PRIMAS

PROMOTING INQUIRY IN MATHEMATICS AND SCIENCE EDUCATION ACROSS EUROPE

Context analysis for the implementation of IBL: International synthesis report

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PROMOTING INQUIRY IN MATHEMATICS AND SCIENCE EDUCATION ACROSS EUROPE

PRIMAS stands for Promoting inquiry in mathematics and science education across Europe. PRIMAS is an international project within the Seventh framework Program of the European Union. Fourteen universities from twelve different countries are working together to further promote the uptake of inquiry-based learning (IBL) in mathematics and science.

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Context analysis for the implementation of IBL: International synthesis report

Within the PRIMAS project, the national contexts in 12 European countries have been analysed with regard to the implementation of inquiry-based pedagogies and a more widespread uptake of IBL in mathematics and science education. The international synthesis report is based on a comparison of national education contexts. It points out differences and commonalities among European countries, thus providing an overview of the situation in Europe when it comes to promoting IBL implementation. The report provides interesting resources and relevant initiatives suited for adaptation and use at the international level. The synthesis report consists of two parts. Included in Part 1 is an initial analysis conducted in 2010 and Part 2 contains a supplement analysis conducted in 2012.

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Context analysis

for the implementation of IBL:

International synthesis report

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PART 1

1. EXECUTIVE SUMMARY

1.1. Background

The project PRIMAS regroups 14 teams from 12 different countries. It aims to effect a change across Europe in the teaching and learning of mathematics and science with teachers supported to develop inquiry-based learning (IBL) pedagogies so that students gain experience of IBL approaches. Ultimately, our objective is a greater number of students with more positive dispositions towards further study of these subjects and the desire to be employed in related fields.

1.2. Aims and purpose

The purpose of work package 2 (WP2) "Analysis" is to produce an analysis of existing factors, structures, opportunities and obstacles that might help or hinder the widespread take up of inquiry-based methods in each country. This analysis will ensure maximum potential leverage and impact for the measures to be taken and the optimal use of existing structures and materials to make this impact cost-effective.

1.3. Theoretical background and method

In a first phase (6 first months), every country involved has produced an analysis of each national context, which has been advised by each *National Consultancy Panel* (NCP). These national reports deal not only with the content of the teaching of mathematics and sciences in each of the 12 countries involved in PRIMAS but also with the structure of the teaching and teachers' training at different levels. The analysis aims at pointing out the constrains and conditions on the various levels of the national educational system that can foster or hinder the realisation of our project, in terms of dissemination through professional development of IBL approach in the teaching of science and mathematics. It is impossible in such a report to measure individual resistance or on the contrary willingness of teachers as individual to implement IBL teaching in their practice. Thus, an analysis of structural constraints and conditions is the only possible entry in order to give a faithful overview of the situation in each country.

Therefore, we used a systemic theoretical approach proper to structure our analysis. It is based on Chevallard's Anthropological Theory of Didactics (ATD) which gives tools for a description of mathematical or science activity in terms of praxeologies as a way to describe *mathematical or scientific organisations* at stake in institutions. We specifically used in the

ATD the scale of levels of didactical determination in order to structure our analysis and identify the source and origin of constrains and condition for the implementation of our project either at four principal levels which are: civilisation and society (tradition or recent changes in education, specific role of mathematics and sciences in society), school (global organisation, separations between primary, lower and upper secondary education, pre-service and in-service teachers' training), pedagogy (general law of education, teachers' practices, national assessment) and discipline (place of mathematics and sciences in the curricula, competences of teachers, signs of IBL, type of resources like textbooks).

The national reports, advised by each National Consultancy Panel analysed information from official documents, existing reports and studies, interviews of key actors, textbooks, etc. The object of the synthesis is not to show in detail precise situations in any specific country, but rather to pinpoint the resemblances and differences among the 12 countries which are key-points regarding the implementation of PRIMAS and a successful dissemination of IBL. Specific issues for each country can be found in each national report, therefore, we tried to be as synthetic as possible and avoid giving detailed descriptions of any national aspect, in order to focus on an overview of the diversity.

1.4. Summary and conclusions of the analysis

We now give an overview of the main results of our analysis according to the division in 4 levels of didactical determination (as defined above).

At the levels of civilisation and society, in spite of strong differences in tradition, that may have been still quite important in the last decades, in all the countries there has been in recent years changes, sometimes quite radical, towards educational paradigms meeting the objectives of PRIMAS and IBL.

At the level of school, there is quite a variety in the division of educational levels (primary, lower and upper secondary) and length of each level. However, primary school teachers are always generalist trained mostly in pedagogy and didactics and usually have weakness in disciplinary training (especially in mathematics and sciences). Upper secondary school teachers are mono-disciplinary and usually well trained in their discipline, but may be weak in pedagogy. The intermediate level between primary and upper secondary education (usually reckon as lower secondary but in some cases as upper primary) is more heterogeneous from one country to another, the status of teachers vary from generalists to mono-disciplinary, and often bi-disciplinary specialists, with a university degree only in one discipline. In-service teachers' training and professional development are usually very poor in most countries. Most of the time, the offer is limited to one-day sessions without much supervision. Beyond the question of motivation from teachers, in several countries, there is a real problem of accessibility to in-service training and professional development, including financial aspects.

At the level of pedagogy, in all the countries of our consortium the general laws of education (or equivalent) advocate some type of pedagogy, which totally supports IBL. There is, indeed, a real homogeneity in the description of pedagogy in all countries' official documents. This clearly reflects an actual international orientation in educational policies, which is a real opportunity for PRIMAS. Yet, beyond this uniformity, there are varied situations. In some countries, this orientation in pedagogy is very recent. In some others, on the contrary, there is a long tradition for constructivist orientated pedagogy. However, if educational policies are in support of IBL, it does not mean that this actually reflects teachers' practices. This is actually the black spot in all countries. The reasons evoked vary from one country to another but it is always a mixture of the following with different repartition of weight depending on the national context (past and recent) and the cultural background: lack of training for teachers who have usually never experienced IBL methods as students, reluctance for changes, weight of traditions, lack of time (the first priority is to accomplish the whole programme). Moreover, in many, if not all countries, the resistance does not only come from teachers, but also from students, or even parents and maybe the society as a whole. In several countries (but not all) assessment has also evolved in order to take into account the changes in the educational policies. Yet, in many cases the changes have been slow and not always sufficient to really encourage IBL. Therefore, in most countries assessment remains a barrier that prevents teacher from adopting IBL methods.

At the level of discipline (and lower), in all countries at all levels there are explicit signs of more or less recent evolutions in official curricula of mathematics and sciences that are in favour of IBL as well as more coherence between the disciplines, with recommendation for cross and inter-disciplinary activities. However, in most countries, this official positioning hides another type of reality. Indeed, there are some strong evidences that in practice, IBL orientated teaching is not largely implemented at all levels of education in all countries. Indeed, traditional transmissive teaching still seems to dominate in most countries, even if there are some local differences, due to various parameters, especially concerning pre-service teachers' training and the fact that the changes toward constructivism, problem solving and IBL in the curriculum are more or less recent. This resistance to changes is accredited by international studies. However, in most countries, some studies attest of local successful IBL experiments that remain limited. Furthermore, in most countries (with some notable exceptions), resources, especially textbooks, do not provide explicit IBL activities. Nevertheless, in several cases, even if the textbooks are not explicitly IBL orientated they could provide good opportunity for IBL activities. However, even explicitly IBL and problem-solving orientated documents can be used by teachers in an inadequate manner, leading to very poor practice in reality.

1.5. Recommendations and outlook

We now come to the recommendations that follow from our analysis, for a most successful implementation of PRIMAS in the various contexts of our 12 countries.

• A generally good context regarding national policies, but careful to the excess of reforms

Indeed, we have seen that in all countries the most recent policy regarding the teaching of mathematics and sciences meets the goals of PRIMAS project. Of course, there are some nuances in the various countries, but still, it is clear that one common strength for the PRIMAS partners is that we can rely on official documents to support our action. Indeed, our project may be a consistent response to the decreasing interest of students in mathematics and sciences, an alarming fact shared by all countries. Nevertheless, one has to be careful about the historical background and traditions, which vary greatly from one country to another and still may be a barrier in order to make changes efficient. Furthermore, there are important negative factors appearing in several countries. One is due to the succession of reforms in recent years in many countries resulting in a rejection of changes by teachers and sometimes by parents. In some countries as well, this resulted in a resurgence of reactionary ideas defending a return to traditional pedagogical paradigms and to fundamental contents like reading and counting. On the positive side, another support on which we can rely concerns the fact that in several countries a new tendency appears asking to build bridges and develop more coherence between the disciplines, especially mathematics and the science subjects. It is therefore, an opportunity for PRIMAS to provide materials and didactical devices in order to build bridges between the various disciplines, in using IBL orientated common activities in mathematics and different science subjects.

• Necessity to adapt the general schema of our project to local specificity

From our analysis it also appears that in our 12 countries, there is quite a variety in school organisations from one country to another. This is a challenge for PRIMAS, since the conditions of implementation and the possible impact of the project may be quite different and therefore necessitate a careful analysis of different parameters, resulting in local adaptation to the general schema of our project. This is particularly challenging for the design of PRIMAS professional development programme, that has to be flexible enough to be adaptable to every national context but, at the same time, robust enough to keep its essence.

• IBL in pre-service teachers' training

In most countries, pre-service teachers' training is rarely IBL oriented. Therefore, with differences from one country to another, it is an opportunity as well as a challenge for PRIMAS to implement some type of IBL orientated training into pre-service teachers' training at various levels of education. The situation may be more or less positive depending on the level of expertise of teachers in the subject to be taught especially for primary education and in some cases for lower secondary education (especially in sciences), and also considering the differences regarding the type of training in didactics.

• Necessity to take into account teachers' level of expertise in their subject and in didactics

We have also seen that between the countries, but also between the different levels of education, the expertise of teachers in disciplines and in didactics are really different. Furthermore, in most countries the usual offer in in-service teachers' training and professional development is poor, not well-structured and above all rarely popular. Thus, in most cases, it seems like a real challenge for PRIMAS to find the right way to display a well-structured and attractive offer for in-service teachers training and professional development, introducing IBL.

• How can we succeed in making the change in policies effective in classroom practice?

Furthermore, the fact that in spite of the changes in favour of IBL in educational policies in all countries, the changes in teachers' practices are not effective at a large scale is certainly the main challenge for PRIMAS. The analysis of the context in all 12 countries of our consortium shows that this cannot be accomplished if we do not operate at a large scale, not only by training a large number of teachers, but also by developing supporting activities towards various target groups inside and outside school. The situation is of course different in the various countries. For instance, in the countries where the change in policies is more recent and the tradition of transmissive teaching still active, the necessity for a change is more radical, but in a way the novelty of the situation may be a positive factor for motivation. On the contrary, in those countries, where the change in policy dates back from the 70s or 80s and transmissive tradition has been chased from then, IBL may seem less far from actual practices. Yet, on the other hand, if practices remained traditional where changes have been advocated for decades, the resistance for changes is likely to be even stronger.

• Necessity to take into account the possible negative side-effect of national assessment

Another important challenge for PRIMAS is to take into account the possible negative side effects due to national policy in terms of assessment, which might even be in contradiction with the curriculum and IBL. Yet, in some countries, PRIMAS has an opportunity to support and interact with national assessment, but, in all cases, the pressure on schools and teachers coming from assessment is to be taken into account, especially concerning the question of time, an important factor in the resistance to changes seen as time consuming.

• Necessity to adapt according to the variety of pedagogical/didactical resources

Finally, our analysis showed great differences among countries in the type of resources (especially textbooks) at disposal for teachers and also in their way to use them. Thus, PRIMAS should appear as an opportunity either to share some IBL orientated material, where it is missing, or to highlight and reinforce IBL orientation already existing in some national textbooks and material. The use of a website for resources is of course important, as well as translations and adaptations to national contexts. Furthermore, it seems vital that the material that PRIMAS will work on, be accompanied by didactical comments on how the situation can be efficiently implemented in class and imbedded into a device to be used for professional development.

Outlook for the project

These recommendations are general guidelines in order to inform the consortium for the realisation of the whole project, it gives us some useful information for the construction of the general framework of the whole project and some hints for the implementation of the project in each national context. Moreover, in this second phase, the detail information is to be found in each national report and in interaction with each *National Consultancy Panel*.

2. REPORT AND RESULTS OF THE ANALYSIS OF CONTEXTS

2.1. Background and objectives of work package 2

The project PRIMAS regroups 14 teams from 12 different countries. “It aims to effect a change across Europe in the teaching and learning of mathematics and science with teachers supported to develop inquiry-based learning (IBL) pedagogies so that students gain experience of IBL approaches. Ultimately, our objective is a greater number of students with more positive dispositions towards further study of these subjects and the desire to be employed in related fields.” (Description of PRIMAS, abstract).

The purpose of work package (WP) 2 “Analysis” is to produce “an analysis of existing factors, structures, opportunities and obstacles that might help or hinder the widespread take up of inquiry-based methods in each country. This analysis will ensure maximum potential leverage and impact for the measures to be taken and the optimal use of existing structures and materials to make this impact cost-effective” (Ibid., p.29).

In a first phase (6 first months), every country involved has produced an analysis of each national context, which has been advised by each *National Consultancy Panel* (NCP). The collection of data and analyses offer us strategic information that will ensure that the rest of the project is conducted in an efficient, cost-effective and successful manner.

According to the presentation of the project, each national analysis was to cover 5 tasks:

- Task 1 – Identifying the constraints and opportunities in each local context.
- Task 2 – Identifying professional development resources and classroom materials that develop mathematical and scientific inquiry.
- Task 3 – Analysing existing professional development initiatives.
- Task 4 – Identifying supporting actions for teachers that will foster the widespread take-up of inquiry-based teaching.
- Task 5 – Identifying dissemination actions to out-of-school target groups.” (ibid., pp. 29-30)

The description of the 5 tasks is a first frame in order to collect the data and carry out the analysis. Furthermore, it has been underlined during the first meeting of the consortium, that each national report had to focus on the aims and objectives of the whole project in order to select carefully the collection of data and organise the analysis. It is neither possible, nor useful to give a full description of the situation of teaching and teachers’ training in every country; what is needed is an analysis, not a description. In other words, the project needs to provide a brief description in order to understand the main structures, but the main focus has to be put on points related to IBL and professional development (PD) and the analysis of the reasons, constrains and conditions, which can foster or on the contrary hinder the dissemination of IBL.

Moreover, in order to be able to make comparisons between the different countries and to facilitate (or simply make possible) the synthesis of the 12 national documents, we advocate that each national document follows a common pattern. Of course, the division in 5 tasks, in the description of WP2 (see above) gives a first level of the structure. Yet, it does not give all the keys in order to organise the analysis.

Therefore, the work of the consortium at the very beginning of the project was to decide on a common structure and a theoretical background in order to develop a framework for the national reports, which will organise as well the global synthesis.

During the first meeting of the consortium, we proposed a general theoretical framework to help organise the national reports, that we will present it in the following section.

WP2 presents an analysis of existing factors, structures, opportunities and obstacles that might help or hinder the widespread take up of inquiry-based methods. The goal is to ensure maximum potential leverage and impact for the measures to be taken and the optimal use of existing structures and materials to make this impact cost-effective.

2.2. Theoretical framework and methodology

The national reports deal not only with the content of the teaching of mathematics and sciences in each country but also with the structure of the teaching and teachers' training at different levels. The analysis aims at pointing out the constrains and conditions on the various levels of the national educational system that can foster or hinder the realisation of our project, in terms of dissemination through professional development of IBL approach in the teaching of science and mathematics. It is impossible in such a report to measure individual resistance or on the contrary willingness of teachers as individual to implement IBL teaching in their practice. Thus, an analysis of structural constraints and conditions is the only possible entry in order to give a faithful overview of the situation in each country.

2.2.1. Chevallard's Anthropological Theory of Didactics

We therefore need a systemic theoretical approach to give us tools to think and structure our analysis. In the field of research in education and more especially in the French "Didactique des mathématiques", Chevallard has developed since the 80s a theory that originates in the now famous notion of *Didactic Transposition* (Chevallard 1985). This initial work, inspired from sociology, has been a crucial step to think of the didactical system as part of society at large, interacting with various spheres, in particular the academic sphere of the discipline (producing and controlling the scholarly knowledge) and what Chevallard named the *Noosphere* (from the Greek *noos*, "the place where one thinks") the sphere where different actors select and adapt the knowledge to be taught. Then, this knowledge is transposed into taught knowledge, in a process that includes writing textbooks and materials for teachers, as well as individual preparation from teachers. Finally, this knowledge is actualised in the classroom and studied by students, this becomes the learned available knowledge.

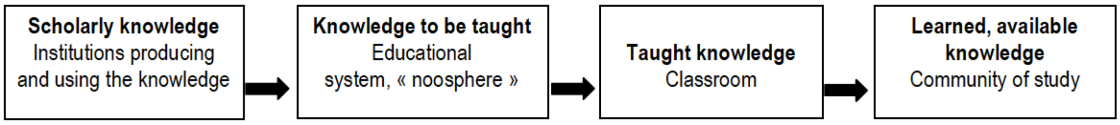

Figure 1. The didactic transposition process (Bosch & Gascón 2006, p. 56)

This theoretical approach is not prescriptive (in this sense, it does not suggest that there is good or bad transpositions) but it essentially gives a model in order to explain and describe the process of modifications of the knowledge from its sphere of academic production to the places where it is taught (in a wide sense, this can be extended to explain the use of mathematical related professional know-how, in building for instance). From the original work of the didactic transposition, Chevallard moved on and started modelling the educational system as a complex structure of different institutions. These institutions may have different sizes and be more or less visible as such. For instance, secondary education in a certain country is an institution but the mathematical class of grade 10 in the same country is also an institution, which is part of the first. Moreover, institutions outside the educational system have also to be taken into account: like mathematicians or physicists for instance. Any group of individuals with a common practice may form an institution; the division is not pre-established but results from a choice, which is part of the modelling process of the researcher. Within an institution, individuals are subjects, who bear certain constrains that organise the conditions of their relation to the objects of knowledge at stake. This is what Chevallard names the *institutional relation* to an object of knowledge. An individual, as a subject of an institution, is therefore constrained by a certain official relation to the objects of knowledge he has to deal with. Nevertheless, theses institutional constrains leave a certain leeway (*marge de manoeuvre*), this is why the model takes also into account the personal relation to the objects of knowledge. In fact the personal relation is the results of the fact that each individual is or was a subject of other institutions, in which the same objects of knowledge are at stake (think of a teacher as an ex-student, or teaching in different school levels, or at different times with different programmes, etc.).

This *institutional approach* enriched the model of the didactic transposition to explain the complexity of educational systems where different *objects of knowledge* are interacting with different individuals in different places (*institutions*). This is why Chevallard named his approach the *Anthropological Theory of Didactic* ATD (Chevallard 1992a & b). A third step consisted in importing in the theory what is known as the ecological approach. The idea is to see the elements of knowledge within an institution as living organisms occupying a certain place, their *habitat* or their address, and a specific function, their *niche*, in this habitat. For instance, in the institution of mathematics lower secondary education in most countries, Pythagoras' theorem lives in the habitat of Geometry and its niche is the metrical characterisation of right-angled triangles. In this sense, some objects of knowledge nourish others. Moreover, in order to survive and develop harmoniously in a didactical system, an object of knowledge has to fit into a *trophic chain*, i.e. be nourished by other elements of knowledge present in previous stages of the institution and be an aliment for further elements of knowledge. With this model, one can explain why some elements of knowledge can or cannot exist or survive in certain institutions with a specific ecosystem of the elements of knowledge (Chevallard 2002). In particular, it gives a new dimension to the notion of didactic transposition, in the sense that it provides a model in order to explain in terms of ecological constrains and conditions, the possibility of a transposition. The next step within ATD was to give a model of the use of the objects of knowledge by individuals within the institutions.

Chevallard considers mathematical activity like any human activity, in terms of praxeology. A *praxeology* models the activity as a quadruplet made of a *task* (what one has to do: sweep the floor, or solve a quadratic equation), *techniques* that can be used in order to solve the task (like the algorithm for solving quadratic equations), the *technology* that explains, justifies the technique (like the canonical form of a quadratic equation and the fact that any positive number has two square roots, etc. in order to justify the algorithm, the technology is centred on the properties of polynomial equations) and a *theory* that justifies the technology (like algebra of polynomials for the previous example). The block Task-Technique, is the *praxis*, if alone it defines know-how, and the block Technology-Theory is the *logos*, which makes the difference between know-how and a proper knowledge. A description of mathematical or science activity in terms of praxeologies is a way to describe *mathematical or scientific organisations* at stake in institutions.

We used a systemic theoretical approach proper to structure our analysis. It is based on Chevallard's Anthropological Theory of Didactics (ATD) which gives tools for a description of mathematical or science activity in terms of praxeologies as a way to describe mathematical or scientific organisations at stake in institutions.

2.2.2. The scale of levels of didactical determination

The praxeological organisation is also used in order to describe how mathematical or scientific organisations are taught; this is described in terms of *didactical organisations*. Both mathematical or scientific organisations and didactical organisations are co-determined (i.e. determined in their mutual interaction) by a whole hierarchy of institutional levels, which successively condition and constrain each other. It is an important contribution of ATD to provide a detail model of these levels of co-determination.

In the description of these levels, a *Subject* is the lower level and is organised around one type of task and technique (like quadratic equations). A *Theme* is centred on one technology (like polynomial equations). A *Sector* is centred on a complex of paraxeologies within a same theory (like polynomials). Of course different sectors are part of a same *Domain*, like algebra being a domain of which polynomial is a sector. The next level is the *Discipline*, here mathematics is the discipline of which the domain of algebra is part. Clearly these levels are issued form the modelling in terms of praxeology, but in the framework of ATD, higher levels are also considered which take into account the complex structure of various institutions. Therefore, after the discipline, Chevallard takes into account the level of the *Pedagogy*, i.e. the general teaching principles included in the description of the curriculum of an institution. Then the level of *School*, takes into account how the general curriculum is structured, the division into disciplines, the time allocated to each, the fact that teachers are mono- or pluri-disciplinary, etc. The next level deals with *Society*, that is to say, the institutional organisation of the educational system in a country or a region, the most general level of the curriculum, etc. The highest level has to do with *Civilisation*, it takes into account variations between different cultures, like western versus eastern culture. But it may also be the difference for instance between British pragmatism versus French Cartesian influence. This may have a strong influence in major choices in the curriculum, see for instance the use of statistics in society, which is partly determined by a cultural component, which is in turn determined by the relation of certain civilisations to the numerical data and their use, and on the other side determines the way this sector of mathematics can be developed (or not) in each country and consequently the effects on the transposition in school at all the lower levels (see Wozniak's work on this matter, in Chevallard & Wozniak 2007).

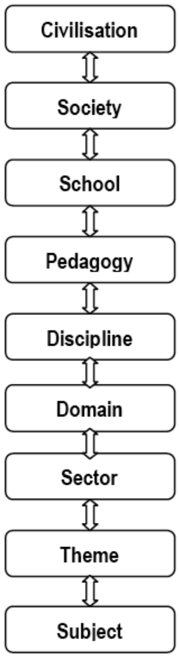

Figure 2. Scale of levels of determination

"The study of the ecology of mathematical and didactic praxeologies states that, when the teacher and the students meet around a knowledge to be taught, what can happen is mainly determined by conditions and restrictions that cannot be reduced to those immediately identifiable in the classroom: teacher's and students' knowledge, didactic material available, software, temporal organisation, etc. Even if these conditions and restrictions play an important role, Chevallard recently proposed to consider a scale of 'levels of determination' (see figure 2) that may help researchers to identify conditions that go beyond the narrow space of the classroom and the subject that has to be studied in it ." (Bosch & Gascón 2006, pp.60–61).

In our project, we decided to use the distinction in these 9 levels of determination, in order to help differentiating between the various factors in the analyses of constrains and conditions that characterise the teaching of mathematics and sciences in different countries. In this sense, Artigue and Winslow have recently shown how this can be useful in international comparison researches (Artigue & Winslow, 2010).

It is clear that this short presentation of a vast theory (furthermore, we have not presented the most recent developments of ATD) is not sufficient to grasp all the aspects, yet our aim was only to give a general overview, that can be completed by reading the texts given in reference.

We specifically used in the ATD the scale of levels of didactical determination in order to structure our analysis and identify the source and origin of constrains and condition for the implementation of our project either at the level of civilisation and society, school, pedagogy or discipline.

2.2.3. Methodological issues

We will now try to be more 'practical' and see how this theoretical framework may help organising the 12 national reports and their synthesis within WP2 of PRIMAS.

The fives tasks in the description of WP2 are essential milestones in order to organise the reports. Moreover, it is necessary to focus on constrains and conditions that might help or hinder the widespread take up of inquiry-based methods in each country. The use of the preceding theoretical framework is a possibility in order to organise the analysis and to try to identify at which level the constraints and conditions operate. This does not mean that we neglect completely individuals' beliefs and attitudes. Indeed, like Chevallard says: "Behind the persons, and the knowledge, there appeared the institutions, to be regarded with the persons, in the light of a dialectic between persons and institutions. Persons are the makers of institutions, which in turn are the makers of persons. Generally, however, institutions come before those persons – their "subjects" – thanks to whom they will continue to exist and change. So that, in order to understand what persons are made of, we have to understand how institutions live, develop or recede." (Chevallard 2006, p. 4).

Moreover, this theoretical framework must be used in an open way, i.e. not a limiting scheme, but a way to synthesise and organise the data. Again, we insist that we do not need a full description of the educational system in each country, but a focus on points related to IBL in mathematics and sciences as well as professional development.

The following table is a proposition in order to organise each national report as well as the synthesis, according to Chevallard's framework.

Level of determination	Sources
Civilisation	- Historical account of the role of mathematics and sciences in your country both in teaching and in general. Influence of great educators, mathematicians or scientists.
Society	- Local traditions in teaching mathematics and science - General socio-economical constrains that could have influenced orientations in education - General orientations of teaching at different levels in your country or region (this could be in the introduction of the official curriculum or in other official documents like guidelines about how the curriculum should be implemented or about the role school should play within society…) - National reports about the situation of the teaching of mathematics and science in your country (from teachers' professional associations, from the ministry of education, from private institutions, from other projects, from universities, from groups of experts…) - Interviews with key actors (for instance, educational authorities, teachers' associations, parents' associations…) - General guidelines and structures for pre-service and in-service teachers training. Moreover, socio-economical contexts that may condition the recruitment of teachers.
School	- Official documents about school organisation, the distribution of subjects in the school system, time allocated to mathematics and science education in school, possibility of implementing IBL in school, flexibility in the organisation of the teaching at school, possibility of teachers' training in the school… - Structure of pre-service and in-service teachers' training - Autonomy of school in their organisation regarding the national or regional curriculum and regarding professional development. - Interviews with key actors like educational authorities, teachers' associations, school principals…)
Pedagogy	- General pedagogical principles to deliver the curriculum: does it suggest any relation to IBL? - Other official documents setting important pedagogical issues that may affect the teaching of mathematics and science at school as well as the training of teachers. - National reports explaining how mathematics/sciences are taught and professional development implemented - Sources to have information about dominant teaching practices. The official

	documents may not be sufficient. - Interviews with key actors like teachers' associations and experienced teachers and trainers.
Disciplines **Domains** **Sectors** **Themes**	- Official curriculum in mathematics and sciences. Specific instructions for each sub-disciplinary level that might be relevant for IBL. - Textbooks in mathematics and science: are the mathematical, scientific or didactical organisations at stake in textbooks compatible with IBL? What could be an obstacle? - Interviews with experienced teachers. Are they already using IBL or something near? If not, why? And would they be reluctant to use it?

On a methodological point of view, in each country, the PRIMAS team has made an analysis of the national context according to the previous table. The material used included:

- All official documents related to education and especially the teaching of mathematics and sciences at all levels of education (Law on education, curricula, regulations concerning the recruitment and training of teachers (present but also in recent past);
- All kind of existing national studies or report on questions related to connected subjects (from teachers' professional associations, from the ministry of education, from private institutions, from other projects, from universities, from groups of experts…);
- Interview with key actors like educational and school authorities, teachers' associations and experienced teachers and trainers;
- Textbooks and various resources used by teachers, previous experiments regarding professional development and Inquiry based learning.

Moreover, the national reports have been advised by the *National Consultancy Panel* established in every partner country according to the terms of the proposal. From the reports, the partners were asked to fill in a document with synthetic information according to the levels of didactic determination. There were 8 different sections with the following entries:

- Levels of Civilisation and society – Specific role of mathematics and sciences in society, tradition or recent changes in education.
- Level of school (global organisation) 1 – Separations between primary, lower and upper secondary education.
- Level of school (global organisation) 2 – Pre-service and in-service teachers' training.

- Level of pedagogy 1 – Law of education: general statement on pedagogy, tradition in education (transmissive or constructivist tradition, place of the learner...).
- Level of pedagogy 2 – Type and role of national assessments.
- Level of discipline (and lower) 1 – Links between mathematics and sciences in the curricula. Integrated science or separate subjects, etc.
- Level of discipline (and lower) 2 – Place of mathematics and sciences in the curricula (number of hours). Competence of teachers in mathematics and sciences (profile of teachers).
- Level of discipline (and lower) 3 – Type of curricula in mathematics and sciences, signs of IBL?
- Level of discipline (and lower) 4 – Type of resources for teachers in mathematics and sciences (textbooks, web, etc.).
- Level of discipline (and lower) 5 – Are mathematics and science teachers using IBL? Why? If it is a requisite in the curriculum, even in the textbooks, why not?

These entries will structure the section on results of our report in four points (we have gathered in one all points referring to same level). In addition, we have asked each partner to fill in a synthetic table presenting each national school organisation put in the appendices (the countries were put in the order they appear in the description of the project: Germany (DE), Switzerland (CH), Nederland (NL), England (GB), Spain (ES), Slovakia (SK), Hungary (HU), Cyprus (CY), Malta (MA), Denmark (DK), Romania (RO) and Norway (NO)).

The object of the synthesis is not to show in detail the precise situation in any specific country, but rather to pinpoint the resemblances and differences among the 12 countries which are key-points regarding the implementation of PRIMAS and a successful dissemination of IBL. Specific issues for each country can be found in each national report, therefore, we tried to be as synthetic as possible and avoid giving detailed descriptions of any national aspect, in order to focus on an overview of the diversity.

The national reports, advised by each National Consultancy Panel analysed information from official documents, existing reports and studies, interviews of key actors, textbooks, etc. The synthesis pinpoints the resemblances and differences among the 12 countries which are key-points regarding the implementation of PRIMAS and a successful dissemination of IBL, without giving details to be found in each national report.

2.3. Results

2.3.1. Levels of civilisation and society – Tradition or recent changes in education, specific role of mathematics and sciences in society

The situations in the 12 countries of our consortium regarding tradition in education and the place of mathematics and sciences in society are quite varied.

In many countries, there is a strong tradition of transmissive-type of education, centred on basic fundamental notions, which may have been supported by political or religious backgrounds. In some other countries, the cultural and political backgrounds have allowed to develop less traditional models of education for already a long time.

Moreover, there are important differences regarding the share of responsibility and autonomy in education. In some countries, local or national governments have a strong power, while in others, teachers or local schools hold most of the power of decision.

Regarding the place of mathematics and sciences in society, in a country like Hungary, these academic subjects have been traditionally favoured as a mean for being part of the intellectual sphere, escaping ideological pressure; this resulted in a tradition of talent development. In the most industrial countries like Norway, England or the Netherlands, technological development is important and therefore, mathematics and sciences are seen as important educational topics. This is also very important for ex-communist countries.

In spite all these differences in tradition, that may have been still quite important in the last decades, in all the countries there has been in recent years a common trend in the promotion of mathematics and sciences for students, resulting in changes, sometimes quite radical, towards educational paradigms, in which students should be more active. Therefore, the curricula are less content centred, more formulated in terms of competences, in relation with the outside world. Moreover, in all countries as well, the results of international evaluations like PISA and the decreasing number of students choosing mathematics or sciences in their university studies resulted into political decisions to reform the teaching of these subjects.

These last points, however, may appear as positive aspects regarding the implementation of PRIMAS. Indeed, IBL meets the objectives of recent changes in the curricula of all countries and may be a consistent response to the decreasing interest of students in mathematics and sciences, an alarming fact shared by all countries. Nevertheless, one has to be careful about the historical background and traditions, which vary greatly from one country to another and may still be a barrier in order to make changes efficient.

Furthermore, there are important negative factors appearing in several countries. One is due to the succession of reforms in recent years in many countries resulting in a rejection for changes by teachers and sometimes by parents. In some countries as well, this resulted in a resurgence of reactionary ideas defending a return to traditional pedagogical paradigms and to fundamental contents like reading and counting.

At the levels of civilisation and society, in spite of strong differences in tradition, that may have been quite important in the last decades, in all the countries there have been in recent years changes, sometimes quite radical, towards educational paradigms meeting the objectives of PRIMAS and IBL.

2.3.2. Level of school – Global organisation, separations between primary, lower and upper secondary education, pre-service and in-service teachers' training

The global organisations of school levels in the different countries are quite varied but still one can see a certain homogeneity among the 12 countries of the consortium (see tables describing the global organisation in each country in appendix n°1).

Primary school usually starts at age 6, and lasts between 4 and 6 years. Mathematics is taught at each level of primary school in all country and usually with a rather important number of hours. Science is always taught as an integrated subject but with a small number of hours and in many cases it includes also subjects like geography and/or social sciences. In most countries primary school teachers are not sufficiently trained neither in mathematics nor sciences. This aspect is pointed out as a potential problem regarding the implementation of PRIMAS, especially because primary school teachers are rarely willing to be trained in mathematics or sciences.

The organisations of lower secondary schools are more varied. It lasts between 3 and 6 years depending on the country. It is usually undifferentiated for all children but may also be selective (like in Germany). In most cases the structure of lower secondary education is close to upper secondary education. However, in some countries, the structure still reflect Primary education (and appear more like upper-primary than lower secondary education) with generalist teachers (Denmark) or bi-disciplinary teachers (Slovakia and Hungary). Sciences might be integrated or already divided into 2 or 3 different subjects (not all necessary taught at each level). The curriculum includes some mathematics and some sciences in all cases but the number of hours is quite different from one country to another. Teachers are usually mono- or bi-disciplinary specialists.

Upper secondary education is also quite varied. It lasts between 2 and 4 years and is usually differentiated and selective. Mathematics is taught in nearly all branches, although not always in non scientific branches at the end of the curriculum. The teaching of sciences varies quite considerably depending on the specialty and is usually divided into 2 or even 3 different subjects (Physics, Chemistry and Biology/Geology).

In most countries primary school teachers are trained in a special institute or a university for at least 3 years (up to 5). The training is mostly in educational sciences, but in most cases, it includes courses in didactics of mathematics and science (that may be IBL orientated, but this not the majority of cases). Didactics of mathematics and science usually represents a small part of the training, in very rare cases there are complements in mathematics and/or sciences, while in most countries the training in didactics includes some complements in these disciplines.

Upper secondary teachers on the contrary usually have at least a 3 year (up to 5) university degree in mathematics or one science subject. On the other hand, their pedagogical training varies from nearly nothing up to 2 years (usually partly in service) and includes some didactics and sometimes some courses in IBL and/or modelling.

The training of lower secondary school teachers is less uniform. In some countries it is the same as upper secondary while in others it is more like primary with a specialisation in one or two subjects.

If mathematics teachers at upper secondary level are usually experts in their subject, the competencies in mathematics of teachers at lower secondary education level may be less adequate, especially in those countries where they are trained more like primary school teachers or if they are bi-disciplinary, in which case they might be more specialised in one science subject. Moreover, in sciences, there is a problem of specialisation, since university degrees are mono-disciplinary while teachers may have to teach two or three science subjects. Additionally, the training in didactics and especially regarding IBL, problem solving or modelling varies from one country to another.

In-service teachers' training and professional development are usually very poor in most countries. Most of the time, the offer is limited to one-day sessions without much supervision. Although in some places, like Andalusia (Spain), there are regional teacher centres supervising in-service training, but there is a lack of motivation from teachers! In Hungary the system for professional development seems to be well structured according accreditation via the Bologna system. Beyond the question of motivation from teachers, in several countries, there is a real problem of accessibility to in-service training and professional development, including financial aspects.

From this brief overview one can see that there is quite a variety in school organisations from one country to another. This is a challenge for PRIMAS, since the conditions of implementation and the possible impact of the project may be quite different and therefore necessitate a careful analysis of different parameters, resulting in local adaptation to the general schema of our project.

Concerning the implementation of PRIMAS, the situation may be more or less positive depending on the level of expertise of teachers in the subject to be taught especially for primary education and in some cases for lower secondary education (especially in sciences). The differences regarding the initial training in didactics are also to be considered in the implementation of PRIMAS. Moreover, in most countries, PRIMAS should be an opportunity to introduce IBL in pre-service training.

Thus, in most cases, it seems like a real challenge for PRIMAS to find the right way to display a well-structured and attractive offer for professional development.

At the level of school, it appears that primary school teachers usually have weakness in disciplinary training, while upper secondary school teachers are usually well trained in their discipline, but may be weak in pedagogy. The intermediate level between primary and upper secondary education may be more from one side or the other depending on the country.

2.3.3. Level of pedagogy – General law of education, teachers' practices, national assessment

At all levels of education and in all the countries of our consortium the general laws of education (or equivalent) advocate some type of pedagogy, which totally supports IBL. Indeed, with different formulations, one find in all countries recommendations in order to develop students' creativity, supporting open problems in relation with everyday life, in which students can develop in a balanced manner their personality and get ready for social and professional life. National curricula advocate a constructivist approach where teachers do not lecture, but organise activities and help students in order to develop their own access to knowledge in the respect of their diversity, trying to erase inequalities. One also finds recommendations for less memorisation and more initiative from students, development of analytical and critical skills, which sometimes is the idea of pedagogy by projects. Moreover, most countries have adopted a description of the curriculum in terms of competencies rather than contents. This results in a tendency to encourage cross-disciplines and interdisciplinary activities. Transmissive practices are condemned sometimes explicitly in official documents. A general idea is to open school to the outside world and give children means to live in modern world involving an increasing rate of changes and a necessity for rapid adaption to new situations.

There is a real homogeneity in the description of pedagogy in all countries' official documents, indeed. This clearly reflects an actual international orientation in educational policies, which is a real opportunity for PRIMAS. Indeed, we have to take advantage of this state of art for our project in order to be supported by educational authorities. Moreover, in some countries this is a real opportunity to give actual means in order to fulfil some of the political requirements, by providing supports to teachers, parents and ultimately students.

Yet, beyond this uniformity, there are varied situations. In some countries, this orientation in pedagogy is very recent (Malta, Hungary, Romania, Slovakia, Cyprus, Spain…). In some others, on the contrary, there is a long tradition for constructivist pedagogy (Norway, Nederland, Denmark, Geneva…). In some country like Germany, the change has been quite radical after the first Pisa study results.

Moreover, if educational policies are in support of IBL, it does not mean that this actually reflects teachers' practices. This is actually the black spot in all countries. The reasons evoked vary from one country to another but it is always a mixture of the following with different repartition of weight depending on the national context (past and recent) and the cultural background: lack of training for teachers who have usually never experienced IBL methods as students, reluctance for changes, weight of traditions, lack of time (for teachers the first priority is to accomplish the whole programme). Moreover, in many, if not all countries, the resistance does not only come from teachers, but also from students, or even parents and maybe the society as a whole.

Clearly, there lies one of the main challenges for PRIMAS: to succeed in making the change in policies effective in the class! The analysis of the context in all 12 countries of our consortium shows that this cannot be accomplished if we do not operate at a large scale, not only by training a large number of teachers, but also by developing supporting activities towards various target groups inside and outside school.

The situation is of course different in the various countries. For instance in the countries where the change in policies is more recent and the tradition of transmissive teaching still active, the necessity for a change is more radical, but in a way the novelty of the situation may be a positive factor for motivation. On the contrary, in those countries, where the change in policy dates back from the 70s or 80s and transmissive tradition has been chased from then, IBL may seem less far from actual practices. Yet, on the other hand, where practices remained traditional where changes have been advocated for decades, the resistance for changes is likely to be even stronger.

At the level of pedagogy, the issue concerning national assessment is also important. Indeed, this also reflects choices in the pedagogical policies and moreover, it may help or hinder the adoption of IBL by teachers. Here as well, in several countries (but not all) the national policies have evolved in the sense of less traditional assessment, taking into account the changes in the educational policies, as well as, in some countries, the results and spirit of international evaluations like PISA. Yet, in many cases the changes have been slow and not always sufficient to really encourage IBL. Therefore, in most countries assessment remains a barrier that prevents teacher from adopting IBL methods. Indeed, in many countries there is an increasing pressure on schools due to national ranking or students' orientation resulting from the national assessment. Thus, if the assessment is not compatible with IBL methods, the effect on teachers may be disastrous, since teachers spend lots of time and energy preparing students for the assessment. Moreover, assessment puts pressure on teachers so that they fully cover the curriculum; thus, this is a hindering factor for using IBL activities, which are seen as time consuming. It is one challenge for PRIMAS in many countries to take into account these kinds of side effects due to national policy in terms of assessment, which might be in contradiction with the curriculum and IBL. In some countries on the contrary, PRIMAS has an opportunity to support and interact with national assessment. In all cases, the pressure on assessment is to be taken into account, especially concerning the question of time.

At the level of pedagogy, in all the countries of our consortium the general laws of education (or equivalent) advocate some type of pedagogy, which totally supports IBL (this might be a very recent and radical shift or inscribed in a constructivist tradition from the 1970s). Assessment is also evolving but still remains a barrier for IBL use in many countries.

2.3.4. Level of discipline (and lower) – Place of mathematics and sciences in the curricula, competences of teachers, signs of IBL, type of resources (textbooks)

In all countries of our consortium, mathematics and sciences have been traditionally taught as separate subjects. It is still the case in most countries. However, in several places, a new tendency appears in order to build bridges and more coherence between the disciplines. For instance, in primary education in Germany, it is said: "On the one hand, mathematics are tools to answer scientific questions and solve problems. On the other hand, science offers the topics for the teaching of mathematics and allows the acquirement of mathematical competencies". In Switzerland the new curriculum (to be implemented in 2011) regroup in one single domain, mathematics and sciences for all compulsory education with some common goals even if the core of the description in the curriculum remains divided. In the Nederland as well a new subject NLT (Advanced Science, Mathematics and Technology; started in 2007) integrates at least two subjects in thematic learning units. In Spain, the curriculum is now declined in common competencies to be developed in all disciplines and the regional curriculum for Andalusia recommends that some connections between the different school disciplines should be made. In Denmark, the curriculum for secondary school explicitly requires some interactions between mathematics and the various science subjects. In Norway, there is a strong emphasis in the competencies on culture and modelling and general modelling, which include the formulation of mathematical models based on observed data, the use of technological tools, mathematical proof, and practical experiments. However, even in these countries, and obviously in the others, the disciplinary division is traditionally strong. Regarding only sciences, it is usually taught as a single integrated subject in primary education, but it breaks into 2 or even 3 different disciplines usually from lower secondary education. It is therefore a challenge for PRIMAS to give opportunities to build bridges between the various disciplines in using IBL orientated common activities in mathematics and different science subjects.

As we mentioned above, in most countries the level of qualification in mathematics and sciences is usually low for primary school teachers. In many countries, in particular, the teaching of science in primary education seems to be lacking of consistency. Mathematics is usually seen as more important, but its teaching is usually traditional and transmissive in spite of new curricula advocating more constructivist approaches and some IBL components (see below). In lower secondary education teachers' disciplinary qualification is a bit better, yet, in several countries teachers have to teach 2 or 3 different subject while being correctly qualified only in one (in some countries particularly, mathematics may be taught by teachers having a university degree in science not in mathematics, or physics may be taught by teachers with qualification in biology…). In upper secondary education, teachers' disciplinary qualification is in all cases mainly adequate, sometimes even excellent. However, their didactical qualification may be in some cases very poor, and in no sense IBL orientated. Therefore, with differences from one country to another, it will be a challenge for PRIMAS to implement some type of IBL orientated training into pre-service training at various levels of education as well as interdisciplinary activities.

The real positive point shared by all countries (to some different degrees) is that, in accordance to what we said about official texts about pedagogy, the most recent curricula of all countries show explicit signs of IBL or related recommendations. Since we are here at the heart of our project, we chose to quote some extracts of these curricula supporting IBL in the teaching of mathematics and sciences from all the countries of our consortium. We do not aim at being exhaustive, but we want to give evidences of existing IBL support in official documents defining the teaching of mathematics and sciences in all countries and the variety of ways to express concordant ideas:

- Problem-oriented and inquiry-based learning have to be used age-based. Typical working methods like observing, analysing, planning, exploring, experimenting, constructing, assembling, evaluating should be practiced and used. (Germany)

- The didactical approach at stake for mathematics is before all to place pupils in situation to solve problems in order to develop attitudes and build concepts, tools, notions, summonable in classes of problems. […] Situations-Problems are offered in order to make pupils build and use new notions and tools, in a context proper to provide meaning through a demanding thinking process. […] Open problems or mathematical situations are even more ambitious. To some respect they are close to what mathematicians deal with. They open the door of curiosity and desire to investigate. (Switzerland)

- To let students experience the importance of interdisciplinary coherence in the development of science and technology (after all, many scientific issues and practical problems demand knowledge from different disciplines) (Nederland)

- The study of science fires pupils' curiosity about phenomena in the world around them and offers opportunities to find explanations. It engages learners at many levels, linking direct practical experience with scientific ideas. Experimentation and modelling are used to develop and evaluate explanations, encouraging critical and creative thought. (England)

- From a formative perspective, problem solving activates basic capacities of individuals, like understanding reading, reflection, setting a working plan, revising and adapting it, formulating hypothesis, verifying the range of validity of a solution, etc. (Spain)

- Aims of education in mathematics includes (among others) the ability to use mathematics in future life; to reason and communicate; (…) to develop logical and critical thinking; (…) to cooperate in groups while solving problems; to acquire new knowledge through solving problems with different contexts; to create simple hypothesis; (…) to build the connections between mathematics and reality; to create mathematic models. (Slovakia)

- Mathematical competence is the ability to develop and apply mathematical thinking, which also enables an individual to solve a range of problems in everyday situations. The emphasis is as much on process and activity as on knowledge. Mathematical competence - although to different extents - embraces the development and use of abilities related to mathematical modes of thought, the application of mathematical models (formulas, models, constructs, and graphs/charts), as well as an inclination to apply these. (Hungary)

- In mathematics students are expected (among other things) to develop flexibility and creativity in applying mathematical ideas and techniques to unfamiliar problems arising in everyday life, and develop the ability to reflect critically on the methods they have chosen; become effective participants in problem-solving teams, learning to express ideas, and to listen and respond to the ideas of others. (Cyprus)

- The curriculum in mathematics advocates (among others) to develop in each student the ability to communicate confidently using mathematics by means of multiple representations; to develop in each student the ability to recognise and use connections among mathematical ideas; to develop in each student the ability to recognise and apply mathematics in real life contexts; to adopt an inquiry-based and problem solving approach that allows each student to develop mathematical thought and ability. (Malta)

- The curriculum in mathematics says that the overall purpose is that the students (…) can experience independently and through dialog and cooperation with others that engaging in mathematical activities promotes creativity and that mathematics provide tools to problem solving, argumentation and communication. Finally it is stated as an overall purpose that the teaching should contribute to the students' experience and acknowledgement of the role of mathematics in culture and society, to their ability to evaluate applications of mathematics so they are prepared to take responsibility and to exercise influence in a democratic community. (Denmark)

- The objectives of the mathematics curriculum includes: building capacity of exploration/investigation and problem solving; building and training capacity to communicate using mathematical/scientific language; developing interest and motivation for study and application of mathematics in different contexts. (Romania)

- General mathematical skills includes: being able to express oneself orally, which includes reasoning, explaining etc.; being able to express oneself in writing, which includes solving problems, drawing sketches and also mathematical language; being able to read, which includes interpreting texts, and also mathematical expressions etc.; being able to do mathematics, which is said to include problem solving and exploration etc. (Norway)

From these 12 quotations, one can see that in all countries the policy regarding the teaching of mathematics and sciences meets the goals of PRIMAS project. Of course, there are some nuances in the various countries, but still, it is clear that one common strength for PRIMAS partners is that we can rely on official documents to support our action.

However, in most countries, this official positioning hides another type of reality. Indeed, there are some strong evidences that in practice, IBL orientated teaching is not largely implemented at all levels of education in all countries. Indeed, traditional transmissive teaching still seems to dominate in most countries, even if there are some local differences, due to various parameters, like pre-service teachers' training, the fact that the changes toward constructivism, problem solving and IBL in the curriculum are recent (Cyprus, Hungary, Malta, Romania, Slovakia, Spain) or more ancient (England, Denmark, Germany, Nederland, Norway, Switzerland). In any cases the differences mostly bear on the little percentage of teachers who are really using successfully IBL methods (this oscillates between nearly 0% up to 25% in best cases). It is obviously difficult to give precise statistical results as well as to clearly evaluate teachers' actual practice and decide whether it is successful IBL methods. In several countries, there are interesting studies mostly of clinical type, showing some successful experiments involving IBL orientated teaching, but there are also studies showing the resistance to change in teaching methods of most teachers. There are also international surveys, involving some countries of our consortium that show similar results in most countries. For instance, the TIMSS video studies, has proven that in mathematics and science lessons more "traditional" activities dominate in almost all of the countries involved (Hiebert et al., 2003). Moreover, Talis study led by OECD (2009) has evaluated classroom practices, dividing them between.

- *"Structuring practices" were measured with five items, such as "I explicitly state learning goals." The other items include summary of earlier lessons, homework review, checking the exercise book, and checking student understanding during classroom time by questioning students.*
- *"Student-oriented practices" were measured with four items, such as "Students work in small groups to come up with a joint solution to a problem or task." The other items include ability grouping, student self-evaluation and student participation in classroom planning.*
- *"Enhanced activities" were also measured with four items, such as "Students work on projects that require at least one week to complete." The other items include making a product, writing an essay, and debating arguments.* (Op. Cité, p.100).

This categorisation does not exactly take in account IBL strategies, however, it is quite clear that structuring practices are not characteristics of IBL methods, while student-orientated practice are a bit more likely to be used within IBL methods, while enhanced activities seem to have a strong relation with IBL.

However, the results from Talis show that especially in mathematics and sciences (as well as in foreign languages) "structuring practices, such as checking understanding, summarising and controlling assignments, are especially strong". Thus we can interpret this as another indicator of the poor use of IBL method in mathematics and science teaching in many countries.

Furthermore, this study tried to see if there were any common features between teachers of a same school or of a same country. Their statistical analysis shows that:

The variance distribution across levels of analysis (Figure 3) shows that teaching practices – like beliefs about instruction – represent personal strategies and habits to a great extent and vary noticeably among teachers within a school. The effect of socialisation processes and other factors to which all teachers in a school are exposed is quite small (the variance between schools is only about 5%), but it is stronger for teaching practices than it is for beliefs about the nature of teaching and learning. Cultural factors and pedagogical traditions shape teaching practices significantly (variance between countries constitutes 17 to 34% of the total variance).

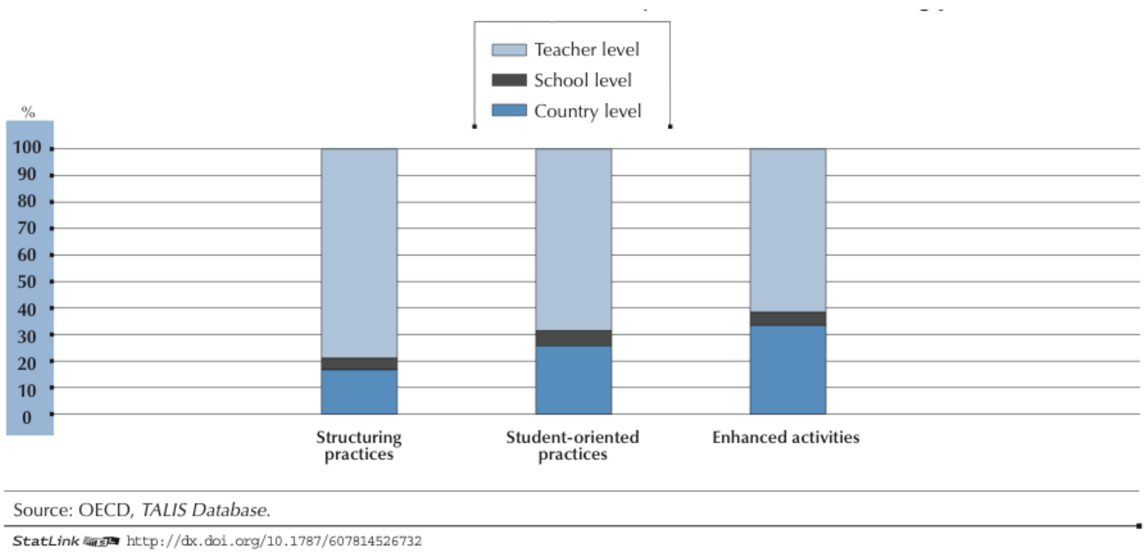

Figure 3. Distribution of total variance across the three levels of analysis for classroom teaching practises (2007-08)

Interestingly, countries differ especially with regard to the frequency of enhanced activities, whereas structuring activities seem to be about equally popular across countries. Again, these results point to the significance of individual professional learning experiences and psychological processes as well as national pedagogical traditions and culture for shaping teachers' beliefs and practices, while the local context, i.e. professional norms and practices that are specific to schools and socialisation within a school, seems to play a relatively subordinate role (Ibid., pp.100-101).

This is precious information for PRIMAS since it shows the importance of individual actions but also of national pedagogical traditions and culture in order to achieve a significant change in teachers' practice. This is a most important challenge for PRIMAS.

An important issue regarding teachers' practice concerns the use of resources, especially textbooks but also web resources, including didactical literature. In this matter, the situations in the countries of our consortium are very different. In most countries though, it seems that teachers (especially in primary and lower secondary education) rely a lot on textbooks. In a majority of countries, these can be chosen freely either by schools or teachers themselves. In some countries though, they are imposed by government policy or even be official specific documents. In most countries, the use of web resources of all kinds is getting more and more popular. Textbooks providing IBL opportunities are very rare. Exceptions are in the Nederland, where they are of very good quality and in Switzerland (in mathematics) where the official material from the state for compulsory education provides material with problem solving and didactical comments. In some countries on the contrary, like Romania and Slovakia, there is a lack of textbooks that meet the new curricula requirements regarding IBL orientation. In several cases, even if the textbooks are not explicitly IBL orientated they could provide good opportunity for IBL activities. However, even explicitly IBL and problem-solving orientated documents can be used by teachers in an inadequate manner, leading to very poor practice in reality.

Here again, national contexts are important to be taken into account. In all the cases anyway, PRIMAS is an opportunity either to produce some IBL orientated material, where it is missing, or to highlight and reinforce IBL orientation already existing in some national textbooks and material. The use of a website for resources is of course important, as well as translations and adaptations to national contexts. Furthermore, it seems vital that the material that PRIMAS will produce be accompanied by didactical comments on how the situation can be efficiently implemented in class and imbedded into a device to be used for professional development.

At the level of discipline, IBL orientations (or similar) are included (with variations) in the most recent curricula of mathematics and sciences in all countries at all levels of education. Yet, teachers' resources, in particular textbooks, very rarely reflect this evolution in policies. Finally, teachers' practices do not change radically, even if some successful pockets of teachers using IBL exist.

3. SUMMARY AND CONCLUSIONS OF THE ANALYSIS OF CONTEXTS

In this chapter, we summarize the main results we have developed in the preceding sections (1.3.1 to 1.3.4). Before, we give in a final chapter the recommendations that follow for the implementation of our project.

At the levels of civilisation and society, in spite of strong differences in tradition that may have been still quite important in the last decades, in all the countries there has been in recent years changes, sometimes quite radical, towards educational paradigms meeting the objectives of PRIMAS and IBL.

At the level of school, there is quite a variety in the division of educational levels (primary, lower and upper secondary) and length of each level. However, primary school teachers are always generalist trained mostly in pedagogy and didactics and usually have weakness in disciplinary training (especially in mathematics and sciences). Upper secondary school teachers are mono-disciplinary and usually well trained in their discipline, but may be weak in pedagogy. The intermediate level between primary and upper secondary education (usually reckon as lower secondary but in some cases as upper primary) is more heterogeneous from one country to another, the status of teachers vary from generalists to mono-disciplinary, and often bi-disciplinary specialists, with a university degree only in one discipline. In-service teachers' training and professional development are usually very poor in most countries. Most often the offer is limited to one-day sessions without much supervision. Beyond the question of motivation from teachers, in several countries, there is a real problem of accessibility to in-service training and professional development, including financial aspects.

At the level of pedagogy, in all the countries of our consortium the general laws of education (or equivalent) advocate some type of pedagogy, which totally supports IBL. There is indeed a real homogeneity in the description of pedagogy in all countries' official documents. This clearly reflects an actual international orientation in educational policies, which is a real opportunity for PRIMAS. Yet, beyond this uniformity, there are varied situations. In some countries, this orientation in pedagogy is very recent. In some others, on the contrary, there is a long tradition for constructivist orientated pedagogy. However, if educational policies are in support of IBL, it does not mean that this actually reflects teachers' practices. This is actually the black spot in all countries. The reasons evoked vary from one country to another but it is always a mixture of the following with different repartition of weight depending on the national context (past and recent) and the cultural background: lack of training for teachers who have usually never experienced IBL methods as students, reluctance for changes, weight of traditions, lack of time (for teachers the first priority is to accomplish the whole programme). Moreover, in many, if not all countries, the resistance does not only come from teachers, but also from students, or even parents and maybe the society as a whole. In several countries (but not all) assessment has also evolved in order to take into account the changes in the educational policies. Yet, in many cases the changes have been slow and not always sufficient to really encourage IBL. Therefore, in most countries assessment remains a barrier that prevents teacher from adopting IBL methods.

At the level of discipline (and lower), in all countries at all levels there are explicit signs of more or less recent evolutions in official curricula of mathematics and sciences that are in favour of IBL as well as more coherence between the disciplines, with recommendation for cross and inter-disciplinary activities. However, in most countries, this official positioning hides another type of reality. Indeed, there are some strong evidences that in practice, IBL orientated teaching is not largely implemented at all levels of education in all countries. Indeed, traditional transmissive teaching still seems to dominate in most countries, even if there are some local differences, due to various parameters, especially concerning pre-service teachers' training and the fact that the changes toward constructivism, problem solving and IBL in the curriculum are more or less recent. This resistance to changes is accredited by international studies. However, in most countries, some studies attest of local successful IBL experiments that remain limited. Furthermore, in most countries (with some notable exceptions), resources, especially textbooks, do not provide explicit IBL activities. Nevertheless, in several cases, even if the textbooks are not explicitly IBL orientated they could provide good opportunity for IBL activities. However, even explicitly IBL and problem-solving orientated documents can be used by teachers in an inadequate manner, leading to very poor practice in reality.

4. RECOMMENDATIONS AND OUTLOOK

We come now to the recommendations that follow from our analysis. Most of them have been made along the presentation of our results in separate sections. In this final chapter, we have gathered them and reorganised their presentation in order to give a general overview of what we can recommend for a most successful implementation of PRIMAS in the various contexts of our 12 countries.

• A generally good context regarding national policies, but careful to the excess of reforms

Indeed, we have seen that in all countries the most recent policy regarding the teaching of mathematics and sciences meets the goals of PRIMAS project. Of course, there are some nuances in the various countries, but still, it is clear that the common strength for PRIMAS partners is that we can rely on official documents to support our action. Indeed, our project may be a consistent response to the decreasing interest of students in mathematics and sciences, an alarming fact shared by all countries. Nevertheless, one has to be careful about the historical background and traditions, which vary greatly from one country to another and still may be a barrier in order to make changes efficient. Furthermore, there are important negative factors appearing in several countries. One is due to the succession of reforms in recent years in many countries resulting in a rejection of changes by teachers and sometimes by parents. In some countries as well, this resulted in a resurgence of reactionary ideas defending a return to traditional pedagogical paradigms and to fundamental contents like reading and counting. On the positive side, another support on which we can rely concerns the fact that in several countries, a new tendency appears asking to build bridges and develop more coherence between the disciplines, especially mathematics and the science subjects. It is therefore an opportunity for PRIMAS to provide materials and didactical devices in order to build bridges between the various disciplines, in using IBL orientated common activities in mathematics and different science subjects.

• Necessity to adapt the general schema of our project to local specificity

From our analysis it also appears that in our 12 countries, there is quite a variety in school organisations from one country to another. This is a challenge for PRIMAS, since the conditions of implementation and the possible impact of the project may be quite different and therefore necessitate a careful analysis of different parameters, resulting in local adaptation to the general schema of our project. This is particularly challenging for the design of PRIMAS professional development programme, that has to be flexible enough to be adaptable to every national context but, at the same time, robust enough to keep its essence.

• IBL in pre-service teachers' training

In most countries, pre-service teachers' training is rarely IBL oriented. Therefore, with differences from one country to another, it is an opportunity as well as a challenge for PRIMAS to implement some type of IBL orientated training into pre-service teachers' training at various levels of education. The situation may be more or less positive depending on the level of expertise of teachers in the subject to be taught especially for primary education and in some cases for lower secondary education (especially in sciences), and also considering the differences regarding the type of training in didactics.

• Necessity to take into account teachers' level of expertise in their subject and in didactics

We have also seen that between the countries, but also between the different levels of education, the expertise of teachers in disciplines and in didactics are really different. Furthermore, in most countries the usual offer in in-service teachers' training and professional development is poor, not well-structured and above all rarely popular. Thus, in most cases, it seems like a real challenge for PRIMAS to find the right way to display a well-structured and attractive offer for in-service teachers training and professional development, introducing IBL.

• How can we succeed in making the change in policies effective in classroom practice?

Furthermore, the fact that in spite of the changes in favour of IBL in educational policies in all countries, the changes in teachers' practices are not effective at a large scale is certainly the main challenge for PRIMAS. The analysis of the context in all 12 countries of our consortium shows that this cannot be accomplished if we do not operate at a large scale, not only by training a large number of teachers, but also by developing supporting activities towards various target groups inside and outside school. The situation is of course different in the various countries. For instance, in the countries where the change in policies is more recent and the tradition of transmissive teaching still active, the necessity for a change is more radical, but in a way the novelty of the situation may be a positive factor for motivation. On the contrary, in those countries, where the change in policy dates back from the 70s or 80s and transmissive tradition has been chased from then, IBL may seem less far from actual practices. Yet, on the other hand, if practices remained traditional where changes have been advocated for decades, the resistance for changes is likely to be even stronger.

• Necessity to take into account the possible negative side-effect of national assessment

Another important challenge for PRIMAS is to take into account the possible negative side effects due to national policy in terms of assessment, which might even be in contradiction with the curriculum and IBL. Yet, in some countries, PRIMAS has an opportunity to support and interact with national assessment, but, in all cases, the pressure on schools and teachers coming from assessment is to be taken into account, especially concerning the question of time, an important factor in the resistance to changes seen as time consuming.

• **Necessity to adapt according to the variety of pedagogical/didactical resources**

Finally, our analysis showed great differences among countries in the type of resources (especially textbooks) at disposal for teachers and also in their way to use them. Thus, PRIMAS should appear as an opportunity either to share some IBL orientated material, where it is missing, or to highlight and reinforce IBL orientation already existing in some national textbooks and material. The use of a website for resources is of course important, as well as translations and adaptations to national contexts. Furthermore, it seems vital that the material that PRIMAS will work on is accompanied by didactical comments on how the situation can be efficiently implemented in class and imbedded into a device to be used for professional development.

Outlook for the PRIMAS project

These recommendations are general guidelines in order to inform the consortium for the realisation of the whole project, it gives us some useful information for the construction of the general framework of the whole project and some hints for the implementation of the project in each national context. Moreover, in this second phase, the detail information is to be found in each national report and in interaction with each National Consultancy Panel.

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6. APPENDICES

Appendix 1: Organisation of Education in Germany

<table>
<tr><th>Gr</th><th>Age</th><th colspan="3">Type of school[1]</th><th colspan="3">Disciplines[2]</th><th colspan="3">Type of teachers[3]</th><th colspan="3">Initial training[4]</th></tr>
<tr><td>-3</td><td>3</td><td colspan="3" rowspan="3">Kindergarten</td><td colspan="3">-</td><td colspan="3">Nursery-school teacher</td><td colspan="3">apprenticeship</td></tr>
<tr><td>-2</td><td>4</td><td colspan="3">-</td><td colspan="3"></td><td colspan="3"></td></tr>
<tr><td>-1</td><td>5</td><td colspan="3">-</td><td colspan="3"></td><td colspan="3"></td></tr>
<tr><td>1</td><td>6</td><td colspan="3" rowspan="4">Primary school</td><td colspan="3" rowspan="4">M & S</td><td colspan="3" rowspan="4">G</td><td colspan="3" rowspan="4">3 years at University / University of Education
+ 1,5 years of Induction phase
Ped./dida</td></tr>
<tr><td>2</td><td>7</td></tr>
<tr><td>3</td><td>8</td></tr>
<tr><td>4</td><td>9</td></tr>
<tr><td>5</td><td>10</td><td rowspan="6">Hauptschule (supposed to be for low-achieving students)</td><td rowspan="6">Realschule</td><td rowspan="6">Gymnasium (high achieving students)</td><td colspan="3" rowspan="2">M & S</td><td rowspan="6">G</td><td rowspan="6">2D</td><td rowspan="6">2 D</td><td rowspan="6">3 years Uni
+ 1,5 years induction
Ped./dida</td><td rowspan="6">4 years Uni + 1,5 years induction
Ped./dida</td><td rowspan="6">5 years Uni + 2 years induction
Dis</td></tr>
<tr><td>6</td><td>11</td></tr>
<tr><td>7</td><td>12</td><td rowspan="4">M & S</td><td rowspan="4">M & S</td><td rowspan="4">M, B, P, C (8)</td></tr>
<tr><td>8</td><td>13</td></tr>
<tr><td>9</td><td>14</td></tr>
<tr><td>10</td><td>15</td></tr>
<tr><td>11</td><td></td><td colspan="3" rowspan="3">Gymnasium</td><td colspan="3" rowspan="3">M, B, C, P</td><td colspan="3" rowspan="3">2 D</td><td colspan="3" rowspan="3">5 years Uni + 2 years induction
Dis</td></tr>
<tr><td>12</td><td></td></tr>
<tr><td>13</td><td></td></tr>
</table>

1. Nursery, primary, upper-primary, lower secondary, upper secondary

2. Maths and sciences not separated or not (One), maths and integrated sciences (M & S) – 2 or 3 subjects in sciences (M & S2 or M & S3) or just one type of sciences Bio or Phys (M&Bio – M&Phys)

3. Generalist G, 2 disciplines specialists 2D, mono-discipline specialists 1D, nD, 2/1D…

4. Number of years in tertiary education of training (+n) , type of institution (Uni, PHS – Pedagogical High School) Discipline (disc) or pedagogy (ped.) orientated, courses in Didactics (Dida)

Appendix 2: Organisation of Education in Geneva

Gr .	Age	Type of school[1]	Disciplines[2]	Type of teachers[3]	Initial training[4]
-2	4	Nursery	one	Generalists	+4 years University. Pedagogy orientated Didactics in Maths and sciences
-1	5				
1	6	Primary	M & S		
2	7				
3	8				
4	9				
5	10				
6	11				
7	12	Lower second.	M&Bio	1D (except. 2)	+6 years University Disc. Orientated (+4) Didactics in Maths and sciences and Ped (+2)
8	13		M&Bio		
9	14		M&Phys		
10	15	Upper second.	M&S3	1D (except. 2)	
11	16				
12	17				
13	18				

1. Nursery, primary, upper-primary, lower secondary, upper secondary

2. Maths and sciences not separated (One), maths and integrated sciences (M & S) – 2 or 3 subjects in sciences (M & S2 or M & S3) or just one type of sciences Bio or Phys (M&Bio – M&Phys)

3. Generalist G, 2 disciplines specialists 2D, mono-discipline specialists 1D, nD, 2/1D…

4. Number of years in tertiary education of training (+n), type of institution (Uni, PHS – Pedagogical High School) Discipline (disc) or pedagogy (ped.) orientated, courses in Didactics (Dida)

Appendix 3: Organisation of Education in the Netherlands

<table>
<tr><th>Gr.</th><th>Age</th><th>Type of school[1]</th><th>Disciplines[2]</th><th>Type of teachers[3]</th><th>Initial training[4]</th></tr>
<tr><td>-3</td><td>3</td><td></td><td></td><td></td><td></td></tr>
<tr><td>-2</td><td>4</td><td rowspan="9">primary</td><td></td><td rowspan="9">G</td><td rowspan="12">+4,
PHS,
disc/ped
Dida

(New option for lower secondary: Uni; disc +3 incl. educational minor)</td></tr>
<tr><td>-1</td><td>5</td><td></td></tr>
<tr><td>1</td><td>6</td><td rowspan="7">M&S</td></tr>
<tr><td>2</td><td>7</td></tr>
<tr><td>3</td><td>8</td></tr>
<tr><td>4</td><td>9</td></tr>
<tr><td>5</td><td>10</td></tr>
<tr><td>6</td><td>11</td></tr>
<tr><td>7</td><td>12</td><td rowspan="3">lower secondary (A)</td><td>M&B</td><td rowspan="6">1D</td></tr>
<tr><td>8</td><td>13</td><td>M&B&P</td></tr>
<tr><td>9</td><td>14</td><td>M&S3</td></tr>
<tr><td>10</td><td>15</td><td rowspan="3">upper secondary (A)</td><td>M&S3</td><td rowspan="3">Three options:
a. masters study in PHS (part time)
+3
disc,Dida

b. Uni
disc +3
ped/dida+2</td></tr>
<tr><td>11</td><td>16</td><td>M&S2 (B)</td></tr>
<tr><td>12</td><td>17</td><td>M&S2 (B)</td></tr>
<tr><td>13</td><td colspan="5">-</td></tr>
</table>

1. Nursery, primary, upper-primary, lower secondary, upper secondary
2. Maths and sciences not separated or not (One), maths and integrated sciences (M & S) – 2 or 3 subjects in sciences (M & S2 or M & S3) or just one type of sciences Bio or Phys (M&Bio – M&Phys)
3. Generalist G, 2 disciplines specialists 2D, mono-discipline specialists 1D, nD, 2/1D…
4. Number of years in tertiary education of training (+n) , type of institution (Uni, PHS – Pedagogical High School) Discipline (disc) or pedagogy (ped.) orientated, courses in Didactics (Dida)

(A) Three different streams in secondary education: - pre vocational (L,H) = (2,2)
- pre higher vocational (L,H) = (3,2)
- pre university (L,H) = (3,3)

(B) Depends on the chosen profile
Science & Health: M, C, B are obligatory. P and NLT can be chosen
Science & Technique: M, C, P are obligatory. B and NLT can be chosen

Appendix 4: Organisation of Education in England

Gr.	Age	Type of school[1]	Disciplines[2]	Type of teachers[3]	Initial training[4]
-3	3				
-2	4	Nursery	M (Number)	generalists	
-1	5	Reception (Infant)	M (Number)	generalists	Either 3 year education degree or 3 year subject degree + 1 year education course
1	6	Infant	M	generalists	
2	7				
3	8	Primary	M & S	generalists	
4	9				
5	10				
6	11				
7	12	Secondary	M & S	Either M or S usually teach 2/3 D	3 year specialist subject degree followed by 1 year education course (for a small minority: 3 year education degree)
8	13				
9	14				
10	15				
11	16				
12	17	Secondary or College	M & S3	1D	
13	18				

1. Nursery, primary, upper-primary, lower secondary, upper secondary

2. Maths and sciences not separated or not (One), maths and integrated sciences (M & S) – 2 or 3 subjects in sciences (M & S2 or M & S3) or just one type of sciences Bio or Phys (M&Bio – M&Phys)

3. Generalist G, 2 disciplines specialists 2D, mono-discipline specialists 1D, nD, 2/1D…

4. Number of years in tertiary education of training (+n) , type of institution (Uni, PHS – Pedagogical High School) Discipline (disc) or pedagogy (ped.) orientated, courses in Didactics (Dida)

Appendix 5: Organisation of Education in Spain

Gr.	Age	Type of school[1]	Disciplines[2]	Type of teachers[3]	Initial training[4]
-3	3	Nursery	One	Generalist	University degree (4 years). Pedagogy oriented. Didactic in Maths and science.
-2	4				
-1	5				
1	6	Primary school	M&S	Generalist	University degree (4 years). Pedagogy oriented. Didactic in Maths and Science.
2	7				
3	8				
4	9				
5	10				
6	11				
7	12	Compulsory Secondary school	M&S	1 D	University degree in one subject (4 years) Master degree in education
8	13		M&S		
9	14		M&S		
10	15		M&PhyChe&BioGeo		
11	16	Baccalaureate	M&S&BioGeo&PhyChe&Bio&Geo&Phy&Che	1 D	University degree in one subject (4 years) Master degree in education
12	17				

1. Nursery, primary, upper-primary, lower secondary, upper secondary

2. Maths and sciences not separated or not (One), maths and integrated sciences (M & S) – 2 or 3 subjects in sciences (M & S2 or M & S3) or just one type of sciences Bio or Phys (M&Bio – M&Phys)

3. Generalist G, 2 disciplines specialists 2D, mono-discipline specialists 1D, nD, 2/1D…

4. Number of years in tertiary education of training (+n) , type of institution (Uni, PHS – Pedagogical High School) Discipline (disc) or pedagogy (ped.) orientated, courses in Didactics (Dida)

Appendix 6: Organisation of Education in Slovakia

Gr.	Age	Type of school[1]	Disciplines[2]	Type of teachers[3]	Initial training[4]
-3	3	nursery	maths and integrated sciences	G	uni 3 years
-2	4				
-1	5				
1	6	primary	maths and integrated sciences	G	uni 3+2 years
2	7				
3	8				
4	9				
5	10	upper-primary	maths, biology, physics, chemistry, geography, computer science	2D	uni 3 + 2 years
6	11				
7	12				
8	13				
9	14				
10	15	secondary	maths, biology, physics, chemistry, geography, computer science	2D	uni 3 + 2 years
11	16				
12	17				
13	18				

1. Nursery, primary, upper-primary, lower secondary, upper secondary

2. Maths and sciences not separated or not (One), maths and integrated sciences (M & S) – 2 or 3 subjects in sciences (M & S2 or M & S3) or just one type of sciences Bio or Phys (M&Bio – M&Phys)

3. Generalist G, 2 disciplines specialists 2D, mono-discipline specialists 1D, nD, 2/1D…

4. Number of years in tertiary education of training (+n) , type of institution (Uni, PHS – Pedagogical High School) Discipline (disc) or pedagogy (ped.) orientated, courses in Didactics (Dida)

Appendix 7: Organisation of Education in Hungary

Gr.	Age[5]	Type of school[1]	Disciplines[2, 6]	Type of teachers[3]	Initial training[4]
-2	4	Nursery	one	Generalists	+4 years bachelor's degree Pedagogy orientated Didactics in Maths and sciences
-1	5				
1	6-7	Primary[7]	Mathematics+ General Science	Generalists	+4 years bachelor's degree Pedagogy orientated Didactics in Maths and sciences
2	7-8				
3	8-9				
4	9-10				
5	10-11	Lower secondary	M + General Science	mostly 2 domains (frequent pairs: math-phys, math-chem, phys-chem, math-geography, biol-geog, biol-chem)	+ 4 years bachelor's degree OR +5 years master's degree, both disc. orientated (+4) Didactics in Maths and sciences and Ped (+2)
6	11-12				
7	12-13		M + Phys + Chem + Biol + Geography		
8	13-14				
9	14-15	Upper secondary	Separate subjects (M and Phys 4 years, Biol and Chem 3 years, Geog 2 years)	mostly 2 domains (frequent pairs: math-phys, math-chem, phys-chem, math-geography, biol-geog, biol-chem)	+ 5 years master's degree, tendency towards becoming more pedagogy oriented and less discipline oriented
10	15-16				
11	16-17				
12	17-18				

1. Nursery, primary, upper-primary, lower secondary, upper secondary

2. Maths and sciences not separated or not (One), maths and integrated sciences (M & S) – 2 or 3 subjects in sciences (M & S2 or M & S3) or just one type of sciences Bio or Phys (M&Bio – M&Phys)

3. Generalist G, 2 disciplines specialists 2D, mono-discipline specialists 1D, nD, 2/1D…

4. Number of years in tertiary education of training (+n) , type of institution (Uni, PHS – Pedagogical High School) Discipline (disc) or pedagogy (ped.) orientated, courses in Didactics (Dida)

5. Average age interval at the beginning of the school year

6. The National Core Curriculum enables for many different subject systems, but the table contains the most frequent variation.

7. Most of the children attend so-called « general schools » that have eights grades. Therefore, schooling levels of primary and lower secondary types are in fact institutionally merged into an eight-level « general school »

Appendix 8: Organisation of Education in Cyprus

Gr.	Age	Type of school[1]	Disciplines[2]	Type of teachers[3]	Initial training[4]
-3	3	Nursery	M&S	G	3, College, Ped, Dida.
-2	4				4, Univ. Ped. Dida.
-1	5	Pre-primary (compulsory)			4, Univ. Ped. Dida.
1	6	Primary	M&S2	G	4, Univ. Ped. Dida. .
2	7				
3	8				
4	9				
5	10				
6	11				
7	12	Lower secondary	M&S3	1D	4, Univ. Disc. Dida* (26 weeks separate course)
8	13				
9	14				
10	15	Upper secondary	M&S3	1D	4, Univ. Disc. Dida* (26 weeks separate course)
11	16				
12	17				
13	18	Upper secondary **Only in some private schools, not public schools*	M&S3	1D	4, Univ. Disc. Dida* (26 weeks separate course)

1. Nursery, primary, upper-primary, lower secondary, upper secondary

2. Maths and sciences not separated or not (One), maths and integrated sciences (M & S) – 2 or 3 subjects in sciences (M & S2 or M & S3) or just one type of sciences Bio or Phys (M&Bio – M&Phys)

3. Generalist G, 2 disciplines specialists 2D, mono-discipline specialists 1D, nD, 2/1D…

4. Number of years in tertiary education of training (+n) , type of institution (Uni, PHS – Pedagogical High School) Discipline (disc) or pedagogy (ped.) orientated, courses in Didactics (Dida)

Appendix 9: Organisation of Education in Malta

Gr.	Age	Type of school[1]	Disciplines[2]	Type of teachers[3]	Initial training[4]
-3	2	Nursery		Generalists	
-2	3				
-1	4				
1	5	Primary	M & S		University: Four-year B.Ed(Hons) course – Primary Track
2	6				
3	7				
4	8				
5	9				
6	10				
7	11	Lower Secondary	M & S	Subject Specialists	University: Four-year B.Ed(Hons) course – Secondary Track – with specialisation in Mathematics or Science OR First degree in Mathematics or Science followed by Post Graduate Certificate in Education (University)
8	12				
9	13		M & P or M & S2 or M & S3		
10	14				
11	15				
12	16+	Upper Secondary (Beyond compulsory school age)	No compulsory subjects		Varies. May be as for Lower Secondary or in some cases a Masters degree.

1. Nursery, primary, upper-primary, lower secondary, upper secondary

2. Maths and sciences not separated or not (One), maths and integrated sciences (M & S) – 2 or 3 subjects in sciences (M & S2 or M & S3) or just one type of sciences Bio or Phys (M&Bio – M&Phys)

3. Generalist G, 2 disciplines specialists 2D, mono-discipline specialists 1D, nD, 2/1D…

4. Number of years in tertiary education of training (+n) , type of institution (Uni, PHS – Pedagogical High School) Discipline (disc) or pedagogy (ped.) orientated, courses in Didactics (Dida)

Appendix 10: Organisation of Education in Denmark

<table>
<tr><th>Gr.</th><th>Age</th><th>Type of school[1]</th><th>Disciplines[2]</th><th>Type of teachers[3]</th><th>Initial training[4]</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>0</td><td>6</td><td>Kindergarden</td><td></td><td>Generalists</td><td>Pedagogy 3 years</td></tr>
<tr><td>1</td><td>7</td><td rowspan="6">Primary</td><td rowspan="6">M , S</td><td rowspan="6">Generalists</td><td rowspan="6">+4 years
Teacher training college Pedagogy orientated
Didactics in Maths and sciences</td></tr>
<tr><td>2</td><td>8</td></tr>
<tr><td>3</td><td>9</td></tr>
<tr><td>4</td><td>10</td></tr>
<tr><td>5</td><td>11</td></tr>
<tr><td>6</td><td>12</td></tr>
<tr><td>7</td><td>13</td><td rowspan="3">Primary (Lower secondary)</td><td rowspan="3">M, Bio, Geo
Pys-chem</td><td rowspan="3">Generalists</td><td rowspan="3">+4 years
Teacher training college Pedagogy orientated
Didactics in Maths and sciences</td></tr>
<tr><td>8</td><td>14</td></tr>
<tr><td>9</td><td>15</td></tr>
<tr><td>10</td><td>16</td><td rowspan="3">Upper secondary</td><td rowspan="3">M, Bio, Geo
Phys, chem</td><td rowspan="3">2D</td><td rowspan="3">+6 years
University
Disc. Orientated (+5)
Didactics in Maths and sciences and Ped (+1)</td></tr>
<tr><td>11</td><td>17</td></tr>
<tr><td>12</td><td>18</td></tr>
<tr><td>13</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

1. Nursery, primary, upper-primary, lower secondary, upper secondary

2. Maths and sciences not separated or not (One), maths and integrated sciences (M & S) – 2 or 3 subjects in sciences (M & S2 or M & S3) or just one type of sciences Bio or Phys (M&Bio – M&Phys)

3. Generalist G, 2 disciplines specialists 2D, mono-discipline specialists 1D, nD, 2/1D…

4. Number of years in tertiary education of training (+n) , type of institution (Uni, PHS – Pedagogical High School) Discipline (disc) or pedagogy (ped.) orientated, courses in Didactics (Dida)

Appendix 11: Organisation of Education in Romania

Gr.	Age	Type of school[1]	Disciplines[2]	Type of teachers[3]	Initial training[4]
-3	3	Kindergarten (not compulsory)	No disciplines	Generalists	It is possible to obtain qualification with 0 years in tertiary education, just based on special upper secondary
-2	4				
-1	5				
1	6-7	Primary	M&S	Generalists	3 years BSC + pedagogical module + master in one discipline
2	7-8				
3	8-9				
4	9-10				
5	10-11	Lower secondary	M&1S	Mono-discipline specialists and very few with double specialisation	
6	11-12		M&2S		
7	12-13		M&3S		
8	13-14				
9	14-15	Upper secondary			
10	15-16				
11	16-17				
12	17-18				
13	-				

1. Nursery, primary, upper-primary, lower secondary, upper secondary

2. Maths and sciences not separated or not (One), maths and integrated sciences (M & S) – 2 or 3 subjects in sciences (M & S2 or M & S3) or just one type of sciences Bio or Phys (M&Bio – M&Phys)

3. Generalist G, 2 disciplines specialists 2D, mono-discipline specialists 1D, nD, 2/1D…4. Number of years in tertiary education of training (+n), type of institution (Uni, PHS – Pedagogical High School) Discipline (disc) or pedagogy (ped.) orientated, courses in Didactics (Dida)

4. Number of years in tertiary education of training (+n) , type of institution (Uni, PHS – Pedagogical High School) Discipline (disc) or pedagogy (ped.) orientated, courses in Didactics (Dida)

Appendix 12: Organisation of Education in Norway

Gr.	Age	Type of school[1]	Disciplines[2]	Type of teachers[3]	Initial training[4]
-3	*			Pre-school teacher	Specialist pre-school Ted: 3/4 years at specialist University College
-2					
-1					
1	6	Primary school	Maths & Integrated science	Generalist up to 2010, and most practising teachers are generalists (after 2010 more specialist teachers)	Generalist Ted at University College: 4 years (+2 years MA if so wished) New reform since 2010 (choice between Ted for grades 1-7, or grades 5-10 - see report)
2	7				
3	8				
4	9				
5	10				
6	11				
7	12				
8	13	Lower secondary		(1) Generalists-Univ Coll (after 2010 more specialisation) (2) Specialists-univ	Two routes: (1)University Colleges used to train generalists, but after 2010 more specialisation (2) University traditionally train specialists (see report)
9	14				
10	15				
11	16	Upper secondary		Specialists in maths, biol, phys & chem	University teacher ed
12	17		Maths obligatory, but science not: Choice of weak and strong maths; Choice between Biol, Chem and Physics		
13	18-19		Maths and science not obligatory, otherwise same choice as above		

1. Nursery, primary, upper-primary, lower secondary, upper secondary

2. Maths and sciences not separated or not (One), maths and integrated sciences (M & S) – 2 or 3 subjects in sciences (M & S2 or M & S3) or just one type of sciences Bio or Phys (M&Bio – M&Phys)

3. Generalist G, 2 disciplines specialists 2D, mono-discipline specialists 1D, nD, 2/1D…4. Number of years in tertiary education of training (+n) , type of institution (Uni, PHS – Pedagogical High School) Discipline (disc) or pedagogy (ped.) orientated, courses in Didactics (Dida)

4. Number of years in tertiary education of training (+n) , type of institution (Uni, PHS – Pedagogical High School) Discipline (disc) or pedagogy (ped.) orientated, courses in Didactics (Dida)

*Note: Kindergarden starts at any age, if so wished, but it is not obligatory. However, every child has the right (but not obligation) to attend kindergarden, and it is a government policy that every child has a place. Anecdotal evidence shows that some kindergardens actually already teach a bit of maths at that age.

PART 2

COMPLEMENT TO DELIVERABLE 2.1

1. INTRODUCTION

The project PRIMAS comprises 14 teams from 12 different countries. It aims to effect a change in the teaching and learning of mathematics and science with teachers being supported to develop inquiry-based learning (IBL) pedagogies, so that students gain experience with IBL approaches across Europe. Ultimately, our objective is a greater number of students with more positive dispositions towards further study of these subjects and the desire to be employed in related fields.

The purpose of WP2 “Analysis” is to produce an analysis of existing factors, structures, opportunities, and challenges that might help or hinder the widespread take up of inquiry-based methods in each country. This analysis will ensure maximum potential leverage and impact for the measures to be taken and the optimal use of existing structures and materials to make this impact cost-effective.

In the first Deliverable 2.1 of this WP, we produced a synthesis of national reports informed by each National Consultancy Panel. In order to structure our synthesis, we used a systemic theoretical approach proper to structure our analysis. It is based on Chevallard’s Anthropological Theory of Didactics (ATD), which provides tools for a description of mathematical or science activity in terms of praxeologies as a way to describe mathematical or scientific organisations in institutions.

This led us to a presentation using Chevallard’s nine levels of determination in order to help differentiate between the various factors in the analysis of constraints and conditions that characterise the teaching of mathematics and science in different countries: Since the 5 lower levels (subject, theme, sector, domain, and discipline) are mostly visible when one makes fine-grained observations of classroom practices, which is not within the scope of our analysis, we regrouped these into one level of discipline. Moreover, the two highest levels (civilisation and society) have been regrouped into one, reflecting the fact that the differences between these two levels did not seem very relevant to our purpose. Thus, the 9 levels were regrouped into 4 levels, but previously separated levels were still separated into different aspects. This led us to the following overall framework, which organised each national report:

Level 1: Civilisation and society
Civilisation and society – specific role of mathematics or science in society, tradition, or recent changes in education …
Level 2: School
School/global organisation 1 – Separations between primary, lower secondary, and upper secondary education School/ global organisation 2 – Pre-service and in-service teacher training
Level 3: Pedagogy
Pedagogy 1 – Law of education: general statement on pedagogy, tradition in education (transmissive or constructivist tradition, place of the learner, ...) Pedagogy 2 – Type and role of national assessments
Level 4: Discipline
Discipline1 – Links between mathematics and science within the curriculum. Integrated science or separate subjects, ... Discipline 2 – Place of mathematics and science within the curriculum (number of hours). Competence of teachers in mathematics and science (profile of teachers) Discipline 3 – Type of curricula in mathematics or science, signs of IBL? Discipline 4 – Type of sources for teachers in mathematics and sciences (textbooks)? Discipline 5 – Are mathematics and science teachers using IBL? Why? If it is a requisite in the curriculum, even in the textbooks, why not?
In addition: Examples of successful professional development or IBL
Identification and collection of relevant IBL professional development and classroom materials (M 2.1, further used in WP3)

The international synthesis led us to a set of conclusions regarding the objectives and tasks assigned to our WP. Mainly we came to the following conclusions:

- There is a generally good context regarding national policies, but in some countries one needs to be careful about excessive reforms, while in others IBL is a totally new paradigm.
- There is clearly a necessity to adapt the general schema of our project to local specificity regarding not only culture in IBL but also school organisations and professional development opportunities.
- Regarding pre-service teacher training, in most countries it is rarely IBL oriented. Therefore, it is an opportunity as well as a challenge for PRIMAS to implement some

type of IBL-oriented training into pre-service teacher training at various levels of education.

- There is, however, a necessity to take into account teachers' level of expertise in their subject and in didactics.
- One big issue is to succeed in making the change in policies effective in classroom practice.
- We also need to take into account the possible negative side effects of national assessment and to adapt according to the variety of pedagogical/didactical resources.

The recommendations given in Deliverable D2.1 are general guidelines in order to inform the consortium about the realisation of the whole project; it gives us useful information for the construction of the general framework for the whole project and hints for the implementation of the project in each national context.

The identification of similarities and differences as well as good-practice examples has provided invaluable learning and knowledge exchange potential for the consortium members, as well as beyond.

In this complement to Deliverable 2.1, after more than 2 years of life of the project PRIMAS, each participating country produced a short document pointing out 2 or 3 specific issues that respectively made it particularly difficult, or on the contrary favoured, the realisation of PRIMAS objectives, i.e., the implementation of professional development in order to promote the use of IBL teaching in mathematics and the sciences.

In this report, a complement to Deliverable 2.1, the answers from participants are synthesised. To be consistent with our first deliverable we propose to follow the same schema: the organisation we proposed based on our theoretical framework with 4 levels (see table above).

Our aim is to point out differences and commonalties as well as interesting resources and initiatives that may be adapted for use in other nations.

In this complement, we also point out issues that led PRIMAS participants to adapt their initial strategies to specific conditions and constraints of their national context in order to fulfil the general framework of the consortium project as good as they can.

2. LEVELS OF CIVILISATION AND SOCIETY – TRADITION OR RECENT CHANGES IN EDUCATION, SPECIFIC ROLE OF MATHEMATICS AND SCIENCES IN SOCIETY

As we mentioned in the initial international synthesis in all countries of the consortium there have been recent changes in curricula (more or less significant when compared with the previous specification) that favour an IBL orientation in the teaching of mathematics and the sciences. In terms of policy this is both a response to poor results in international evaluations such as PISA and a means of arresting the decreasing number of students choosing mathematics- or science-oriented university studies.

In most countries this response has resulted in a description of the curriculum that emphasises competencies in addition to "academic" content, although that is not true for either Hungary or Romania, where the curricula remained content oriented, which tends to inhibit the development of IBL.

Nevertheless, even when curriculum intentions support IBL in a country's curriculum and educational policy the means by which the objectives might be supported and reached are very varied. Although in most countries school authorities are supportive towards an implementation of IBL, in several, financial shortcuts and sometimes a strong tradition in a transmissive-type of education prove to be barriers when it comes to ensuring an effective change in teaching practices.

Altogether, at the level of civilisation and society, indications are that the political climate is in favour of IBL in the teaching of mathematics and the sciences.

One important objective for PRIMAS has been to communicate and promote IBL to out-of-school target groups including parents and politicians. In this sense, many varied actions such as mathematics and science fairs, exhibitions, open-days in research laboratories, and a night of sciences have been really successful (**Deliverable D.6.1** PRIMAS "Guide for supporting actions in promoting inquiry-based learning in out-of-school target groups"). Such actions are likely to support policy changes by ensuring that IBL ideas permeate the public consciousness most widely.

Globally at the level of civilisation and society, it is important to take into account **Deliverable D.7.1** about policy; it reinforces and complements some issues discussed here.

3. LEVEL OF SCHOOL – GLOBAL ORGANISATION, SEPARATIONS BETWEEN PRIMARY, LOWER SECONDARY, AND UPPER SECONDARY EDUCATION, PRE-SERVICE AND IN-SERVICE TEACHER TRAINING

At this level, the global organisation of schools is quite varied in the different countries, which can have strong influences on the implementation of PRIMAS. However, we note a major variation across the project partnership concerning the training of teachers (especially in-service training) which potentially has a major impact on the intentions of PRIMAS.

As identified in the initial international synthesis, in all countries the lack of qualifications in mathematics and science of primary school teachers, as well as lower secondary school teachers in some countries, is problematic, since these teachers lack relevant pedagogic content knowledge to implement IBL into their pedagogic practice (this is particularly relevant in the UK, Norway, and Spain).

In Hungary, a recent political decision ensured support and improvement in conditions for schools in disadvantaged areas. This has provided an opportunity for the work of PRIMAS in Hungary.

In most countries, pre-service training seems to be a good place in order to make beginning teachers aware of IBL approaches. In countries like Spain, Switzerland, Slovakia, and Cyprus it is acknowledged that a good IBL-oriented training in mathematics and science education has been possible and reinforced through PRIMAS, especially when changes in teacher training had occurred recently. This has been the case to some extent in the UK, but recent policies there tended to shift the emphasis of initial teacher education directly to schools, which militates against curriculum development and supports the status quo in teaching methods.

On the contrary, in practically all countries of the consortium, difficulties in in-service teacher training have provided challenges to the implementation of PRIMAS. Examples of reasons that hindered the implementation of PRIMAS are given by all countries.

Most of the time the structure of in-service training is controlled loosely, and the training mainly consists of one- or two-day sessions organised by some volunteer teachers, who do not have qualification as trainers. Moreover, teachers do not gain any gratification for participating in training courses, and in some cases, they have to take part in this training in addition to their usual teaching time, or even have to personally pay for the training. Moreover, in most countries, there is very little pressure on teachers to make them take any in-service training course. Even if teachers are willing to participate in training courses, they are usually not willing to do work outside of the session (for example, doing some homework such as reading a relevant article). In general, teachers are usually interested in ready-to-use recipes to be implemented in their class the next day and prefer to be given materials ready for immediate use. It generally is the case in all countries that there is no strategic structure supporting, nor any culture that values, in-service training and professional development. It has consequently been a problem in most countries even to train multipliers. Yet, there are some exceptions.

In Romania, in-service teacher training is controlled by inspectors, who do not offer IBL-oriented training and moreover never take it into account when inspecting teachers. Since these inspections are the only measure used to determine a teacher's improvement in salary, this situation proves a major challenge for enrolling teachers in IBL professional development programmes.

In Spain, there is a powerful and well-established structure for teachers' professional development called 'teachers' centres'. The PRIMAS team in Andalusia was able to collaborate with these centres, yet they were faced with a problem of teachers' motivation since in spite of these centres there is no reward and very little recognition for teacher development. Moreover, the government recently announced some financial cuts that might result in a loss of potential for the teachers' centres.

In Switzerland (Geneva), all teachers (at all levels) are entitled to 5 days of in-service training every year, and replacement teacher costs are provided. However, participation is voluntarily, and only a small number of teachers are keen to take part. However, the PRIMAS team was provided with a mandate from the ministry of education to run a compulsory course in conjunction with the introduction of a new curriculum and a new textbook that is IBL oriented. However, mainly for financial reasons, this course was only one day long and required adaptation to a local structure to make the training more efficient.

In Norway, there are national centres supporting mathematics and science education that organise professional development. However, these centres mainly fulfil the directives of the government. As a result, it has been quite difficult for the PRIMAS team in Norway to collaborate with these centres, and therefore they had to look hard for opportunities to attract teachers to in-service training courses, since teachers have to pay for courses other than those of the national centres.

In Denmark, in primary and lower secondary education, IBL-oriented training courses in mathematics and science are available, and teachers are in general willing to participate. Yet, the conditions for participating have recently deteriorated since teachers now have to pay some tuition fees that neither the government nor their school can cover. In upper secondary schools (gymnasium), a network called *Danish Science Gymnasiums* (DASG) exists. The network, which includes about half the high schools in Denmark, requires that the member schools work explicitly towards contributing to professional and didactic development within mathematics and the sciences and are willing to allocate teaching resources accordingly. Individual schools must be involved in at least one of the current projects within the network at any given time. The mission of DASG is to:

- develop new teaching and learning systems and new teaching resources based on curriculum research and recent pedagogical thinking,

- support and promote in-service training activities, including seminars and conferences,
- provide the framework for cooperation between upper secondary schools, universities, and trade and industry,
- highlight best-practice mathematics and science teaching.

PRIMAS is currently collaborating with the DASG in educating upper secondary mathematics and science teachers as PRIMAS multipliers. The DASG network has turned out to be strong asset in educating such multipliers.

In the Netherlands, *Platform Beta Techniek* (PBT) is an umbrella organisation funding initiatives in schools to focus more on mathematics and science in ways that support IBL. Many schools are taking part in this kind of activity. This has prompted a need for professional development, and the PRIMAS team has been collaborating with the scheme, working with the modules developed in conjunction with the Freudenthal Institute.

In Slovakia, three professional development courses for practising teachers have been developed with IBL content promoting IBL pedagogies. These have been accredited by the Slovak Ministry of Education, Research, Science, and Sport since the beginning of year 2012. Three courses in mathematics, chemistry, and physics have been designed to support practising teachers in using IBL pedagogies and content. The courses cover some 110 lessons. One half of the lessons are taught as demonstration lessons in classrooms and laboratories of a PRIMAS partner university (Faculty of Natural Sciences). The other half of the lessons is taught using e-learning support. PRIMAS IBL modules are translated into the Slovak language and supplemented by tasks and problems focusing on the content of a particular subject (chemistry and physics). Teachers are awarded credits when they fulfill the course requirements successfully. Those credits will help them reach the next level in their salary scale.

In the UK, a change of government in 2010 brought about many systemic changes in relation to all aspects of education including at the fundamental level of school governance and funding. Most significantly for the work of PRIMAS, systems of support and professional development that were previously well-established by local authorities have ceased to exist in the new regime. Also the Centre for Excellence in Teaching Mathematics that was established to support teachers' in-service professional development was re-established in a new and less-ambitious format. Consequently, the in-service professional development programme of PRIMAS has been difficult to establish.

It seems that across the partnership the general situation regarding in-service training and professional development of teachers is often not very well structured or supported at a systemic and institutional level. Participation does not give teachers sufficient reward. Even in such difficult circumstances in most partnership countries there have been successful initiatives in every country. Yet, where this is not the case, partners continue to plan effective work in the later stages of the project. This seems to be a key issue for the success of a widespread and durable dissemination of IBL in teachers' practice.

Here again, our conclusions can be put in perspective with the conclusions of Deliverable D.7.1 about policy. Moreover, PRIMAS is developing a collection of IBL classroom materials and IBL professional development materials for teachers in Europe (see **Deliverables D.3.1** and **D.3.2)** and a guide for professional development providers that offer courses for mathematics and science teachers in IBL pedagogies (see **Deliverable D.4.1**). These are important achievements of PRIMAS in order to bring more unity across Europe regarding teachers' professional development and particularly access to IBL courses.

4. LEVEL OF PEDAGOGY – GENERAL LAW OF EDUCATION, TEACHERS' PRACTICES, NATIONAL ASSESSMENT

As we noticed in the initial international synthesis, at all levels of education and in all the countries of our consortium the general laws and policies of education (or equivalent) advocate some type of pedagogy, which is mostly, if not totally, supportive towards IBL. There is indeed a real homogeneity in the description of pedagogy in all countries' official documents. This homogeneity clearly reflects an actual international orientation in educational policies, which is a real opportunity for PRIMAS. Yet, beyond this uniformity, there are varied situations. In some countries, this orientation in pedagogy is very recent (Malta, Hungary, Romania, Slovakia, Cyprus, Spain et al.). In some others, on the contrary, there is a long tradition of constructivist pedagogy (Norway, the Netherlands, Denmark, Switzerland, the United Kingdom et al.). In some countries, like Germany, the change has been quite radical after the first PISA study results.

In many countries, indeed, it is noticed that teachers' beliefs may hinder changes towards IBL. In Spain, for instance, it seems that teachers' beliefs are strongly oriented towards transmissive-type teaching. This orientation is reinforced by the popularity of textbooks that are mostly written according such a teaching paradigm. Similar situations appear to pertain in Romania and Hungary. In Germany, a reluctance to change seems to come from the fact that teachers (as well as students) feel that IBL results in more stress and significant changes from the comfortable norm. It is thought that teachers and pupils might feel uncomfortable with a change of expectations and atmosphere in the classroom (because of the newness). Thus, at the beginning of the implementation of PRIMAS IBL methodologies, the difficulties might be very conspicuous, and the positive effects of IBL might not be visible or not be experienced immediately. Instead, the way to gratification might be partly unknown, longer, or harder than expected. This is a big challenge for the implementation of the project PRIMAS. In Switzerland, one problem comes from the fact that constructivism has a long tradition, teachers feel that IBL is not new, and they believe they already use it; moreover, teachers are fed up with reform. In England, competition between schools, measured by aggregating national test or national exam results, is another source of stress that makes the adoption of IBL difficult: Teachers are reluctant to take risks in changing their teaching when their pupils' outcomes are monitored continuously.

Our survey suggests that clearly whatever changes are introduced in national curricula and the general law of education, these cannot be effective in changing teachers' practices if a wide range of conditions are not also altered in ways that support teachers in changing their views and attitudes in addition to providing structured support to make the desired changes. This is a real challenge for PRIMAS, and it is clear that in some countries constraints because of teachers' beliefs or working conditions are strong barriers to change. Regarding this issue, the survey of IBL teaching conducted in WP9 (see **Deliverable D.9.2**) is an important complement to inform the general impression discussed here. Moreover, WP5 about supporting actions for dissemination among teachers (see **Deliverable D.5.1**) is an important achievement of PRIMAS in order to respond to this difficulty.

At the level of pedagogy, national assessment is also an important issue. Once again, in most countries, this is reported to be a challenging factor for the implementation of IBL since these national assessments are usually not IBL-oriented and therefore do not support teachers' use of IBL. This challenge is especially acute since these national assessments are very important for the institutions, parents, and students. However, we found one interesting exception. This issue is also well documented in **Deliverable D.7.1** about policy.

In Denmark, there is a tradition of the oral examination of students. Until 2006, it was possible to have such oral examinations with groups of students. At that time, students took an oral examination in mathematics and in physics-and-chemistry combined at the end of 9th grade. The students were assessed in pairs. They were given a problem set and a bank of materials from which they could choose elements to use in their investigation and solutions of the given problems. Each group of students was given a different problem set. The teacher and an external evaluator (a teacher from another school in Denmark) would monitor and observe how the groups of students discussed and solved the problem, what kind of experiments they performed, and why. After some time, they would question the students about their answers to the problems and listen to their justifications and explanations. Based on the observations and dialogue with the students about their solutions and their strategies for finding solutions, the teacher and the external evaluator assessed the students, who were given individual marks. This type of assessment fosters IBL teaching methodologies. Following recent political developments in Denmark, the possibility of a re-implementation of oral group examinations is being considered. This type of assessment is IBL-friendly because it gives opportunities to assess inquiry processes. Hence, a re-implementation of oral group examinations in Denmark might help PRIMAS implementation there in the future.

5. LEVEL OF DISCIPLINE (AND LOWER) – PLACE OF MATHEMATICS AND SCIENCE IN THE CURRICULUM, COMPETENCES OF TEACHERS, SIGNS OF IBL, AND TYPE OF RESOURCES (TEXTBOOKS)

Due to politicians' awareness of students' reluctance to study mathematics and science, these subjects are usually supported and reinforced in policy developments in most countries (see **Deliverable D.7.1**). In Hungary, for instance, the numbers of teachers of physics and chemistry are low, which has been recognised by giving teachers of these subjects a salary increase of 10–15%, even though at the same time, the number of teaching hours in science and mathematics have been slightly reduced in some cases! In Malta, science is reaffirmed as one of the fundamental components of secondary education. In secondary schools, the maximum number of students in all science classes is now 16, and students can choose a specific scientific option with a considerable number of hours being allocated to science. In Switzerland, the overall number of hours devoted to teaching mathematics and science has increased. Moreover, the fact that in the new curriculum mathematics and science have been put together in one domain is an opportunity for PRIMAS. In the Netherlands, there has been a reform of all science and mathematics examination programs for senior high schools, with the resulting programs starting at the national level in 2015. One of the main aims of renewing the single disciplines was to make them more coherent. All programs define common competences related to research in science. Pre-service and in-service teacher training programs that prepare for these reform programs will certainly profit from PRIMAS PD-modules (see **Deliverables D.3.1, D.3.2 and D.4.1**). In the United Kingdom monetary incentives have been put in place to draw top graduates into the teaching profession in mathematics and the sciences.

Here we see that in spite of the recognition by politicians of all countries of the necessity to improve the teaching of mathematics and science in order to attract more students, the changes in school - regarding the number of hours and the conditions of teaching for these subjects - are not always coherent. However, these are important issues for a successful implementation of PRIMAS.

One important issue here concerns the material that teachers can use. Here again, the situation varies in consortium nations. In some countries, teachers can benefit from the use of textbooks that are IBL oriented (Switzerland, the Netherlands, Denmark, Cyprus et al.). In some countries, on the contrary, textbooks mostly support transmissive teaching, as in Spain, where such texts are very popular and therefore prove a challenge to teachers' adoption of IBL. In some countries, such as Slovakia and Romania, the recent changes and the lack of IBL-oriented textbooks is an opportunity for PRIMAS. Indeed, providing all countries with a wide range of IBL activities in mathematics and science at all school levels is one of the main beneficial outcomes of the work of the PRIMAS consortium. These activities are available at the PRIMAS website (not all languages are accounted for at this stage).

Other aspects of the work of partners in different nations have helped inform developments in other countries of the consortium. In Slovakia, for instance, there has been a very interesting adaptation of the mathematical B-day inspired by the Dutch original. This adaptation resulted in 40 students (ages 16–18) from six secondary grammar schools being involved in a mathematical contest in two cities: Nitra and Bratislava. Secondary school mathematics teachers were also involved in conducting the contest. PhD students, PRIMAS mathematics multipliers, and university professors from Nitra and Comenius University in Bratislava participated in particular tasks in the contest preparation, organisation, and evaluation.

6. CONCLUSIONS

This complement to our initial international synthesis allows us to point out some specific points of the international context that have been key issues in the implementation of PRIMAS in order to reach the widespread take up of inquiry-based methods in each country.

In concordance with **Deliverable D.7.1,** contextualising the European policy space in support of inquiry-based learning in mathematics and science, we have pointed out that in all countries more or less recent changes in the curriculum are globally supporting an IBL orientation in the teaching of science and mathematics. This is a very positive aspect. However, we also pointed out that this support is not sufficient to achieve our goal. Indeed, changes in curricula and a favourable political orientation are insufficient to make a radical change in teaching practices.

At the level of society, there is a need for information and support from different actors, especially parents, in order to make an IBL orientation truly effective. In this sense, the PRIMAS project has taken this dimension into account by setting up in every country supporting actions in promoting IBL in out-of-school target groups (see **Deliverable D.6.1** and the various actions reported on the PRIMAS website).

One main issue concerns teachers' beliefs and ideas regarding IBL. The situation is quite varied in the different countries (depending the history and the culture in mathematics and science education), but differences also exist among primary, lower secondary, and upper secondary school culture. In most countries, the lack of mathematics and science training of primary school teachers is reckon as a major issue. The survey conducted for PRIMAS WP9 (see **Deliverable D.9.2**) is a precious resource for tackling this issue.

Moreover, the problem is not individual, and the evolution in teachers' mentality towards IBL is a collective professional issue that call for specific actions regarding teacher training and professional development. At the general level of pedagogy, PRIMAS WP5 is an important component for developing supporting actions for dissemination among teachers to promote IBL (see **Deliverable D.5.1** and the various actions reported on the PRIMAS website).

Moreover, the structure of teacher training is a major issue. In most countries, it seems quite possible to implement IBL-oriented courses within initial pre-service training. The main difficulties concern in-service training. In this matter, the development by PRIMAS of a collection of IBL classroom materials and IBL professional development materials for teachers in Europe (see **Deliverables D.3.1** and **D.3.2**) is important. However, good material is not sufficient; the structure of in-service training is a key issue. In this regard, we have given examples of the variety of situations in the 12 countries of our consortium. In most countries, we have pointed out some negative aspects that make it difficult to reach all teachers, motivate them, and make access to professional development attractive or plainly feasible, in terms of recognition and reward, financial or not. Some of these national conditions and constraints regarding the structure of in-service teacher training are out of reach for PRIMAS, since they involve policy issues (see **Deliverable D.7.1**). However, PRIMAS WP4 is an important component of our project to provide a global reflection and some propositions regarding this important issue of professional development through the realisation of a guide for professional development providers who offer courses for mathematics and science teachers in IBL pedagogies (see **Deliverable D.4.1**). These are important achievements of PRIMAS to bring more unity across Europe regarding teachers' professional development and particularly access to IBL courses. However, one conclusion of this international synthesis is that the question of professional development is not only a question of improving access to material and the structure of in-service training. It seems that there is also a need for a change in mentality and culture regarding the issue of teachers' professional training.

At the level of pedagogy as well national assessment is also an important issue. Here again in most countries, this is reported to be a challenging factor for the implementation of IBL since these national assessments are usually not IBL oriented and therefore do not support teachers' use of IBL. This problem is especially acute since these national assessments are very important for the institutions, parents, and students. However, we found one interesting exception in Denmark. This issue is also well documented in **Deliverable D.7.1** about policy.

Finally, at the level of the discipline, our survey points out that in spite of the unity in the changes regarding curricula and the necessity to reinforce the teaching of mathematics and science (especially in response to both poor results in international evaluations like PISA and the alarming decrease in the number of students choosing mathematics) or science-oriented university studies, the conditions regarding the time allotted to mathematics and science and the recruitment of teachers are in conflict (see **Deliverable D.7.1**). PRIMAS can take, of course, no possible action in this matter, which is a strictly political and financial issue. On another hand, our analysis showed that the access to IBL-oriented material, through textbooks for instance, is quite varied across the countries of our consortium. PRIMAS WP3, through the collection of IBL classroom materials (see **Deliverables D.3.1** and **D.3.2)** and the international website with the national versions, is an important achievement of our project that will enrich the situation in every country by pooling resources.

In this complement, and throughout the deliverable and data collection of all other PRIMAS WPs, we have shown some very inspiring successful actions that circulate among the many partners of the project. These can be new material for class or for a training course, but they can also be supporting actions for teachers or out-of-school target groups as well as examples of professional development programmes.