices), which involved fifty papers divided into four main commissions. In the commission to which the TRACES researchers took part, it the diversity of contexts and themes of each work was highlighted. There were presentations about ethic and gender questions in the Caribbean region, issues relating to the inclusion of children from poor and violent areas, strategies for the qualification of teachers through education by research, the use of new technologies to enhance learning, among other topics. However, despite the diversity of issues, the participants (teachers and researchers) noted the similarity between the factors that delineate the interaction between the teaching practice in schools and research in science education. It was also noted that the teaching practice still has a transmissive character, despite public educational policies present an innovative and not constrained character. Findings like these reinforce the need for initiatives such as the TRACES project. The participating teachers expressed great interest in future activities of the project, such as providing a web site in order to disseminate the innovative activities implemented in schools. For the TRACES Project, such events are very important since the emphasis placed on the school culture rather than the academic culture helps us to understand more about the gap, the main focus of the research.

As coordinator of the TRACES project, UNINA has been involved in the **Pro.Co.Net network** (Project Coordinators' Network of European projects in science education), comprising the coordinators of current European FP7 projects in STEM education together with colleagues from similar projects funded from other sources and having the aim of disseminating IBSE on a wide scale at European level. This network will be exploited in order to disseminate the TRACES results towards the science education research community. The TRACES coordination team is directly involved in the "Inquiry Network for Science Technology Engineering Mathematics education" (INSTEM-ProCoNet) project.

The TRACES coordination team will also bring lessons learnt in TRACES to the Science Laboratory activities with Parents and Kids (LLP) project aimed at developing teacher training activities in IBSE at kindergarten level involving the kids and their parents. The project – started in 2011 and lasting two years - is being developed in cooperation with the Municipality and the local science centre. Information about TRACES was also distributed at Science for Society networking event in Science in Society held in Brussels in October 2011 (see brochure in APPENDIX C).

Traces final conference

The project final conference involved researchers, teachers, school principals, administrators and policy makers from all partner countries, two members of the external evaluation committee (Prof. Michela Mayer, Dr. Mónika Réti; Prof. Rut Jiménez Liso was not able to attend), two keynote speakers (Prof. Maurìcio Pietrocola from the University of Sao Paulo and Prof. Paolo Guidoni, formerly at the University of Naples) and the Project Officer in charge Noora Eronen.

In order to build a link and establish a dialogue with another important FP7 project committed to promote research based practice in schools we also invited Dr. Susana Borda Carulla, member of the coordination team of the Fibonacci project. Dr. Carulla was invited to both give a presentation and participate in the conference workshop with the other invited stakeholders. The presentation focused on Bridging the gap between Inquiry-Based Science Education research and practice. Reflexions based on an experience from the Fibonacci Project.

All conference participants (with the exception of the Project Officer) were involved in the thematic workshops. They were divided in three groups, according to the criteria that each group should involve participants from all six partner countries and the largest possible variety of actors (teachers, researchers etc.).

For the conference, a dedicated website[4] was developed. Through the website, all relevant information and content related to the conference workshops and experts' presentations was made available. The website also included a discussion forum on the workshop focus themes, which were translated into all partner languages (except Hebrew). All posters presented in the teachers' poster session were published on the website.

Prior and after the conference, partner TRACES teams organized local meetings with teachers involving them in pre-discussions about the conference workshop foci.

For full details about the final conference please refer to the conference website and to Deliverables D5.1 e D6.1.

TRACES website

A website aimed at disseminating TRACES outcomes and manage communication among stakeholders involved in the project is online since Month 6 (December 2010). Website's target groups are teachers, researchers, educators, administrators and policy makers. The section devoted to the project description has been translated into all partner languages (except Hebrew). Through the website, all project activities have been publicized (main articles) and all project outcomes (surveys, criteria for the field actions, case studies, findings and recommendations etc.) have been made available to the broader public, together with all project deliverables, newsletter issues and external evaluation reports. The website is also meant to work as a resource centre offering selected research materials (What's relevant section on the homepage) to a varied audience including both the people directly involved in the project and a wider audience of stakeholders involved in the science education arena. The website is highly ranked on the main internet search engines and this ensures it already reached strong visibility and that the website can be used beyond the lifespan of TRACES as a dissemination channel aimed at a reaching a potentially unlimited audience. By now the website has collected around 20000 content view hits.

The section for registered users only includes a number of community tools (blog, forums, etc.) and was used during the Italian field actions to create online workgroups with the schools involved. These workgroups served as online repositories of shared materials and to set up discussions on the development

[4]Accessible at http://www.fisica.unina.it/traces/index.php?option=com_content&view=article&id=229&Itemid=119&lang=en.

of the classroom activities. The TRACES community has partly been used as a communication tool within the consortium and will be exploited in the future to keep the exchange of experience and ideas within the global network of people constructed during the project alive. The TRACES community counts at the moment around 200 members (mainly teachers and researchers involved in TRACES in the six participating countries).

A special section of the website has been created for the TRACES final conference. This section was used to continue sharing experiences and materials and discussing the TRACES final guidelines until the end of the project.

In order to make the project's ultimate outcomes – the findings and recommendations – more visible and accessible, the TRACES website (www.traces-project.eu) was completely restructured during Month24. The restructuring involved removal of out of date information and introduction of new sections dedicated to the seven themes in terms which the findings and recommendations are organized and to the case studies. All 24 case studies have been divided in separate pdf files for easy access. Recommendations and findings are in foreground and accessible both as web pages and pdf files. Website visitors can leave comments about the recommendations through the provided "Comment" tool.

IMPACT RELATED TO EACH PARTNER COUNTRY

In **Argentina**, a collaboration was established with the local (province of Salta) coordinators of the Scientific and Technological Activities for Youth, a national initiative fostering school projects in S&T. In order to establish contact with the schools in the sample, an agreement was settled with the Directorate of Primary and Early Childhood Education, which provided official authorization for the survey.

The interaction with the Directorate proved to be a strategic move for the overall impact of the project. The Board of Supervisors recognized the topic of TRACES as one addressing important issues of the local school system and offered full cooperation during the survey phase and beyond. The Board requested and was provided access to the results of the investigation as a source of information meant to inform curricular policy. Due to the particular geography of the region, some schools in the sample required special transportation means to be reached. For this reason, another collaboration was established with the General Directorate for National Parks.

Altogether, 3500 questionnaires were distributed in Argentina. Many schools were later contacted by phone in order to encourage participation and some questionnaires are collected personally by the research team. The total number of collected questionnaires at the time when the analysis was started was 478. On the small scale, 12 individuals were involved in personal semi-structured interviews, including 4 researchers in science education, 1 policy maker (the Province general supervisor for primary school), 3 primary school teachers and 3 teacher trainers.

In **Brazil**, the strategy to involve stakeholders in the surveys implied a collaboration with the regional education coordinators of the region of Rio Grande do Sul, training programmes and research networks. Invitations were sent also to private teachers of the Marist Brothers civil institution, teachers involved in in-service training courses at the Pontificia Universidade, the members of the Network of Research in School (a state education innovation exchange network) and the teachers participating in the 30th Chemistry Teaching Debate Meeting. The letter of invitation included also a request of promotion of the initiative to other colleagues.

The Brazilian team estimates that approximately 1000 teachers were notified of the questionnaire; 145 teachers submitted completed questionnaires. On the small scale, 29 individuals were involved in interviews and focus groups, including: 8 school principals, 5 policy makers, 9 researchers in science education and 7 teachers.

The Brazilian field actions directly involved 15 schools distributed in three case studies located in the region of Porto Alegre for 14 months. Classroom activities carried out during the field actions involved 453

students directly. Considering all teachers and students of the participant schools, the potential indirect impact of the field actions may be quantified in approximately 380 teachers and 7400 students. The Brazilian field actions also involved meetings with teachers, researchers, principals and policy makers aimed at disseminating TRACES research proposal and findings. These included meetings with: stakeholders from the Guaíba's municipal public education department; pre-service and supervising teachers from schools in the PIBID national programme (Scholarship Program for Teaching Initiation); all teachers form the Guido A. Lermen school (Lajeado); stakeholders of Lajeado's municipal public education department; science education master programme students of the PUCRS; TRACES researchers from all partner teams (UNINA, UAB, UPN, Salta, PUCRS), teachers and principals from all schools involved in the field actions.

Dissemination of TRACES and its findings was also promoted by the Brazilian team through papers and presentations in meetings and conferences including: "TRACES - Transformative Research Activities Cultural diversities and Education in Science" (at the Innovation, University and Internationalization Meeting at Pontifical Catholic University of Rio Grande do Sul); "Analysis of the gap between academic research and teaching practice at different contexts " and "Teacher education in an inquiry based teaching and learning approach: a case study with pre-service teachers of a teacher education support national program – PIBID" (7th Education International Conference, Brazil); "TRACES - Transformative Research Activities Cultural diversities and Education in Science" (VI Iberian and American Conference of Networks and Teachers School Groups who using inquiry based teaching); "Science teachers' perceptions about the relationship between research and practice" (ESERA Annual conference 2011); "Research in science teaching: a case study in the context of TRACES project " (XIII Research, Extension and Teaching Show of UNIVATES University); "The relationship between research and science education: an exploratory study" (VII National Meeting of Research in Science Education).

In **Colombia**, the survey involved stakeholders from the Andean, Orinoco and Caribbean regions. An interaction was established with the Ministry of Education, which contacted and informed about the objectives and strategies of TRACES. The Ministry provided A database of teachers in each region, who were contacted directly and invited to fill in the online questionnaire. Meetings were organized in order to disseminate the national version of the TRACES website and the online questionnaire. Some teachers were contacted personally in order to inform them about the project and administer the questionnaire on paper. Other teachers were contacted through graduate and undergraduate programmes of the Department of Physics and training events organized by members of local TRACES team. The rest of the questionnaires were distributed on paper during meetings organized in each sample region.

In the Caribbean region, taking into account the specificities of the region in terms of educational dynamics and relationships with administrative and educational communities in the region led to the following strategy. The project was disseminated at different levels: both the Secretary of Education of the District of Santa Marta was involved and core managers and supervisors who preside over the academic and administrative coordination of the various institutions set up by regional Districts. A regional meeting was organized involving 140 stakeholders, including 80 science teachers.

In the Orinoco region, the Union of Teachers was involved and played an important role as the link between the administration and the academy. The proposal was well received among the higher authorities of the Ministry of Education because it was assumed as an initiative of the teacher's organization that provides opportunities for training and qualification practices. A regional meeting was held involving 60 local teachers.

In the Andean region (which includes the Department of the capital city Bogotá), a collaboration was established with several Secretaries of Education including those of the Municipalities of Facatativá and Mosquera in the Cundinamarca Department. Meetings were organized with the local Undersecretary of Education and the Secretary of Science and Technology. In these meetings the relevance of initiative like the TRACES project for education of the District was discussed. Colombian researchers report that,

although these meetings didn't prove effective in terms of concrete effects in the application of the survey, they represent an important effort in order to extend the impact of the project as well as strengthen the bonds between the Secretary of Education and the National Pedagogical University. The meeting of the "Foro Distrital" was also exploited to disseminate the survey in the Andean region. The 400 teachers taking part in the meeting were informed about the project and 200 of them were involved in the survey. Further dissemination in this region was carried out both online and in print using the contacts of the core team with the teachers graduated from the undergraduate and graduate programs of the Physics Department. In total, 215 complete questionnaires were collected and analyzed and 30 teachers were involved in interviews and focus groups in Colombia.

In Colombia, researchers involved 30 teachers from 8 educational institutes in their field actions in three regions: Caribbean, Orinoco and District capital. To validate the preliminary recommendations emerging from TRACES findings, the Colombian team organized a national meeting of teachers also involving and researchers from University Francisco José de Caldas and Educational Institutions of Bogota. The meeting presented the status of the field actions conducted by the research team at the national level, socialized and discussed the 17 classroom proposals developed in the framework of the Colombian field actions and discussed a draft document with recommendations on policy science education, derived from analysis of the field actions.

The Colombian team also developed a section of the website of the Universidad Pedagogica Nacional aimed at disseminating TRACES in its objectives, development and results (see http://www.pedagogica.edu.co/traces/). Findings from the national surveys were disseminated through the papers "Linkages and contrasts between the investigation of Science Education and school practices of teaching" (presented at the inauguration of the first cohort of the Masters in Teaching of Natural Sciences of the UPN) and "Linkages and contrasts between research and practice in Science Education", "Relations between education policy, science-technology and science education in the last decade in Colombia", and "The Sense of the Science Education in Colombia and its relationship with the research and educational policy: Opinion Survey" (presented at the V International Congress on Science Teacher Education held in Bogota in October 2011).

In **Israel**, due to the specificities of the local context, the local research group considered that it would be nearly impossible to reach a significant large sample for the quantitative survey in the time at disposal. They therefore opted for a large number of in-depth interviews as the core of their national survey. Nevertheless, the questionnaire developed at the consortium level was translated into Hebrew and published as an online form on a page of the Science Teaching Department of the Hebrew University. An invitation to questionnaire was disseminated through the websites of all the five National Science Teacher Centres. The centres include teacher centres of science and technology (middle school) as well as physics, chemistry, biology and earth science (high school).

Three teacher centres published the invitation letter and the link to the online questionnaire on their website (middle school science & technology, chemistry and physics). The other two sent the letter by email to their mailing list. In total, 65 completed questionnaires were collected, largely exceeding researchers' expectations. On the small scale, 34 in-depth interviews were carried out with a sample of stakeholders composed as follows: 10 science teaching researchers (academics, leading in education research); 6 policy makers (administrators and supervisors of the Ministry of Education); 7 teacher educators (trainers of pre- and in-service teachers, some of them researchers as well); 3 school principals; 8 science teachers (experienced teachers, some of them have leading responsibilities).

The Israeli TRACES field actions directly involved 2 schools (Urban science oriented junior-high school in Tel Aviv and Suburban junior-high regular school in Mevaseret) and a group of teachers of the National Program Hila for teaching dropouts students. Altogether 131 students, 23 teachers, 2 principals and 1 policy maker were directly involved.

Researchers in the Israeli TRACES team further disseminated TRACES and related content through participation in the 2011 ESERA Annual conference; the Annual Conference for Physics Teachers 2011 (Israel); courses for pre-service teachers: Achva Academic College (30 teachers), David Yelin College (22), two courses at Jerusalem College (20 each), two courses at Lander College (15 each); workshops for in-service teachers: Kiryat Shemona (25 teachers), Eilat (25), Arava (15), two groups at Bar Ilan university (25 each), Lod (30), Kfar Saba (40), Beit Shemesh (25), David Yellin College (30), Achva Academic College.

In **Italy**, a collaboration was started with the Service of Statistics of the Ministry of Education (which is the national reference institution fur studies such as those carried out by Eurostat and OECD). The Ministry of Education provided an invitation letter that was sent, together with a description of TRACES and its objectives, to over 500 schools selected for the sample. Most relevant associations related to school and science education were also involved, including the National Association of Science Teachers, Association for Science Education, Association of Catholic Teachers. Associations were asked to publish a short description of TRACES and its objectives on the homepage of their website, therefore reaching a relevant number of members.

Over 900 teachers and 250 principals accessed the online questionnaire and respectively 734 and 81 complete answers were collected. Moreover, 32 teachers were involved in focus groups. Another 8 teachers, 4 researchers (in the areas of biology, chemistry and mathematics education), and 1 technical officer of the Ministry of Education were interviewed.

The Italian TRACES field actions directly involved 8 schools distributed on the national territory: 2 in Piemonte (north-west of Italy), 1 in Veneto (north-east), 3 in Campania (south) and 2 in Sicily (south). The schools are also distributed according to school grades: 2 primary schools, 4 comprehensive institutes (primary and lower secondary) and 2 upper secondary schools. The workgroups set up in each school involved in total 94 teachers who actively participated in the development of the actions.

The project activities were of course disseminated within the teaching staff of the 8 participating schools by means of the interaction of the teachers involved with their colleagues and through the communication in the meetings of the school board. This means the field actions had a secondary impact on some hundreds of other teachers.

Classroom activities carried out during the field actions involved on average one hundred students in each of the participating schools, that means a total number of around 1000 students directly involved in the field actions.

Some special dissemination meetings aimed at teachers were carried out during the development of the field actions. Here are some relevant examples:

- During the field actions in Treviso (Veneto), we conducted a workshop aimed at disseminating the results achieved towards a wider audience. The workshop involved around 50 teachers who were invited to participate through the communication channels of the local network of schools constructed within the national project LES (Laboratories for Science Education). This network is active since ten years and is committed with the development and dissemination of laboratorial paths for science education and is in contact with dozens of schools and hundreds of teachers;

- A special workshop was held in one of the TRACES primary schools in Campania (Primary school “G. Quarati, Italian Case Study number 4), involving the entire teaching staff of the school (around 100 teachers participating);

- During the field actions in Sicily, a special workshop (involving around 30 teachers) was organised in collaboration with the local PalermoScienza network of schools, which is composed of dozens of schools in Sicily. The PalermoScienza project stems from the need to offer to the students of Sicily a chance to

experiment activities of science communication in informal settings. Since some years ago larger and larger numbers of students are involved as the main actors of temporary exhibitions in which they explain to their peers exhibits they produced by themselves. The two schools involved in the field actions in Sicily are active members of PalermoScienza. UNINA is developing a long-term collaboration with the network, which has been and will be exploited in order to disseminate the results of the project.

Some of the schools participating in the field actions have also actively involved in the activities developed in the framework of the Italian Ministerial Plan ISS (in which the TRACES research group at UNINA has been strongly involved and committed with scientific and organisational management tasks). This Plan was based on the construction of local networks of schools collaborating with other stakeholders (researchers, teacher trainers, school administrators) in order to construct significant experiences of peer-to-peer professional development among the teachers involved. The complex networks of contacts build during the ISS have been and will be exploited in order to disseminate the TRACES results towards a huge audience teachers and other relevant actors.

Together with all other Italy's main research groups in science education, UNINA has developed a research and activity plan which has been submitted to the Ministry for national funding. The project (INES- "INnovation in physics Education facing Societal challenges: models and strategies for teacher education) is informed by TRACES results related to the relationship between research and practice and the training of teachers. The project has passed pre-selection for funding.

In **Spain**, the national survey was restricted to the Autonomous Community of Catalonia. In order to build a consistent database of schools, Spanish researchers worked together with the Serveis Territorials, the local education services representing the Department of Education of the Generalitat de Catalunya. The resulting database included an extensive amount of schools and had shown useful for organizing CRECIM activities, obtaining high proportions of response and participation from addressed schools. Comparing with the last statistical official data in Catalonia regarding schools, the final database (2.844 schools) used to spread the questionnaire roughly approximately the 85% of the Catalan school centres. The nine Catalonian district services were sent information about the project and asked to spread the survey via official channels. Administrative support was also asked via the General Centres of Resources for the teaching of science, which is an educational service belonging to the Department of Education (the main authority in education in Catalonia). They accepted to distribute the questionnaire within their internal database both of primary and secondary schools.

Apart from these official channels, the Spanish team also exploited the database of schools provided by their institute of reference, the Research Centre for Science and Mathematics Education (CRECIM) of the Faculty of Education. Also, other science teachers' associations and groups of teachers usually collaborating with the CRECIM were asked to disseminate the questionnaire. The teachers' questionnaire was published on the Internet as an online form and a general message was sent to all schools in the sample. Over 200 teachers submitted completed questionnaires. On the small scale, teachers, school administrators, researchers in science education and policy makers were involved in personal interviews and focus groups. The sample included 5 school administrators, 7 teachers, 1 researcher and 2 policy makers from the section of Teacher Education and Professional Development of the Department of Education.

The Spanish TRACES field actions had two different profiles: on the one hand, already existing field actions-teacher professional development initiatives (teachers' groups) which were already taking place when TRACES project was initiated-; on the other hand, field actions designed and carried out by Spanish TRACES team within the TRACES project framework.

For the first type of field actions, researchers within the TRACES Spanish research team monitored and studied the existing initiatives. To do so, teachers in the group as well as the groups' coordinators-science education researchers- participate in questionnaires or interviews being then directly involved in these

initiatives. Altogether, **37 people** (36 primary school level teachers; 2 science education researchers) were **directly involved** in these initiatives. Being teachers in both groups actively working in their respective schools, **thousands of students** were secondary impacted by these field actions.

Second type of field actions directly involved **2 semi-private schools** (Mare de Déu de Lourdes and Mare de Déu del Roser-Amilcar). Several workshops and training sessions were carried out in each of the schools, being **directly involved** a total of **37 kindergarten and primary school teachers** and **671 students from kindergarten and primary school levels)**

Taking into account that these schools were also secondary level schools and even though the field actions were carried out only with primary school level teachers, all teachers and students in the school were **secondary impacted** by the field actions (about 50 teachers and 730 students in total).

Once the first phase of the TRACES project was finished and before the Field Actions were initiated, a **national TRACES Website** (grups.crecim.cat/traces/) was created with two objectives. Firstly, to disseminate the National Survey results; and secondly, to have a national platform that facilitate the communication with all the Field Action participants. In this sense, the national TRACES web has been used to share science teaching and learning materials with teachers, to upload teachers' and researchers' proposals, to host teachers' diaries, to schedule meetings, etc. The National TRACES web counts at the moment around 80 members (mainly teachers and researchers involved in TRACES Spanish field actions).

It has to be highlighted that both the general and the national TRACES web pages are or will be linked to existing web pages from different science education institutions (e.g.: CRECIM (http://www.crecim.cat)).

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APPENDIX A – LOGOS

1. TRACES logo

2. TRACES Community logo

3. TRACES Conference logo

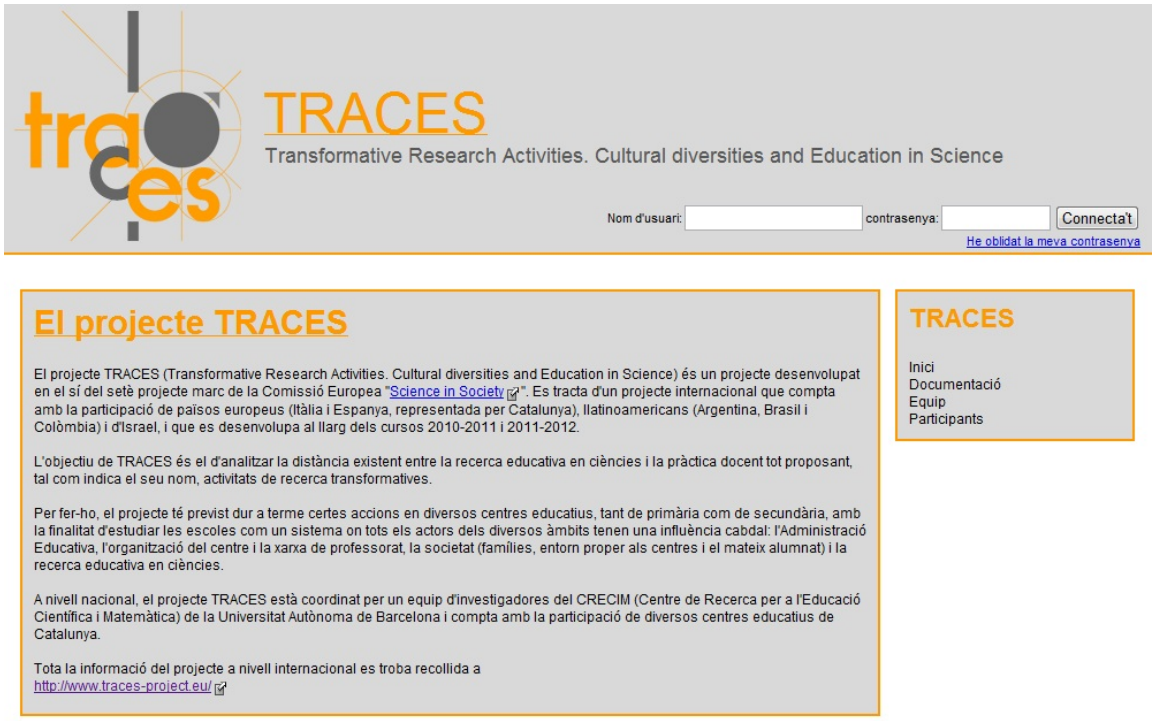
APPENDIX B – WEBSITES' SCREENSHOTS

1. Original TRACES website homepage

2. Original TRACES web community homepage

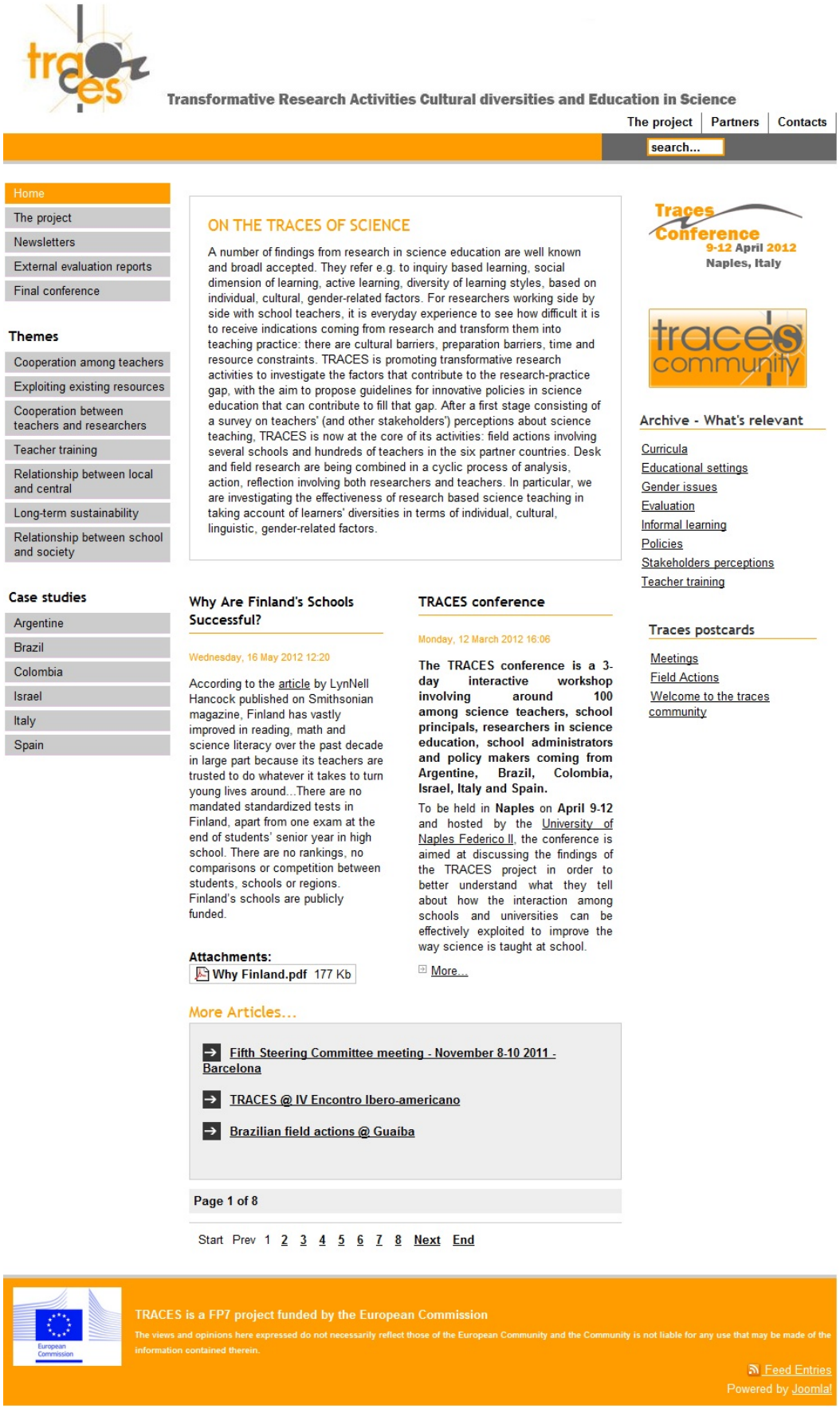
3. Homepage of the TRACES website @ Universidad Pedagogiga Nacional (Colombia)

4. Homepage of the TRACES website @ CRECIM (Spain)



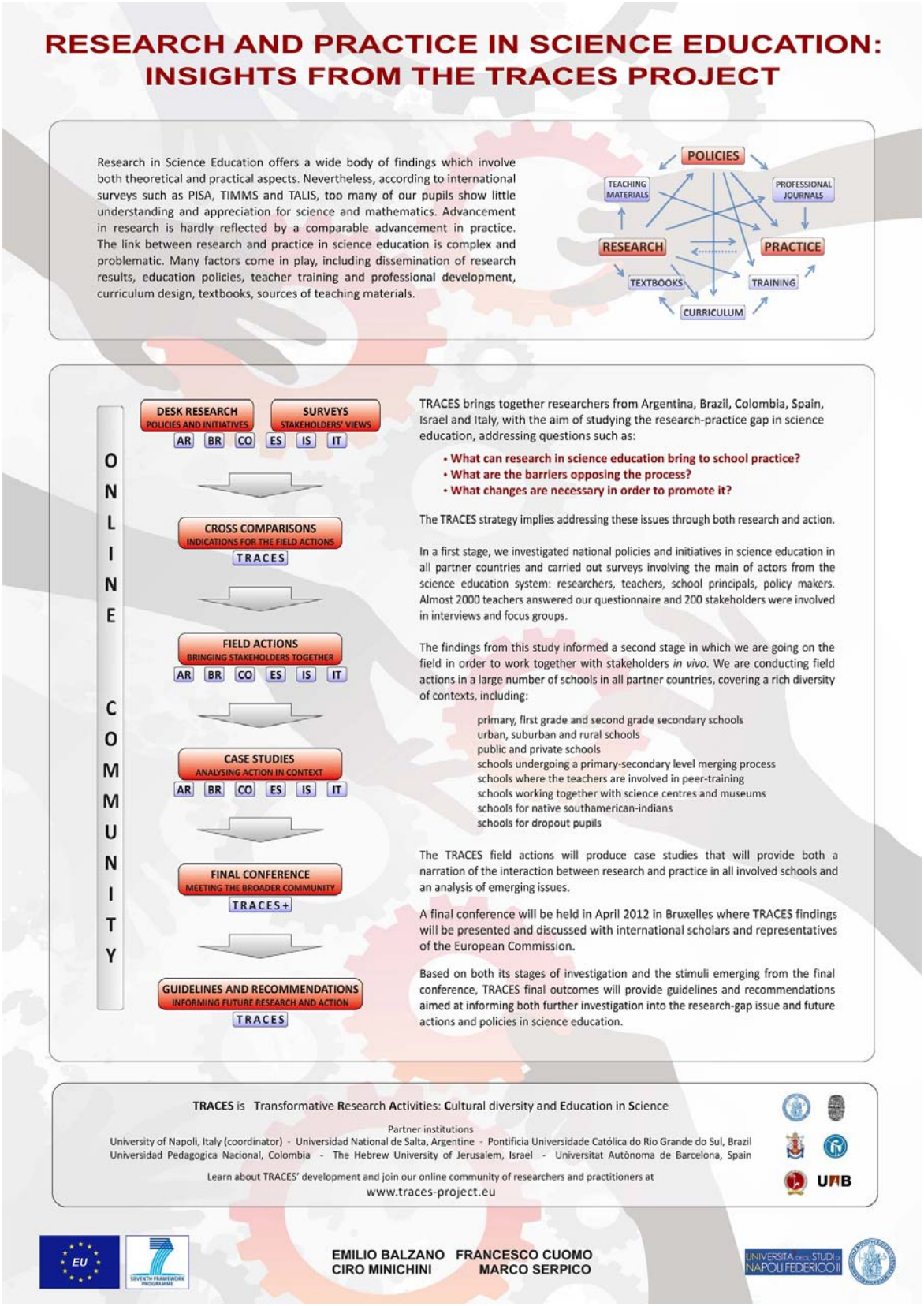
5. Homepage of the TRACES Conference website

6. Restructured TRACES website (from Month24)



APPENDIX C – POSTERS

1. Poster presented at the Scientix Conference 2011



2. Poster of the TRACES Conference

3. Poster about Italy's Case Study 2 presented by teachers involved

4. Brochure distributed at the Science in Society meeting 2011

The activities of our research group stem from our idea of educational practice as a research work.

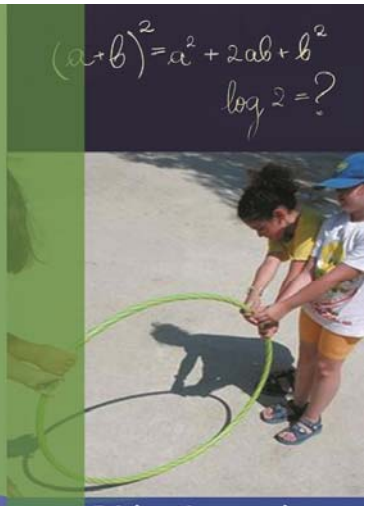
We daily work together with schools, science centres, political institutions, science communication media, trying to place their ordinary practice in a wider framework of reflections about social and cultural, epistemological, disciplinary and cognitive apects.

Group coordinator

Emilio Balzano
balzano@na.infn.it
phone: +39 081 676350

Representing the group at
Science for Society 2011
Brussels, 7th October

Ilenia Picardi
Research associate
picardi@fisica.unina.it



Didactics and Communication of Science and Mathematics

University of Naples
Federico II
Italy

Areas of interest
- Social and cultural dimensions of science learning
- Relationship between formal and informal learning
- Development of long-term educational paths for schools
- Teacher training and lifelong learning programmes

Physics Department
University of Naples
Complesso Universitario
Monte Sant'Angelo
Via Cintia
80126, Naples
Italy

Social and cultural dimensions of learning
Teaching and learning styles, gender issues, language issues, self-perceptions of teachers and students within their socio-economic contexts are all factors whose impact on learning processes is still largely unexplored by science education research.
In the **TRACES** project we work side by side with teachers from six countries in Europe and South America to understand how the idea of scientific culture we are portraying can be more strongly rooted in different cultural contexts.

Training and long-life learning
Worldwide school teachers express the need for more specific training and educational resources in order to be able to manage science curricula.
We are involved in both pre- and in-service training courses and in training programmes targeting university students, science museum explainers and other stakeholders in the framework of the lifelong learning programme (**LLP - LIGHT Intensive Program and LLP - Science & Techonology Studies**).

FP7:
TRACES Transformative Research Activities Cultural diversities and Education in Science
www.traces-project.eu - Coordinator
ISWA Immersion in the Science Worlds through the Arts www.iswaproject.eu - Partner

LLP:
LIGHT Intensive Program - Erasmus
www.eiplight.eu/ - Partner
Science & Techonology Studies - Coordinator

FP6:
PENCIL Permanent EuropeaN resource Centre for Informal Learning
www.pencil.unina.it/ - Partner

Italian Ministry innovation plans:
SeT - LES - Laboratories for Science Education
www.les.unina.it/
ISS - Teaching Experimental Sciences
www.lfns.it/PianoISS

Science in society
In the knowledge society, studies about the new communication ecosystems are becoming more and more necessary. Ecological sustainability and the use of new technologies and its implications are just some examples of issues that can't be undervalued by people working in the education and communication fields.
In this context the project **ISWA** aims to involve young people in a process of reflection on topical scientific issues through the creation of artworks and the participation in a web contest.

Between formal and informal learning
Informal science covers a broadening range of learning contexts and has a growing impact on individuals, schools, families and society.
The EU project **PENCIL** was designed in order to explore the opportunities offered by the cooperation between formal and informal institutions.
We were charged with the monitoring and evaluation of pilot educational projects designed and carried out by 14 science centres in Europe and Israel.

Developing educational paths
Working on a long-term basis with groups of teachers at the design, planning and implementation of educational paths is a mean to bridge the gap between science education research and practice.
Since some decades we are working with an action- research approach at national plans (**LES, ISS**) for curricula development and dissemination of good and innovative practice, trying to build stable relationships with a number of entire schools.

APPENDIX D – EXAMPLES OF INVITATION LETTERS (SURVEYS)

1. Invitation letter sent by the statistics department of Italian Ministry of Education to the schools to be involved

From: infostat@istruzione.it
To: RNIC80600R@istruzione.it
Sent: Thursday, October 21, 2010 1:11 PM
Subject: Progetto TRACES (Attività di ricerca trasformativa. Diversità culturali e educazione alla scienza) - Scuola RNEE80602X

Ministero dell'Istruzione, dell'Università e della Ricerca
Dipartimento per la Programmazione e la gestione delle risorse umane, finanziarie e strumentali
Direzione Generale per gli Studi, la Statistica e i Sistemi Informativi

Oggetto: Progetto TRACES (Attività di ricerca trasformativa. Diversità culturali e educazione alla scienza)

Gentile Dirigente,

Le comunichiamo che la scuola in oggetto è stata selezionata per contribuire, attraverso la compilazione di un questionario, alle attività del progetto "TRACES" di ricerca internazionale in didattica delle scienze. Questo progetto coinvolge sei paesi diversi (Argentina, Brasile, Colombia, Israele, Italia e Spagna) ed è coordinato dal gruppo di didattica delle scienze dell'Università degli studi di Napoli Federico II.

Le modalità dell'indagine, le indicazioni operative ed ulteriori dettagli saranno indicati in una successiva e-mail inviata a breve dal gruppo di didattica delle scienze dell'Università degli studi di Napoli Federico II.

Considerata la rilevanza in ambito educativo delle finalità di questa ricerca sull'insegnamento delle scienze confidiamo in una sua proficua collaborazione.

Roma, 20 ottobre 2010

Direzione Generale per gli Studi, la Statistica e i Sistemi Informativi

2. Letter of invitation sent to the schools involved in the Spanish sample

A l'atenció de la direcció del centre

Benvolgut/da,

Ens posem en contacte amb vostè des del CRECIM, centre de recerca de la UAB per a l'Educació en Ciències i Matemàtiques.

L'objectiu es demanar-li el **reenviament d'aquest missatge als docents que imparteixen ciències** al seu centre (mestres o professors) per col·laborar en un **estudi internacional** finançat per la Comissió Europea anomenat **TRACES** *(1)*. Aquest estudi té com a objectiu **conèixer l'opinió del professorat de ciències** en relació a la vinculació entre la recerca en didàctica de les ciències i la pràctica a l'aula.

Considerem que **l'opinió del professorat és clau** a l'hora d'orientar la recerca educativa per tal de garantir que aquesta sigui el més efectiva possible, per la qual cosa els demanaríem que l'equip docent de ciències del seu centre completés el qüestionari que poden trobar en el següent enllaç abans del proper **10 de novembre.**

http://www.surveymonkey.com/s/6NNXR9G

Les dades recollides en aquest qüestionari seran tractades confidencialment i només amb els objectius exposats anteriorment.

El temps aproximat per completar el qüestionari és d'uns 35-45 minuts i cal completar-lo íntegrament, ja que el sistema no permet desar el qüestionari a mig procés i reprendre'l posteriorment.

Agraint per avançat la seva col·laboració, quedem a la seva disposició per a qualsevol consulta o comentari que puguin tenir a l'adreça pr.eu.traces@uab.cat

Gràcies i salutacions,

Projecte TRACES

Centre de Recerca CRECIM

www.crecim.cat
Tlf. +34 93 581 4496

(1) El projecte TRACES (Transformative Research Activities. Cultural diversities and Education in Science) es desenvolupa en el marc del programa "Science in Society" de la Comissió Europea.