Primas

PROMOTING INQUIRY
IN MATHEMATICS AND SCIENCE
EDUCATION ACROSS EUROPE

PRIMAS PROJECT
FINAL PUBLISHABLE SUMMARY REPORT

PROMOTING INQUIRY IN MATHEMATICS AND SCIENCE EDUCATION ACROSS EUROPE

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Part I: EXECUTIVE SUMMARY

PRIMAS (Promoting inquiry in mathematics and science education across Europe, 2010-2013) is an international project within the Seventh Framework Programme of the European Union. The project aimed to effect a change across Europe in the teaching and learning of mathematics and science at school. PRIMAS supported teachers in developing inquiry-based learning (IBL) pedagogies so that their students gain experience of inquiry, develop related competences and increase their interest in these subjects. Ultimately, our objective was a greater number of students with more positive dispositions towards further study of maths and sciences and the desire to be employed in related fields.

The proposal brought together 13 teams of experts in IBL in mathematics and science education from 12 nations and was led and managed by a researcher with recent, successful experience of this type of work at the European-wide level. Appropriate experts from the wider team led each of the nine work packages (WPs) and these WP leaders ensured the successful completion of each stage of the project. Throughout the project, the overall design was focused to ensure maximum impact by using a multi-level dissemination plan addressed to teachers and important stakeholders. This plan included: providing best possible support and training of teachers and teacher trainers; creating and selecting high-quality, multi-lingual materials and methods for working with teachers; supporting actions addressed to teachers to advertise IBL; methods of working with out-of-school parties, such as local authorities and parents; and summaries of analyses that informed a wide range of policy makers about how they can support the required changes.

During PRIMAS lifetime, the project partners educated over 350 multipliers, around 2800 in-service teachers and more than 4200 pre-service teachers. Furthermore, PRIMAS partners organised over 365 dissemination activities with more than 26 000 face-to face contacts.

Throughout the project, national consultancy panels and two international panels provided ongoing advice and orientation at key stages. To maximise project 'reach' to teachers, professional development (PD) networks of teachers were expanded and new ones built by using proven and efficient models. Rigorous evaluation both by an internal team and an outside agency provided extremely positive (formative and summative) feedback about the validity of the project and its effectiveness.

The following report details PRIMAS aims, work, achievements and sustainable impact. Further information about the project is also available on the PRIMAS project website: www.primas-project.eu

Part II: SUMMARY DESCRIPTION OF PROJECT CONTEXT AND OBJECTIVES

Across Europe there are calls to attract more students to mathematics and science: As the rate of development of technology increases, we also need to provide adequately prepared workers and citizens who are equipped with knowledge and skills that allow them to be productive members of society today – and in the future. The PRIMAS partners have a vision of young people with curious and inquiring minds, who are intrinsically eager to extend their knowledge of mathematics and science and able to take their role in our modern, knowledgeable world. In achieving this vision, the choice and use of innovative and useful teaching and learning pedagogies – such as inquiry-based learning (IBL) – in schools is decisive. IBL pedagogies of high quality can raise school students' intrinsic interest in mathematics and science and support attaining important competences essential for their futures as world citizens. These include self-directed learning, exploring new knowledge areas and obtaining problem-solving skills. Therefore, the PRIMAS **central and overarching objective** was to promote a more widespread uptake of IBL in mathematics and science education at both primary and secondary school levels in Europe. To help achieve this objective, PRIMAS initiated a wide range of dissemination actions addressed to key target groups and placed special emphasis on professional development interventions related to IBL in mathematics and science. The project aims were achieved over a four year period (2010 – 2013).
In order to effectively approach our aims, this overall objective was accompanied by nine more detailed objectives as described in Annex I (DoW; cf. Annex I Part B, p. 4 et seqq.). These closely relate to the nine PRIMAS work packages (WPs):

- WP1: Management
- WP2: Analysis of national contexts and existing materials
- WP3: Materials for dissemination – mathematics and science
- WP4: Dissemination through teacher training
- WP5: Supporting actions for dissemination among teachers
- WP6: Supporting actions for dissemination among out-of-school target groups
- WP7: Dissemination to policy
- WP8: Internal evaluation
- WP9: External evaluation

The following provides an overview of the nine objectives valid to the whole project. The according progress, accomplishment and objectives will become visible in the subsequent sections which report on detailed progress, results and impacts and include work package specific objectives and tasks.

1) Analysing preconditions

The first objective was to analyse national contexts (contexts for a more widespread implementation of IBL) in all PRIMAS partner countries and to identify, collect and analyse existing materials and professional development initiatives. We then proceeded to identify actions or events that could support the uptake of inquiry-based teaching.
Our focus here was on a careful analysis that was systematically planned and carried out, of comparable nature, and which made visible the knowledge available and transferred it from a local to an international level. It was necessary to carefully analyse national details in order to be able to select and develop a common, international approach that could be implemented successfully in the various local contexts.

This work was mainly accomplished within WP2, thus making this WP a contributor to the other work packages.

2) Selecting materials

The second aim was to select international material collections for IBL at secondary and primary level. Materials (classroom teaching materials as well as materials for effective professional development in IBL pedagogies) are crucial for a high-quality dissemination of inquiry-based learning. The collected (adapted and refined) materials were used within the PRIMAS teacher training and for broader dissemination in and outside the PRIMAS teacher circle.
The aim was also to have a material collection for mathematics and science with a strong focus on interdisciplinary approaches. The systematic analysis (outlined above) contributed to collection development. Other important criteria used for selecting materials for the collection included how (and to what extent) an item fostered: attaining and consolidating basic knowledge; developing a task culture; learning from mistakes; cumulative learning; autonomous learning; promoting student co-operation; and avoiding gender stereotyping. Only materials proven to be appropriate were selected for the final collection.
This work was mainly achieved by WP3, with WP2 being a main contributor.

3) Implementing teacher training courses

The third objective was to identify and analyse existing models of professional development delivery (based on the outcomes of the analysis and international research on high-quality PD initiatives) and subsequently, to implement high-quality teacher training courses.
The PRIMAS PD courses were designed and implemented using the results of our analysis and two models. The PRIMAS spiral model basically states that teachers should be involved in long-term professional development initiatives in which they analyse inquiry-based learning activities, implement them in their classroom and reflect on the experiences. The pyramid model developed and commonly used for PRIMAS involved multi-level and networked implementation of training (cf. Annex I (DoW) Part B, p. 14 et seqq.) Results of the analysis and the model(s) were used to guide important operational decisions and the adaptation and implementation of training courses in local settings.
These aims were mainly accomplished within work package 4. The collection of relevant professional development materials to be used in the training courses was accomplished within the objective and WP3, as has been outlined above. Objective no. 3 and WP3 can thus be seen as also contributing to WP4.

4) Carrying out supporting actions addressed to teachers

The fourth objective was to carry out effective supporting actions addressed to teachers, as the promotion and uptake of inquiry-based learning techniques was fundamental to the project. These teacher-supportive actions helped to advertise the idea of inquiry-based learning and PRIMAS. Therefore, the project also needed to develop a distinctive identity (and accordingly establish suitable logos, brochures, informational material, etc.) Dissemination actions were designed to:

a) help reach teachers who participated in the teacher training courses, and
b) reach beyond these to other teachers.

The objective also included the national analyses of actions, such as talks to teachers on conferences, at school, publications especially addressed to teachers, and supporting materials to inform parents, colleagues and students. This led to the creation of an international guide for supporting actions.

The working tasks related to these objectives were mainly assembled in WP5.

5) Carrying out dissemination actions addressed to out-of-school groups

The fifth objective was related to reaching out-of-school groups, as it has been shown that whether or not a teacher implements IBL also depends on a range of factors in addition to pedagogic choices, for example, the reactions of students, parents and other out-of-school groups. For this reason, dissemination also needed to consider other target groups and plan new, specific dissemination actions.
Next to actually carrying out dissemination actions (that may comprise, for example, open school-days, talks to parents' associations, publications addressed to the general public or at research conferences, etc.) to such groups, the objective also included a national analysis of possible actions that resulted in a guide of supporting actions for out-of-school groups.
The working tasks related to these objectives were mainly assembled in WP6.

6) Informing policy

The objective here was to ensure that PRIMAS accomplished more than 'merely' disseminating the results of the important work it undertook. To this end, the aim was to work with policy makers from the outset in order to ensure that:

- all concerned were able to understand national and EU policy contexts, and
- a strategic vision was developed that encompassed project overall aims and objectives as a whole and in a way that responded to national and EU-wide agendas and further, would develop over the life-time of the project.

The objective included all countries carrying out an analysis so that partner nations would be informed about how their policy makers might act to ensure progression towards meeting our objectives. The project gained in strength over its course and developed an increasing understanding of the constituent partner nations, as well as of the EU context as a whole. In recognition of this, it was intended that this WP develop a dissemination strand of its own that reflected throughout, but particularly towards the end of, the project on how best to interact with policy at national and EU levels.
This objective was to be accomplished by the tasks of WP6.

7) Evaluation of the project

The seventh objective was a well-designed evaluation of project progress and success. The overall objective of the planned evaluation was to find out if the project met its overall aim – the more widespread uptake of IBL at schools within the partnership countries. The objective included two evaluation approaches.
A *formative evaluation* allowed us to monitor project progress and the dissemination actions. Possible means of evaluation included quantifying aspects of the 'reach' of the project (e.g. counting visitors at events, number of teachers taking part in PD interventions or number of magazines distributed), interviews or feedback questionnaires (for teachers taking part in the PD intervention).
This was mainly accomplished within WP8.

The objective also included an independent *summative evaluation* to be carried out by the IPN Kiel, partner no. 14. The aim of this independent evaluation was to find out if the chosen model of in-service teacher training really led to an uptake of IBL and if/how students perceived the uptake. This was carried out with the help of questionnaires for teachers and students.
The objective was accomplished within WP9.

8) Setting up panels

The eighth objective related to the work with relevant national and international panels.
The **International Expert Panel (IEP)** consisted of international key-players in relevant fields. Members of the panel gave substantial advice and secured dissemination within their organisations and areas of work, and thus contributed to the necessary international dissemination not only in Europe, but around the world.
To facilitate the uptake of inquiry-based science teaching, the objective included the work with a **National Consultancy Panel (NCP)** in each partner country. These panel members represented organisations or groups such as teachers' associations, parents' associations, school authorities, industry, publishers, curriculum designers and policy makers. The NCPs also gave advice and support to partners on a national level to help us reach our goals.

1. In addition, the objective aimed for the establishment of an **International Consultancy Panel (ICP)** for a better sharing of experience among practitioners across Europe and was to consist of one member out of each NCP. The aim was that this panel not only provide support to the international PRIMAS Consortium, but also to the national consultancy panels in identifying the European commonalities and differences. The ICP was thus to contribute to the European dimension of the project.

These panels were localised in the management work package (WP1).

9) Delivery of materials & project website

The last objective was to provide public information online about the project and its ongoing work and results. Further, it was to be ensured that the (final) material collections would be assembled in an electronic form suitable for distribution via the project website or on CD/DVD and ultimately be delivered to the central platform provider for science education materials.
This objective was mainly accomplished jointly by WP3 and WP6, see descriptions above.

Part III: DESCRIPTION OF THE MAIN SCIENTIFIC AND TECHNOLOGICAL RESULTS/ FOREGROUND

In the following a concise overview of the progress of the work in PRIMAS is given. Afterwards, a detailed report on the main results/foreground within the nine PRIMAS work packages is described.

1. CONCISE OVERVIEW OF THE PROGRESS OF THE WORK

The work in PRIMAS commenced with the start of the year 2010. The kick-off meeting (Milestone, hence M, 1.1) took place in February 2010 and comprised the first Consortium meeting, the first meeting of the International Consultancy Panel (ICP) and International Expert Panel (IEP, M1.2), as well as a first dissemination event, including a press conference. At local level, the first months of the project were used to set up a National Consultancy Panel (NCP,M1.2) in each partner country and to put in place effective structures for working towards achieving project objectives (forming work teams, disseminating information about the project start at local level). By the first quarter of 2010, the first version of the international website was also online (M6.1) so that information about the project and its aims could be easily accessed by all targeted groups

and the general public (the website was continually updated and edited – cross cutting work of WPs 3,4,5 and 6). Parallel during the first months of the project, extensive work was devoted to creating the necessary means and materials in order to professionally and effectively address our target groups – logo, motto/slogan, brochures, posters and the like were created (M5.1) and have since contributed to the successful dissemination.
The project Consortium went on to meet regularly for intensive 'face-to-face' work towards project implementation. By the end of PRIMAS, a total of eight Consortium meetings (which were themselves evaluated and monitored) took place. The ICP and IEP participated in seven of these meetings. In the phases between Consortium meetings, the results were implemented at local level and the 'to dos' from the last meetings carried out locally, and at the international level via virtual contact. The international, and in particular the local work, benefited extensively from the close collaboration with the consulting panels. These comprised the key actors necessary for collaboration that led to achieving high-quality project implementation, the formation of long-term working relationships and networks, and providing for sustained impact of the measures carried out within the project beyond its four-year lifetime.
Major work in the first project period was also devoted to the analysis of contexts resulting in national reports, as well as an international synthesis report (M2.2, D2.1). The report was shared with Eurydice on their request. As part of this analysis, we identified, analysed and collected inquiry-based learning materials (classroom and professional development resources M2.1) and pointed to successful professional development initiatives, dissemination actions and events. These initial activities further enabled the work to be carried out in the other work packages, most notably WP3 (materials). As a supplement to the international synthesis report (D2.1) and based on the analysis of contexts, a final international comparing analysis of different national contexts was accomplished within the second project period (M2.3, D2.2).
Closely related to the work of WP2, each partner nation prepared interim briefing reports (M7.1, M7.2). This allowed us to gain greater understanding at regional, national and European levels of policy about the amount of young people interested in mathematics and science, the support of the professional development of teachers as well as the national policies and education policy contexts relevant to the dissemination of inquiry-based pedagogies. Based on these reports, international briefing reports were delivered that synthesised policy information across nations (D7.1, D7.2 and D7.3). These analyses further enabled the work to be carried out in all other work packages, most notably WPs 3, 4, 5 and 6.
During the entire projects lifetime, the leading team in the materials work package (WP3) initiated further analysis of identified resources and started a refinement and extension process that eventually resulted in the final collection of IBL classroom and professional development materials. At the end of 2010, the first material collection was made available for trialling on our website (M3.1, D3.1). The second material collection has been available since the end of December 2011 (D3.2). As a consequence of the intensive work with the materials, we invested extensive work in establishing a sound and commonly shared definition of IBL, and in providing a theoretical IBL framework to guide all further work on improving and extending the available collection. The existing collection was then gradually refined and improved and is now guided by a common framework and structure (M3.2). The final collection was made available in the end of September 2013 (M3.3, D3.3).
The professional development resources collected within WP3 were continuously used in WP4 – the training of teachers. Within the first project period, the models

and concepts for delivering effective teacher professional development courses (in- and outside the PRIMAS project) were extensively reviewed (M4.1). This led to the publication of a research-based guide for professional development providers that outlines the key models and concepts (D4.1). A modified version of this guide was created within the second project period (D4.2). Furthermore in the first project period, infrastructures for the local implementation were set up and the models of teacher professional development were applied locally in the teacher trainer/multiplier courses that mostly ran during the second half of 2011 (M4.2, M4.3). Additionally around the beginning of 2012, professional development actions were implemented in every country (M 4.3). Thanks to the infrastructure created in each country and the multipliers trained in the previous phase, professional development actions addressed around 3130 teachers and more than 4200 pre-service teachers (M4.4, M4.5).

Supporting actions for teachers were identified and analysed within the working strands of WP5 and analytical case studies of successful and exemplifying events were created by each partner (M5.3). Eventually in the first project period, these works resulted in an international guide on dissemination actions that can be carried out in order to support teachers directly or indirectly in their use of IBL pedagogies (D5.1). This guide was modified within the second project period (D5.2). Similarly within WP6, the Consortium identified effective actions to disseminate to out-of-school groups, such as parents, local communities or the wider public. Selected actions identified were more precisely analysed in case studies. Extensive research was also done on parent/family/community involvement (M6.2). Based on these working lines, the guide on supporting actions for out-of-school target groups was published within the first, and revised within the second, project period (D6.1, D6.2). Our actions were also continuously documented using the so-called 'project diary' (M5.2) on an internal, electronic knowledge exchange platform (the activities are also documented in ECAS).

As part of our efforts to inform teachers and other groups about the project, PRIMAS partners carried out more than 365 dissemination actions with more than 26 000 face-to face contacts at local and international levels. This number excludes any website contacts. (M5.4, M6.3). The project also had good media coverage and various publications appeared about PRIMAS (cf. publications listed in the Annex of this publishable summary). Across Europe, PRIMAS established networks and/or working partnerships with various actors, which we detail in the report about WP1 below. These networks were strengthened and even expanded during the PRIMAS final dissemination conference held in Brussels in November 2013 that was mainly geared towards educational policy makers, advisors, authorities and researchers (M1.3, D1.1, M7.4).

These activities and extensive efforts (cross-cutting work of WPs 1, 5, 6 and 7) resulted in the project achieving substantial impact at local and international levels. This impact can be seen by the quantitative numbers, but is also evidenced by several other positive indicators. For example, people 'outside' the project regularly used their own initiative to contact project members. Additionally, members also received invitations to give talks and collaboration requests from interested projects, institutions or individuals and registrations for our newsletter increased constantly. PRIMAS was also chosen as the 'project of the month December 2011' by the Federal Ministry of Education and Research in Germany and our Coordinator was appointed to be the German ministerial representative in the Thematic Working Group on Mathematics and Science education of the European Commission. A further notable example of successful and wide project dissemination was the publication of an entire edition of the renowned mathematics and science journal *ZDM* that was dedicated to IBL.

Entitled 'Implementation of Inquiry-Based Learning in Day-to-Day Teaching', this issue contained papers authored by several PRIMAS partners and outlined project concepts and first results.
In working to achieve our aims at the policy level, we included policy makers in regular National Consultancy Panel circles (M 7.3). This allowed the development of networks and influence with policy and key influential groups in policy making in order to prepare and create the necessary infrastructures and support for carrying out key PRIMAS measures. In fact, relations to policy at the local (national) level in the partner countries were developed very successfully within the first 18 months of the project. This can be seen in the way that national authorities contributed, among other things, additional resources to project work. An example here was the granting of support so that teachers were given 'time-off' from school to participate in PRIMAS PD courses (e.g. in Germany).
Regarding the evaluation, one of our first tasks within the first project period was to adequately adhere to data protection guidelines and ensure that we would have the relevant authorisations and necessary documents to inform those participating in research (mixed method approach: the combination of questionnaires and case studies, D8.1). These works were concurrent with drafting and finalising appropriate evaluation instruments for the independent summative evaluation (M9.1, D9.1) that would have the potential to assess the project´s impact (within a pre-post design with a prior status-quo survey) and that would have validity in all national contexts. Prior to the pre-post study, a large status-quo survey on IBL in schools across Europe resulted in a thorough report giving insight into the current uptake of, and teachers' views about, inquiry-based learning. It was published in mid-2011 (D9.2). Within the internal evaluation, which was formative in nature, the framework for the progress and impact assessment was devised and evaluation instruments developed (including short formative questionnaires for different target groups, as well as case studies, M8.1, D8.2). After all evaluation tools had been developed, internal and external data collection started within the second project period (M8.2, M9.2). The evaluation results (D8.3, D9.3) also clearly illustrate that **PRIMAS met its overriding aim**: the change across Europe in the teaching and learning of mathematics and science by supporting teachers to develop IBL pedagogies.
All in all, national contexts for the implementation of the project were diverse and incorporated different teaching, professional development and/or research cultures. This was to an equal degree both a challenge – and of course, an inherent benefit of the project. It was therefore crucial to devote sufficient discussion time and resources to resolving issues that arose from the different cultures and contexts, and also to actively promote exchange within the Consortium. This was 'institutionalised' during the PRIMAS Consortium meetings, for example, with the PRIMAS country poster galleries and the internal exchange forum on national implementation.
Personnel costs are the major cost items for beneficiaries in the project. As has been previously reported and discussed with the responsible Commission project officer (2010), PRIMAS reports more person months than initially planned. This only has slight effects on the personnel costs reported due to the use of employees with rather low remuneration rates (e.g. student assistants) to support operational work. As their remuneration rates were lower than the rates used for many calculations in initial Annex I (DoW), the effect was not reflected in the monetary amounts claimed, but rather in the amount of person months.

2. DETAILED REPORT ON THE MAIN RESULTS/FOREGROUND WITHIN THE NINE PRIMAS WORK PACKAGES

WORK PACKAGE 1: Management

WP1, or more precisely the project office, was charged with overall management of the Consortium and was run by the Coordinator with the help of her employees. The project office was the central hub for PRIMAS management and implementation. It was the contact point for project partners, the local implementation team and network, for the EU, as well as for cooperating partners and any interested persons or institutions at international or national levels. Naturally, the main focus of the project office was the international coordination and management of the project. Responsibilities (parallel and/or in addition to those already put down in the Grant Agreement) included: international coordination; management; quality assurance; communication; liaison; networking; and Consortium-internal technical and finance control. The project office remains the liaison to the EU Commission and our responsible project officers even after PRIMAS lifetime. In the following, we report on these aspects: (a) Project planning and status, project monitoring (incl. finances); (b) Coordination and management of meetings and quality assurance; (c) Collaborations, liaison and the management of international impact; and (d) Extremely fruitful cooperation with the PRIMAS panels.

Project planning and status, project monitoring (incl. finances)

PRIMAS progressed in accordance to the schedule put down in Annex I (DoW), all milestones were achieved and all deliverables submitted through the electronic reporting system (see also the list of milestones accomplished and deliverables submitted in ECAS). Those deliverables consisting of extensive reports or guides are also referenced in ECAS.
Relating to the financial aspect of project planning, only minor changes were needed/made to the budgets initially outlined in Annex I. Budget redistributions between beneficiaries occurred in relation to the transfer of Geoff Wake (from beneficiary no. 11 to beneficiary no. 4; G.A. amendment no. 2) as well as the transfer of Nicholas Mousoulides from beneficiary no. 8 to beneficiary no. 15; G.A. amendment no. 3). In total, beneficiaries claim slightly less costs than available to the project. All project aims have been reached with less than expected costs. Partially beneficiaries have contributed more own resources than they initially envisaged. Some funds were redistributed to partners with additional justified expenses (no. 2, no. 6, no. 10, no. 12 and no.14.
Over the whole project duration the cost-intensive and work-intensive tasks were unevenly distributed so that the amounts reported in different periods by different beneficiaries vary accordingly of course. All details on the funds used are reported through the financial modules in ECAS.
A main vehicle to ensure that the progress was according to schedule was the close monitoring of progress by the Management through interim reporting, as well as informal and regular (email) contact with the work package leaders and the local partner teams. Consortium mailing lists and an internal knowledge and document exchange server, which was also used as the so called project-diary (see WP5) contributed to smooth communication. Work package leaders in turn were in close contact with local partners, each other and with management. The face-to-face work meetings of the Consortium were also key to ensuring timely progress.

Coordination and management of meetings and quality assurance

Management prepared all meetings in collaboration with the local host and the WP leaders – to exactly determine specific needs and the meeting structure/set-up, as well as to ensure a maximum impact on fostering project implementation. In addition, preparation was aided by an external evaluator and the results from the evaluation of the former meetings. The evaluation was carried out (questionnaires) at the end of each meeting and provided in the form of a written report. The evaluation was mainly based on three pillars: 'organisation and working methods', 'theme-based', and 'atmosphere, team relations and progressive spirit'. Results of the evaluation led, for example, to refinements of the meeting schedule and to an intensified integration/ inclusion of the ICP/IEP within all meetings. This intensive collaboration was a tremendous asset to the entire project. Also the evaluation prompted us to revisit the clarification of the common concept for IBL, the framework for IBL materials and IBL professional development – a step which further improved the quality of materials and training. Without the written, comprehensive evaluation, the full ambiguity and the demanded clarification would not have been regarded to the extent that it actually needed.

Work progress during the meetings was also monitored by the Management and the external evaluator, and all meetings concluded with written summaries and lists of next steps and 'to dos'. Meetings usually lasted between three to five intensive working days. Means and modes of working selected depended on needs and included: plenary sessions; presentations; workshops; working groups; poster galleries; special group work like World Café; and WP leader and country implementation presentations. The external evaluation helped tremendously in developing appropriate schedules and working modes and in adjusting and implementing them. Management and WP leaders continuously monitored progress and quality of the project implementation. However, the Consortium meetings provided the central vehicle for progress, meaning they were used for reflection, re-integration of local issues, the formation of common frameworks and perspectives, etc. In this sense, the meetings were a means of quality assurance in and of themselves.

A total of eight Consortium meetings took place during project lifetime. Meetings were hosted by project partners; a written guide for the administrative tasks and regulations to be considered was developed to secure smooth planning and implementation. The Consortium meetings were held concurrently and integrated with the ICP and IEP meetings. The frequency of face-to-face contact and feedback sessions within the Consortium was considered essential – and led to the panels developing into a central support structure (which can be seen as a key achievement in the project). During the Consortium meetings, the Management Board and Governance Board meetings were also held. These structures were established on the basis of the Description of Work. Subsequent to each Consortium meeting, the minutes with overviews of the agreed 'to do´s', deadlines, etc. were prepared and then followed up jointly by WP1 and the other WP leaders.

Collaborations, liaison and the management of international impact

PRIMAS members regularly received invitations to give talks about the project and also had numerous requests from interested institutions, projects or similar to collaborate or share experiences. Such links were created by efforts from members all across the Consortium, but management/the coordinating institution played the central role in integrating and achieving international-level impact. Management maintained (and respectively still maintains) international level

relationships with a range of other projects and initiatives. In the following, we report on some key, international-level dissemination and networking activities.
The project office, together with other WP leaders, was/is the main liaison with European Schoolnet, where Scientix (the European platform provider) and other projects of interest are coordinated. Furthermore, we maintain the project's active participation in ProCoNet – the project coordinators' network on EU-funded projects in science education. ProCoNet has successfully initiated the Comenius Network INSTEM, a meta-network of project coordinators which will ensure further dissemination of PRIMAS – even beyond project lifetime. The Coordinator of PRIMAS is also taking a leading role in the coordination of ProCoNet. PRIMAS has also hosted a ProCoNet meeting with presentations about projects. This created a possibility for further knowledge exchange not only for all of the Consortium members, but also for our International Consultancy Panel. Both ProCoNet and PRIMAS are in contact with the Directorate-General for research and innovation and the Directorate-General for education and culture and the Thematic Working Group of the EC on mathematics and Science education (2011 – 2013), where the PRIMAS Coordinator was the German representative.
Our extensive communication in publications and dissemination events also resulted, for example, in PRIMAS being presented as the 'Project of the Month' (December 2011) by the German Federal Ministry of Education and Research. This is an example of how our work led to further opportunities to reach an even wider audience. In consequence, PRIMAS was presented on the homepage of the Ministry and a leaflet about the project was distributed to the German Parliament. Furthermore in Slovakia, PRIMAS received the Rector´s Award and the Dean's Award from the participating institution, which gave the project further publicity.
As a further consequence of the PRIMAS Brussels Event held in September 2011, the PRIMAS Coordinator became the German ministerial representative in the Thematic Working Group on Mathematics and Science Education of the European Commission.
In addition, PRIMAS participated in the COMENIUS Cluster Meeting (December 2012) in which the above mentioned high level working group was also centrally involved. This meeting brought together a range of projects funded under different programmes and strands also provided for the possibility of extending and further integrating our dissemination efforts at the international level. PRIMAS participation in the meeting is an example of how our efforts and international participation in working groups, meetings, etc. interlink. Since December 2012 and January 2013, the Coordinator of PRIMAS, Katja Maaß, has also been coordinating two other projects: a new network project called INSTEM and a new FP7 project called mascil, from which long-term sustainability of PRIMAS will benefit. Furthermore, in 2013 a collaboration with the EU project SAILS was established, which will also contribute to long-term sustainability of PRIMAS.
Due to her experiences in coordinating international projects, international connections and her expertise in teacher education, in December 2013 Katja Maaß was asked to join the Quality Management and Overall Guidance Department of the German Centre of Teacher Education (DZLM). Moreover, Katja Maaß, in cooperation with outstanding international researchers, edited the *ZDM* journal issue 'Implementation of Inquiry-Based Learning in Day-to-Day Teaching' – in which PRIMAS concepts and first results are outlined.

Extremely fruitful cooperation with the PRIMAS panels

PRIMAS has established consulting and expert panels working with the project Consortium – NCP, ICP and IEP (M 1.2). This is related to project objective no. 8:

the work with the consulting and expert panels (whereby, the local NCPs were, of course, locally implemented and managed at the local level).
The value of these panels was not only in the form of the advice, consultancy and expert opinions they provided to the Consortium. The panel members also received input, information and knowledge generated through the international interaction and they, in turn, took this knowledge to their own local settings and used it to inform their own work, that of their colleagues and project implementation. The panels also took on an active role that went beyond providing advice to the project and can best be described as actively supporting and joining forces with the project. This was reflected in several countries where local developments prompted the NCPs to take the initiative in establishing local contacts with other EU-funded projects running in their particular land in order to coordinate action in an integrated manner (and in conjunction with national initiatives). Impetus for this action had, in turn, come from the International Panel members participating in the international PRIMAS meetings (for example in the ProCoNet meeting that PRIMAS hosted in June 2011). These developments certainly were a major success and achievement and definitely a factor that actively ensures a wider impact of the project and its sustainability.
The NCPs met about every six months, and the ICP and IEP met seven times each. All ICP and IEP meetings were held concurrently with those of the Consortium. As part of the arrangements for these concurrent meetings, we prepared integrated schedules to provide for common working cycles, internal meetings and time for feedback. The ICP expressed the wish to meet both internally, and with the Consortium, more often than initially planned. We were able to achieve this without increasing costs by holding slightly shorter meetings. This was fully supported by the Consortium and also discussed positively with the EU Commission officer. In the second half of 2011, policy makers in each country were included in the NCP meetings (cf. policy report). The analysed and synthesised information resulting from these meetings was given as feedback to the ICP to foster knowledge transfer between the different countries.
At the same time, an intensive question and answer process was institutionalised between the Consortium, the ICP and IEP. For example, after the data comparing all the national contexts was synthesised (M2.2), input was given to the ICP along with the request for feedback. Additionally, preparation for each ICP/IEP meeting included providing panel members with an update about the current status of project work with specific questions that arose during the work process. Based on the updates, questions and results of each ICE/IEP and Consortium meeting, feedback was given to the Consortium in the form of open questions, progress assessment and evaluation of issues panel members had previously raised, etc. WP1's task here was to facilitate these processes and ensure that issues raised were followed up, moved forward and/or successfully resolved. To that end, WP1 worked in close cooperation with the leaders of other work packages. In some countries, there was a slightly different schedule for the NCP meetings due to various requirements and schedules of other activities (e.g. multiplier and PD courses that are organised differently). Thus, adhering to a very strict schedule for NCP meetings in the pertinent countries would not have resulted in their particular NCP being able to provide maximum support to project work.

WORK PACKAGE 2: Analysis

Within the PRIMAS project, the national contexts in 12 European countries were 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 created within WP2 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. In the following we report on the main outcomes of the final deliverable.

The situation in the twelve countries involved in our analysis regarding tradition in education and the place of mathematics and sciences in society is quite varied. Political, historical, cultural and even religious backgrounds were reported to be behind the way mathematics and sciences are conceived within society and to explain teaching traditions. Differences such as: transmissive versus more student-oriented pedagogies; centralised systems with a strong power from national or local governments versus decentralised ones with higher teacher/school autonomy; and the social role of science education were among the instances cited as emerging from these backgrounds. These differences also give rise to opportunities and challenges for the widespread use of IBL.

In past decades, all these differences in tradition may have been quite important. However, in recent years, there has been a common trend in all of the countries for the promotion of educational paradigms in mathematics and sciences in which students should be more active. This has resulted in sometimes quite radical changes. Therefore, the curricula are less content-centred and more formulated in terms of competences related to the outside world. The publication of PISA results has encouraged this movement in all countries and this trend can be interpreted as providing opportunities for spreading IBL.

There are also important challenging factors appearing in several countries. One is due to the succession of reforms in recent years in many countries, resulting in a rejection of change by teachers and sometimes by parents. In some countries as well, this has resulted in a resurgence of ideas defending a return to traditional, pedagogical paradigms and to fundamental contents such as reading and counting. Indeed, in several countries, in spite of official new curricula in favour of IBL, the lobbying for a more traditionalist pedagogy may be very strong.

At the primary school level, each country provides mathematics instruction at each class level, usually with a rather substantial number of hours. Science, though, is always taught as an integrated subject with a small number of hours. It appears that in many countries, primary school teachers do not regard mathematics and science as their favourite subjects, which might be a difficulty for implementing IBL at this level.

The organisations of lower secondary schools are more varied: between three and six years long, depending on the country. It is usually undifferentiated for all children, but may also be selective (for example in Germany). In most cases, the structure of lower secondary education is close to that of upper secondary school. In some countries, though, the structure still reflects primary education (and appears 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 two or three different subjects (not all necessarily 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 is between two and four years long and usually differentiated and selective. Mathematics is taught in nearly all

branches, although not always in non-science and technology branches at the end of the curriculum. Science education varies quite considerably depending on the specialty and is usually divided into two or even three different subjects (physics, chemistry and biology/geology).

In relation to the initial teachers' training, in most countries primary school teachers are trained at a special institute or university for at least three years (up to five). The training is mainly in pedagogy, but in most cases it includes courses in didactics of mathematics and sciences (that may be IBL orientated, but this is not the majority of cases). Science and mathematics education usually represent a small part of the training. In very rare cases, teachers' initial training is complemented with mathematics and/or science courses, while in most countries, some mathematics and/or scientific issues, normally very close to the primary school syllabus, are included in the courses in didactics.

Upper secondary teachers, by contrast, usually have at least a three-year (up to five) university degree in mathematics or one science subject. In contrast, their pedagogical training varies from nearly nothing, to up to two years (usually partly in service) and includes some mathematics/science education 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.

Teachers' initial training might be a significant constraint hindering a consistent use of IBL. Indeed, most primary school teachers and some lower secondary school teachers lack a sufficiently deep and broad understanding of mathematics and science. This is not the case for most lower secondary and upper secondary school teachers. Nevertheless, IBL is not dominant in teachers' initial training. As a consequence, their relation to subject knowledge rarely reflects any IBL perspective. This does not favour IBL, and indeed, may even hinder it in the long term. This is because initial training may influence teacher practices for their whole career, as teachers' knowledge and beliefs (about the nature of science, student learning, and the role of the science teacher) have a major impact on their teaching practices (Keys and Bryan 2001[1]).

The issue of in-service teachers' training and professional development appears to be very connotative (Anderson 2002[2]), and particularly so in the case of the PRIMAS project. The one key issue seems to be changing teachers' practice – and to attempt to do so, all of the national teams had to find ways to make optimal use of the existing structures. However, this appeared to be quite challenging with very different conditions in each country of the consortium.

The supporting infrastructure for providing in-service professional development is quite different in each country. However, it is possible to distinguish between countries in which professional development is delivered mainly by institutions directly connected to the national/local governments (Romania, Spain, Norway, Slovakia, Switzerland) and other countries where another kind of institution (both public and private) also offers professional development (Denmark, England, the Netherlands).

Certainly, there is true homogeneity in the description of the intended pedagogy in all countries' official documents. Moreover, in some countries IBL is a real opportunity to supply the means to fulfil some of the political requirements by providing support to teachers, parents and ultimately, students.

[1] Keys, C. W. and Bryan, L. A. (2001). Co-constructing inquiry-based science with teachers: essential research for lasting reform. Journal of Research in Science Teaching, 38(6), 631–645.

[2] Anderson, R. D. (2002). Reforming science teaching: what research says about inquiry? Journal of Science Teacher Education, 13(1), 1–12.

Yet beyond this uniformity, there are various situations. In some countries, this orientation in pedagogy is very recent (Cyprus, Germany, Hungary, Malta, Romania, Slovakia, Spain). In others, by contrast, there is a long tradition of constructivist pedagogy (England, Norway, the Netherlands, Denmark and Switzerland). In some countries, for example Germany, the change has been quite radical since the first PISA study results.

However, even if educational policies do support IBL, it does not mean that they actually reflect teachers' practices. This discrepancy between what policy says and teachers actually do is found to some extent in all partner countries. The reasons evoked for this vary from one country to another – and the weight given to the various explanations which follow differs as well. National context (past and recent) and the cultural background are two decisive factors here. Moreover, in many, if not all, countries, the resistance does not only come from teachers, but also from students, parents and the society as a whole. This reflects a tension between intended changes and future perspectives at the societal level promoted by trans-national regulations and the current state of our societies.

Finally, there are some structural issues concerning mostly national assessment, the separation of disciplines at school and the use of resources by teachers.

The national assessment issue concerns choices in the pedagogical policies and, moreover, these choices may help or hinder teachers' adopting IBL. In several countries, the national policies have evolved in the sense of less traditional assessment, taking into account the changes in the educational policies, as well as the results and spirit of international evaluations such as PISA. Yet, in many cases the changes are slow and not always sufficient to really encourage IBL.

Traditionally, school is organised in a strict separation between disciplines. Everywhere, mathematics and science have traditionally been taught as separate subjects. In most countries, though, a new tendency is emerging with the aim of creating more coherence between the disciplines. The possibility of building some bridges between different disciplines is a key issue for the promotion of IBL.

Finally, a major issue regarding teachers' practice concerns the use of resources, especially textbooks, but also web resources, including didactic literature. In this matter, the situations in the countries analysed are very different. In most countries, though, it seems that teachers (especially in primary and lower secondary education) rely considerably on textbooks. In a majority of countries, these can be chosen freely by the schools or teachers. In some countries, though, government policy or specific, official documents (Switzerland) set required text books, etc. In most countries, the use of web resources of all kinds is becoming more and more popular, although not always with much critical supervision. Textbooks providing IBL opportunities are very rare, with the exception of the Netherlands, where they are of very good quality, and Switzerland (in mathematics), where the official material from the state for compulsory education provides material with problem-solving and didactic comments. By contrast, in some countries, for example Romania and Slovakia, there is a lack of textbooks that meet the new curricula requirements regarding IBL. In reality, even explicitly IBL or problem-solving orientated documents can be used by teachers in an inadequate manner, leading to very poor practice.

The outcomes of WP2 served as general guidelines in order to inform the consortium for the realisation of the whole project, it gave some useful information for the construction of the general framework of PRIMAS and several hints for the implementation of the project in each national context. Moreover, the detailed information made a fruitful contribution to the interaction with each NCP, as well as the IEP and ICP.

WORK PACKAGE 3: Materials

In order to ensure a collection of high quality materials for PD in IBL pedagogies, as well as IBL classroom activities, that are usable in all partner nations and beyond, in a first step – and based on the work of WP3 – a firm and grounded common understanding of IBL that implicitly and explicitly guided work was developed. The elaborated definition comprises a cloud of five perspectives from which IBL can be viewed with specific characteristics related to each perspective (Figure 1). This clear vision of IBL, which summarises the different definitions that exist across mathematics and science and across countries, can be regarded as one major success of the project.

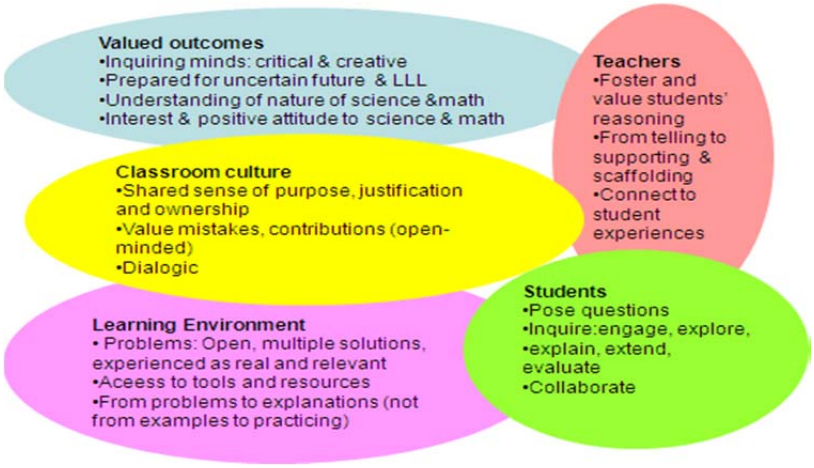

Figure 1: Five perspectives framing IBL.[3]

Based on this common definition, a broad material collection for PD in IBL pedagogies as well as IBL classroom activities was developed which was continuously extended until the end of PRIMAS. The following table shows the number of high quality resources for PD and for inquiry-oriented lessons available at the international PRIMAS website (http://www.primas-project.eu):

	As reported in September 2013 in D 3.2	**Current collection**
Total number of articles	**78**	**108**
Mathematics / science	**42 / 36**	**65 / 47**
Teaching / PD material	**41 / 37**	**69 / 46**
Core set of PD units	**7**	**7**

Table 1: Number of resources in the PRIMAS repository

The collection links new teaching material with extensive support for teacher development in key aspects of IBL. This approach is partly based on the success of two UK projects: 'Improving Learning in Mathematics', funded by the government in England, and 'Bowland Maths', funded by the Bowland Charitable Trust. This is also why next to the team from the Freudenthal Institute at Utrecht University (that led WP3 and contributed mainly to the science-side) an important leadership role in this WP was taken by the team from the Shell Centre at Nottingham University.

[3] LLL= Lifelong learning.

The seven research-based professional development units are the core set of this collection[4]. Each unit focuses on a specific theme that relates to one of the pedagogical issues for teachers (Table 2). These topics were carefully chosen to highlight key aspects of successful IBL which apply to both mathematics and science across a range of ages. Each unit contains a collection of classroom activities combined with detailed suggested lesson plans, integrated into a programme of discussion-based, teacher development activities. Teachers are expected to try some of the materials in their own classrooms as part of these activities – one aim is to introduce an element of inquiry-based teacher development, rather than lecturing teachers on how to do IBL, and to create a bridge between classroom materials and pedagogical theory. This is supported by videos showing the materials in use and of teachers reflecting on their lessons. While the initial units have an emphasis on middle school mathematics, our aim was that these would develop into a 'framework' into which a wider variety of mathematics and science teaching materials from the PRIMAS collection can be incorporated. WP3 worked closely with WP4 to ensure that this was in harmony with their work.

1. Student-led Inquiry. In this unit, teachers are presented with phenomena and are then invited to pose and pursue their own questions. They thus experience what it feels like to think like a mathematician or scientist and are then invited to try a similar activity with their own students and reflect on the outcomes.
2. Tackling Unstructured Problems. This unit invites teachers to consider the decisions that we make for students when we present them with structured problems. It invites comparison of structured and unstructured versions of problems and considers the demands and challenges unstructured problems present in the classroom. Teachers are invited to try out unstructured versions of textbook problems in their own classrooms and report back on their experiences.
3. Learning Concepts through IBL. This unit considers how the processes of inquiry-based learning may be integrated into the teaching of content. Often, these two aspects of learning are kept separate: we teach content as a collection of facts and skills to be imitated and mastered, and/or we teach process skills through investigations that do not develop/incorporate important content knowledge. The integration of content and process raises many pedagogical challenges. The processes under consideration here are: observing and visualising; classifying and creating definitions; making representations and translating between them; finding connections and relationships; estimating, measuring and quantifying; evaluating; experimenting; and controlling variables.
4. Asking Questions that Promote Reasoning. This unit contains a selection of stimuli designed to help teachers reflect on: characteristics of their questioning that encourage students to reflect, think and reason; ways in which teachers might encourage students to provide extended, thoughtful answers, without being afraid of making mistakes**;** the value of showing students what reasoning means by 'thinking aloud' as problems are worked on in collaborative classroom environments. As before, teachers systematically try to develop their own classroom questioning and report back on what happens.

[4] Swan, M., Pead, D., Doorman, M., & Mooldijk, A. (2013). Designing and using professional development resources for inquiry-based learning. *ZDM The International Journal on Mathematics Education*, *45*(7), 945-957.

5. **Students Working Collaboratively.** This unit is designed to offer teachers the opportunity to reflect on the characteristics of student-student discussion that benefit learning; to recognise and face their own concerns about introducing collaborative discussion; to explore researched techniques for promoting effective student-student discussion; and to consider their own role in managing student-student discussion. They plan and carry out discussion-based lessons and report back on what happened.
6. **Building on What Students Already Know.** This unit considers the different ways teachers can use formative assessment techniques to make effective use of students' prior knowledge. It focuses on the following questions: How can problems be used to assess performance? How can this assessment be used to promote learning? What kinds of feedback are most helpful for students and which are unhelpful? How can students become more engaged in the assessment process?
7. **Self and Peer Assessment.** This unit encourages discussion of the following issues: How can we help students to become more aware of IBL processes, and their importance in problem solving? How we can encourage students to take more responsibility for their own learning of IBL processes? How can students be encouraged to critically assess and improve each other's work?

Table 2: An elaboration of the pedagogical issues for teachers in the PD units

WORK PACKAGE 4: Training

The main result of WP 4 was the actual implementation of PD courses in every country that reached the numbers declared in the 'description of work' and thereby contributing to PRIMAS success. This implementation was mediated by the understanding of the national contexts, the development of a PD concept and the creation of national infrastructures.
An important outcome of WP4, respectively PRIMAS, was the creation of these national supporting infrastructures which lead to the expected result: the large-scale dissemination of IBL through teachers' professional development across Europe. On a country-specific level, supporting infrastructures for an effective and deeply-rooted implementation of the PRIMAS PDs beyond project lifetime were identified and are highlighted in the following:

- In Cyprus, the national team identified that the Cyprus Pedagogical Institute, the official centre for providing professional development could play an important role. The Institute provided accreditation for PRIMAS courses, while directors of the Institute acted as members of the NCP. The national team also worked closely with other initiatives (e.g., GeoGebra Institute), teachers' professional associations and policy makers from the Ministry of Education and Culture. These collaborations resulted in identifying key researchers and teachers that could act as multipliers, and in informing a large number of teachers about PRIMAS professional development courses. Those synergies and collaborations ensured the successful implementation of PRIMAS in Cyprus.
- In Denmark, the national team worked with *Danish Science Gymnasiums* (DASG), a national network of upper secondary schools spread all over Denmark. In cooperation with DASG, the Danish national team advertised and offered professional development courses in inquiry-based science teaching in subjects related to green technology. In collaboration with STAR, a project funded by the EU social fund, the national team advertised and offered professional development courses in inquiry-based

mathematics teaching focused on problem-oriented project work in mathematical modelling. This synergy with other projects was important for the success of PRIMAS in Denmark. Regarding primary, middle and lower secondary school, the national team worked closely with the government's advisors to ensure the impact of PRIMAS in science and mathematics teaching and in teacher training. The national team conducted school-based professional development within schools in Denmark. Together, these initiatives ensured PRIMAS was successful at all school levels in Denmark.

- In Germany, the collaboration with the local school authority was crucial for PRIMAS success. The authority participated in a first event to promote PRIMAS PD, and went on to take part in several NCP meetings and further personal meetings. Further, the school authority sent out the call for PD to all the schools. As a consequence, 20 multipliers were educated for large-scale dissemination of the IBL idea. The training of the multipliers lasted over three years with a total of 10 full-day seminars. Within this time, every multiplier changed their role from a normal teacher to a teacher educator and evolved into an expert in IBL education. In the end, the multipliers worked in regional teams of two with professional development groups. As described in Part III, PRIMAS Teacher PD in Germany was also supported by the national authorities willingness to provide funds so that teachers could participate as part of their normal work load. Over two years, each multiplier team educated in 6-8 afternoons over 20 teachers. The success of the training was evident in the final professional development day of all teachers and multipliers at the University of Education in Freiburg. Teachers reported enthusiastically about their new access to school education with IBL.
- In Hungary, accreditation from the Ministry of Education was of great importance to have the chance of success. Therefore, the national team worked intensively with the Office of Education (and the NCP) in order to embed the PRIMAS PD modules in a 36-hour long, accredited, state-approved programme. Once this was achieved, courses were offered by the University of Szeged, attracting teachers' interest and leading to the success of PRIMAS in the country. The PD courses were held by the university staff and by 20 multipliers who worked in small groups in six different towns around the country. Now our PRIMAS-funded CPD courses serve as an exemplary programme, since researchers and in-service teacher multipliers worked together, providing a sound balance and amalgamation of theory and practice.
- In order for the PRIMAS PD to be successful in Malta, the Maltese PRIMAS team worked in close collaboration with the Directorate for Quality and Standards in Education and the administration of the schools participating in the project. The Directorate not only gave the necessary permissions, but also provided important support. Five schools were invited to participate in PRIMAS. When the head of a school agreed to participate, PRIMAS University team members met the teachers working in that school and invited them to participate in the project. As far as possible, the PRIMAS team wanted to have teachers who willingly participated in these PD courses. By arrangement with the Directorate for Education, teachers who agreed to participate were given a reduced teaching load for the two scholastic years of the duration of the project. The school administration also made arrangements to ensure that the participating teachers had a common time during the week when they all did not have classes in order to enable them to meet. Meetings with multipliers occurred in the school,

during school hours. This arrangement greatly facilitated the organisation and the success of the PD course.

- In Norway, the national team identified that the district education authority, in consultation with school heads, were the gatekeepers for professional development initiatives. Hence, the team worked intensely with the district education authority, who in turn called for meetings of school heads interested in working with PRIMAS. Subsequently, official contracts were established between the schools, the education authority and the teacher education team. Each school/head then sent between one to three teachers to participate in our PRIMAS courses. Those teachers became our multipliers who in turn worked with colleagues in their own and in neighbouring schools. As in other countries, synergies between other professional development initiatives and PRIMAS were seen as vital for schools to manage the amount of activities and the success of PRIMAS.
- In Romania, the national team worked on two levels: an accredited course (of 2 semesters) included in the list of training courses offered by the Babeş-Bolyai University at Cluj and several small, local professional communities involved in informal trainings without accreditation (such as the SimpleX Association, Hungarian Teachers Association of Romania). Both types of activities will be available for teachers even after project PRIMAS lifetime. Some of the multipliers built their own courses and linked them to existing teacher training centres. On both levels, the PRIMAS PD team focused on supporting teachers by developing IBL materials that are strongly fitted to the needs of teachers and are well embedded into the national curriculum both on lower and upper secondary level.
- In Slovakia, 114 teachers of mathematics and sciences from all school levels participated in eight PRIMAS continuing professional developments (CPDs). They worked regularly with their lectors (PRIMAS multipliers) from October 2012 until July 2013. Course venues were lecture rooms and laboratories at the Faculty of Natural Sciences, Constantine the Philosopher University in Nitra. Three CPD introductory meetings were organised at two external places, High Tatras and Mojmirovce. Multipliers and/or teachers presented eight completed courses in plenary sessions at the Slovakian final PRIMAS event held in Nitra on 2 July 2013. Teachers were offered PRIMAS IBL-pedagogies materials and other materials which support their teaching at schools. All PRIMAS CPDs were accredited by the Ministry of Education. Teachers were awarded diplomas by PRIMAS and with a university certificate during the PRIMAS event on 2 July 2013 (the certificate is crucial for as evidence of the professional development).
- In Spain, the national team identified that the official net of professional development centres (depending on the Regional Ministry of Education) offered the organisational structure to provide PRIMAS courses to teachers and that this relationship could be strengthened if teachers' professional associations were involved. Therefore, the national team worked intensively with the Regional Ministry of Education (included within the NCP), with directors and science advisors of these centres, and with key actors within the Andalucian Society of Mathematics Teachers. This collaboration resulted in the identification of key teachers that acted as multipliers in an extensive offer of courses all over the region, which ensured the success of PRIMAS. More than 300 teachers have learnt and used IBL with the help of PRIMAS.
- In Switzerland (Geneva) in 2011, an important change in the lower secondary school curriculum and textbooks occurred, which implied a compulsory professional development for teachers. The PRIMAS team was

in charge of this professional development course concerning more than 350 mathematics teachers in lower secondary schools. These teachers are often also science teachers, so the proposed professional development course was not only about IBL in mathematics, but also in science. Other optional professional development courses were organised for primary and upper secondary teachers, but these did not involve as many participants. The PRIMAS PD courses had the additional benefit of enhancing ties between the University of Geneva, the Geneva professional development network and teachers' organisations. A new collaboration with teachers' organisations started that focuses on the evaluation of IBL activities.

- In the Netherlands, the national team contacted regional centres that support connections between secondary schools and science faculties at universities. These recently established centres had already started to set up professional development courses for science and mathematics teachers. This appeared to be a useful situation to spread the PRIMAS modules. Furthermore, the Dutch team succeeded in having a few topics of the PRIMAS modules being integrated in curricula for initial education of teachers at universities and at teacher colleges through the mathematics teacher education network ELWIER and the science teacher education network ECENT. In the Netherlands, a total of 215 teachers and 20 multipliers participated in the PRIMAS PD.
- In the UK, due to the political climate in which structures for supporting professional development are being decentralised, we sought partners and additional funders to set up alternative models for PD. We devised three clear models that provided sustained and successful PD, with very different levels of external support. They were underpinned by the PD materials developed for the project: (1) The Lesson Study model was supported by the Bowland Charitable Trust and project IMPULS at Gakugei University, Tokyo. This model allowed us to develop in-depth IBL training in 9 schools, with 27 teachers over one year. The model involves collaborative planning and analysis of lessons designed to foster IBL pedagogies. It is very labour intensive, but teachers found it the most powerful way of exploring IBL pedagogies. (2) The Linked training event model was supported by the University of Cambridge NRICH project. This involved three, linked, full-day meetings spread over a year with a group of 100 teachers from about 60 schools. This model was less in-depth than the Lesson Study model, but it enabled us to reach more teachers. It proved popular because teachers recognised that it brought together two PD providers with strong track records, and built on previous successful initiatives. It was both sustained and effective. (3) The Self-sustaining model was designed to enable schools to work with our PD materials, with no other external support. This model has the potential to be used widely, however its success depends entirely on the vision, willingness and enthusiasm of the teachers. We tried this model in four schools, supported by a university researcher.

As a result of all this successful work, in PRIMAS around 3130 teachers across Europe have had the opportunity to learn about and experiment with IBL in their classes.

Another important result of WP 4 was the publication of a 'Guide for PD providers'. Written in a practically applicable way, but strongly rooted on research about teachers' professional development, this guide supported the implementation of PRIMAS in each country. But beyond PRIMAS, and in

combination with WP 3 modules for professional development, it is an important contribution for other professional development providers that would like to organise and implement professional development actions in the future. Therefore, the guide is a contribution of PRIMAS to the dissemination of IBL methodologies within the PRIMAS project and beyond.

WORK PACKAGE 5: Supporting actions

WP5 developed – in consultation with the project Consortium and according to the needs for materials in different settings – a broad range of templates and dissemination materials. These include: logos, flyers and posters for different target groups; brochures; small, attention-raising items like name-tags, pens or a bookmark; and presentation slides, etc. In this manner, all PRIMAS dissemination activities (in and outside WP5) were effectively supported by a consistent and recognisable PRIMAS identity, professional appearance and materials designed for different contexts and target groups.
While certain supporting actions were directly addressed to teachers (e.g. reaching out to a wider audience of teachers outside the PRIMAS professional development courses, for example by large-scale dissemination of materials), others were addressed to other key groups in the educational system that can support the work of teachers and the more widespread use of IBL. Such groups range from parents or students (see WP6 that targets these groups in particular) to teacher training providers, educational authorities and policy (see WP7 targeting the latter in particular), curriculum designers, textbook publishers, etc.
From a more technical perspective, supporting actions for teachers as they were carried out in WP5 can be split into two areas:

1. They can be directed to teachers and can either be designed to:
    a. help motivate teachers to participate directly in the project activities (e.g. informing and convincing teachers to become multipliers in the project or attend the IBL PD courses);
    b. reach a wider audience of teachers to benefit from the project results and to use IBL materials and teaching strategies (e.g. by publishing information about the PRIMAS IBL classroom resources available to anyone for free in a teacher´s journal).
2. They can be directed towards 'supportive groups' for teachers in their uptake of IBL teaching strategies – these are groups closely connected to the school system that have a significant role in supporting teachers use of IBL. Included here are head teachers, teachers' networks and associations, school authorities, curriculum & assessment developers, and teacher trainers.

Over the course of the project, the focus on dissemination activities that were directly supportive of the teacher training (category 1a) gradually shifted towards dissemination activities and supporting actions that had the potential to further link, strengthen and extend existing knowledge, networks and initiatives relating to IBL (that have been formed in- and outside PRIMAS) in order to create long-lasting effects and sustainability.
During PRIMAS lifetime, the project diary reports the fact that no month passed in which no project activities were carried out. If the duration of the activities as reported under WP5 is considered, these were dominantly of a one day nature. This feature is reasonable for the WP5 activities, which mainly aimed at piloting and advertising actions for teachers. Reported target groups were mainly teachers, but also teacher educators, students, students, PhD. students, school authorities and also policy makers. The activities realised cover short

professional development days (not long-term, continuous PD as provided by WP 4) for teachers and students, evening meetings, summer schools for (school) students, competitions based on PRIMAS materials such as Mathematical B-day 2011, 2012 and 2013, workshops for teachers, workshops for academic staff, colloquiums for university students, presentations and talks for teachers' networks and meetings with prospective teachers. Several one day and also long term fairs were reported, too. It is noteworthy that there were several bilateral visits on various dissemination activities between partners (cf. WP5 dissemination activities reported on ECAS.

Thanks to the internationally recognised professional work of the PRIMAS project partners, PRIMAS and IBL pedagogies were promoted at more than 30 conferences, congresses, symposiums and other national and international activities.

Venues for the reported events were not only universities, schools and conference facilities, but also public places, such as museums, national science centres (Space Centre Leicestershire, STEM Centre in York, NEMO in Amsterdam) and also shopping malls. The project partners from Nottingham were also invited to give their presentation at a meeting of the Joint Mathematical Council, held at the Royal Society in London. A public lecture was presented by Malcolm Swan in Hong-Kong for more than 150 listeners.

In order to reach even more target groups, PRIMAS also used existing media channels and publications (cf. list of scientific publications in ECAS and list of non-scientific publications in the annex of this report).

Numerous other large and small scale actions were used to help PRIMAS reach its target audiences. In Germany, regular meetings with the public organisation PAD (*Pädagogischer Austauschdienst*) took place. In Switzerland, the partners reported giving newspaper interviews with the potential of reaching more than 200 000 readers. Two massive public events took place in Spain: The Science Fair in Jerez, with more than 7000 visitors and The Science Week organised by the primary school CEIP Atalaya in Atarfe (Granada). More than 600 students were involved in a science fair-like event. Students learned about science and mathematics through experiments. Even pre-school children were involved. The annual Ecent conference in The Netherlands was an event where the PRIMAS homepage, the PD resources and illustrative examples of teaching activities were presented to visitors of the PRIMAS stand. The aim of the presentation was creating awareness among teachers for IBL and showing powerful PD materials and issues for teachers (e.g. the need for well-prepared lesson plans). The other public annual event was University open door day in Slovakia. During the day several PRIMAS materials and ideas were presented to potential future teachers of mathematics and sciences.

In order to advertise PRIMAS and promote beneficial, mutual exchange, the PRIMAS partners were also in intensive contact with other EU projects, for example 7FP Fibonacci, Comenius DynaMAT and Comenius Math2Earth. This close link to other FP7 projects was also institutionalised within the ProCoNet education (Project coordinators network – founded by the coordinator of PRIMAS, Prof. Dr. Katja Maaß and Peter Gray from S-Team). In 2013, PRIMAS also actively participated in meetings of two other new and related projects – mascil and SAILS.

International conferences focused on problems in mathematics and science education were also important venues for PRIMAS. At such events, PRIMAS gave project presentations, displayed posters, and could include related scientific articles appeared in publications of proceedings. For example the CERME8 took place in Turkey in February 2013 with an active PRIMAS presentation and was present at the high ranking ISSEP conference in Oldenburg, Germany.

An interesting, related development reported by project partners in Switzerland, Spain and Slovakia is the use of specially-created software as a means of promoting IBL-oriented pedagogies and teaching and learning with IBL methods.
Project PRIMAS and its activities inspired several partners to create new activities on the national level. For instance, new national projects, such as FYR in Norway were inspired by PRIMAS ideas and activities. Also close bilateral cooperation among partners is documented, mainly between Hungary and Romania (CPD lecturing); Germany and Switzerland (lecture and newspaper interview), Slovakia and The Netherlands (Mathematical team contest B-day).
Many European countries not directly involved in the project were visited by PRIMAS partners. These included Poland, France, Italy, Bulgaria, Iceland, Turkey, Czech Republic, Belgium, Ireland, Scotland and Greece. The aim of visits was the dissemination of PRIMAS achievements, ideas of IBL and sharing supporting actions for teachers' experiences. Furthermore, PRIMAS was promoted on other continents: For example in the context of the ISDDE Conference in Boston, USA, the ICMI 2012 in Seoul, South Korea, the PME 2012 in Taipei, Taiwan and at a conference in Lima, Peru.
Based on the dissemination activities and experiences made with such, a guide of supporting actions for teachers in promoting IBL was created as a supplement to the provision of training and classroom materials – which are key to fostering the implementation of IBL. This guide introduces key issues in implementing supporting actions and presents concrete examples of actions that were carried out within the PRIMAS project – in order to create further interest, and open up and develop spaces that support IBL uptake.
A further success factor of WP5 was also the close collaboration with other work packages, most notably those that also involve specific dissemination to particular target groups, such as WP6 and WP7. There was also very close collaboration with WP1. Exemplifications of these links were the international Brussels events that PRIMAS carried out at the end of June 2011 and at the end of November 2013.
In general, it can be said that a major accomplishment of WP5 work was that through the help of the large amount of activities carried out by the Consortium, PRIMAS is now at local and international levels well known in relevant circles that can support teachers´ uptake of IBL (See also WP1 report). This means that the groundwork for successful spreading of the idea and concepts of IBL has been accomplished.

WORK PACKAGE 6: Dissemination

As the website was an essential tool for disseminating information about the project, it aimed to bring inquiry-based learning closer to all different target groups (e.g. parents, teachers, students). In a first step, the first (and fully functional) version of the homepage was set up within the first months of the project. Subsequently, and in cooperation with WP3, the website was extended to contain the PRIMAS material collection, and to allow direct online access to a rich selection of IBL PD and learning material. During the following months, and until the end of the project, the number of high quality teacher PD modules, the number of IBL classrooms material, and other related information for all involved key-players (teachers, students, parents, researchers) was constantly increased, and became available in all partner languages. Further, in the following months, national websites were also established so as to better serve the specific needs in various countries with regard to PD courses and other dissemination actions. To facilitate the development of national websites, the WP6 leading team provided a fully interactive template for running the national websites, which was modifiable and adoptable.

In a second step in close collaboration with WP1 and WP5, an international collection of dissemination actions to out-of-school target groups and students was set up. The work towards covering this task was organised in the following steps: (a) WP6 in collaboration with WP1 and WP5 prepared and distributed a template for reporting on successful case studies and future ideas for promoting IBL in out-of-school target groups, (b) Each partner provided two case studies, (c) The WP leader team collected and analysed the provided case studies and organised them into sub-categories based on the group that was targeted, (d) The collection of dissemination actions was refined and served as the second part of the Dissemination Guide (see below), and (e) Collection of dissemination actions was extended and after the first reporting period, new actions were included in the revised version of the International Guide.

Furthermore, during project meetings, partners discussed possible publication actions related to out-of-school target groups and prepared an extensive list of possible actions and guidelines on how to work towards these actions. These included researcher nights, open school lessons, workshops for parents, talks to parents' associations or to the general public, round tables, publications (possible journals, conferences, plenary talks), information in regional or national media, and information to parents through teachers (with specifically developed materials). Project outcomes proved PRIMAS to be very successful towards meeting the objectives of Task 2 (Setting up an international collection of dissemination actions to out-of-school target groups and students). Numerous events were organised in all partner countries, targeting a large audience of out-of-school target groups. As mentioned previously, a special issue of *ZDM: International Reviews in Mathematics Education*, a prestigious research journal, consisted of research papers presenting findings from various aspects of the PRIMAS project, was published.

An international guide for all levels of the pyramid model was designed that included clear guidelines about how to carry out dissemination actions to out-of-school target groups. The Guide consisted of two parts, namely a framework that served as the basis for the collection of the successful case studies and a number of case studies, as well. The framework put an emphasis on parental involvement and education, since parents were identified as the most important key factor (among out-of-school target groups) in facilitating the use of IBL. During the second reporting period the optimisation of the Guide was carried out, and resulted in a new revised and improved version. The new guide was much more focused on targeting the out-of-school target groups, with more concrete guidelines for teachers on how to run successful activities and events with parents and community members, and with more refined and analytically presented examples of successful case studies. Further reflections and suggestions provided by partners and the ICP and IEP boards resulted in the final version of the Guide, which was then distributed to all partners for translations and local adaptations.

During PRIMAS lifetime, a very large number of dissemination actions that support teachers in taking up inquiry-based teaching were carried out in all partner countries, and on an international level. These actions include, among others, scientific days, open school lessons, workshops for parents, talks to parents associations or to public, publications, information in regional or national media and information on the international and national websites (cf. WP5). According to the project requirements, at least two dissemination actions were to be carried out in every country in years 3 and 4. Dissemination actions started much earlier in all countries, and the final number of dissemination events and actions in all countries was much higher that the requirements.

As in WP 4, it was considered important to continue with actions to support teachers. Therefore, the leading team, in coordination with all partners explored various venues in order to ensure the sustainability of the inquiry-based approach beyond the end of project lifetime, including possible continuations of supporting actions. Based on the rich experiences gained during project lifetime, and in collaboration with other research initiatives, policy makers, and National Consultancy Panels, partners in each country reflected on and established clear guidelines on how to further promote PRIMAS objectives and materials, beyond the end of the project.

WORK PACKAGE 7: Policy

The work of WP7 in terms of its analysis of policy with regards to mathematics and science education, and resulting outcomes in terms of student outcomes and teacher professional development, was useful in informing partners and policy makers, particularly through their NCPs of national and international policy agendas. This resulted in project actions towards policy having less of a project-based focus (that was necessary in order to set up and secure the implementation of the project) and more of a strategically oriented agenda to create a wider and long-term impact. This assisted in ensuring that issues in relation to policy were raised across the partnership and allowed the dissemination of policy approaches that are favourable towards meeting policy objectives in the later phases of the project.
Major findings were reported in detail in deliverable D7.1 (Briefing report at international level synthesising information across nations in relation to policy). These were disseminated widely. Ongoing monitoring of policy at national and EU levels throughout the project informed the final deliverables: D 7.2: Briefing report at international level to inform policy makers and D 7.3: Final report on the international political situation in relation to the implementation of inquiry-based learning in science and mathematics, about project activities and possible impacts.
In consortium nations, there have been policy developments that have had both positive and negative impact on IBL in mathematics and science. This has resulted, at both European and national levels, in many activities and projects that support IBL - but their impact may have been dissipated because of a lack of overall strategic vision in overall policy direction. The underpinning analysis led to the following recommendations in key areas:

- *Assessment: (a)* current formulations of assessment result in a focus on knowledge recall and standard applications of rules and procedures. Such assessment is leading to a narrow curriculum experience for learners as teachers attempt to ensure that students obtain high marks, *(b) a*ttempting to make short term gains in the rankings provided by studies (such as PISA) should be questioned and a more long term strategic response that develops IBL practices considered, (c) focussing on performance in international studies can lead to a narrowing of the curriculum in ways that can make it less appealing to those other than the highest achievers. It should be remembered that achievement in assessment is only one outcome of learning and that student dispositions towards mathematics and science are also important and can be influenced positively by IBL approaches.

- *Curriculum specification and implementation:* The next iteration of curriculum design at a national level should: (*a)* be informed by the learner experiences and teaching approaches that are desired, *(b)* indicate

clearly expectations in terms of learner experiences that might optimise learners' dispositions as well as outcomes in terms of attainment, *(c)* consider the practicalities of implementation through professional development and other support, *(d)* indicate expectations in relation to learner experiences and teaching approaches to producers of text books and other resources. Policies that can stimulate curriculum innovation at a national level should be considered. A further issue is how to support schools operating within local contexts and structures when they wish to bring about curriculum innovation and change.

- *Professional practice:* Within the national context, thought should be given to how good practice in IBL pedagogies can be supported, for example, through inspection systems, and disseminated more widely. This needs planning and strategic support.

- *Professional development:* Strategic support of teachers' professional development appears rare. This is an essential aspect of bringing about curriculum change and needs to be considered urgently in relation to aims, objectives and priorities in developing mathematics and science education.

WORK PACKAGE 8: Internal evaluation

From the results of the internal, respectively formative evaluation, it can be deduced that PRIMAS made a number of essential contributions to a widespread implementation of IBL in schools. At the same time, the case study research showed that systemic factors, biographical-background and deeply-rooted beliefs and behavioural patterns can impede a broad unfolding of innovative pedagogies like IBL in mathematics and science teaching.

The results of the formative evaluation were built around the experiences and engagement of 24 maths and science teachers involved in PRIMAS PD initiatives. In addition, they include all dissemination activities as reported in our project diary. In the following, we present all results in the form of an overview. The results inform future projects and are valuable in achieving the most successful and wide-spread IBL implementation possible in maths and science classes.

Looking at supporting factors for teachers' successful engagement in PRIMAS activities, it becomes visible that their willingness to be engaged and to accept IBL as a means to improve their teaching and the learning of their students is of high importance. Teachers were aware, and this awareness improved throughout the PD course, that adopting an IBL perspective is demanding and requires much more preparation time and resources, and less 'teacher authoritarianism' during the lessons. Not everything was easy to be implemented, but the fact that students' results were rewarding was a strong motive for them to keep working on better IBL approaches and pedagogies during and after PRIMAS PD.

Furthermore, the design of the PRIMAS PD emerged as the second factor that seemed to have a positive impact on teachers' progress. Particularly the possibilities to exchange with other teachers and try out IBL tasks in the PD modules encouraged teachers to reflect about their practices – and do so away from their usual, hectic routines at school. Putting themselves in the student position also helped the teachers to appreciate the difficulties that students may experience when assessing each other. Further, peer-support within school supplemented the PRIMAS PD in some countries and emerged to be very supportive for a widespread implementation of IBL. Last but not least, the case study research also provided strong indications about the importance of other key placers, namely: competent and committed multipliers; dedicated school directors; and concerned and interested parents. These key players can provide

crucial support to teachers who are exploring the implementation of IBL in their classes. Moreover, these groups also influence teachers' and the uptake of IBL.
Within the case study research, teachers and the multipliers also reported a number of impediments to implementing IBL in day-to-day classroom practices. These include time; available materials; the required curricula/syllabus; and teacher pre- and in-service training on IBL. Such feedback from teachers and multipliers was not unexpected. For example, teachers do have limited time for working through the required curricula – and this time is often not sufficient for them to adopt extracurricular activities, such as the PRIMAS IBL approaches and activities. Therefore, many teachers struggle when it comes to implementing IBL on a regular basis. Another factor here is that, according to teachers, IBL-based lesson planning requires much more time and effort than more traditional approaches. This is an additional burden on teachers. The case study research also provided strong indications that helping teachers – and students – accustom themselves to these new and somehow different roles and become acquainted with the essential skills for IBL based approaches and activities may take a long time. This is particularly true because IBL is a new approach for most teachers.
However, these challenges can be overcome, if: a significant number of teachers act with the same passion (as the teachers accompanied within the case study research are doing) and systemic and structural challenges (like teacher professional development systems or curricular integration of innovative pedagogies) are addressed by policy-making bodies. Here, thinking of professional development as being long-term and the willingness to commit resources to teacher PD are key areas that will need to be addressed in policies. This is necessary to reach the overall – and successfully reached – aim: more students in Europe benefitting from the learning outcomes of well-delivered IBL lessons. That this is realisable could be proven by means of the evaluation of the PRIMAS approach. Finally, dissemination activities for out-of-school-target groups may support the widespread implementation and promotion of IBL. Altogether, the evaluation showed that our high quality PD prompted teachers to implement IBL despite the often difficult framework conditions

WORK PACKAGE 9: External evaluation

Similar to WP8, the results of the external, respectively summative evaluation, can be used to deduce that PRIMAS made a number of essential contributions to a widespread implementation of IBL in schools.
Both the baseline study and the pre-post study provided valuable insight into the variety of IBL-approaches in mathematics and science teaching in the different countries of the consortium (cf. IBL Implementation survey report, D9.3; available on the PRIMAS website). The studies demonstrated the potentials and the challenges of implementing IBL on a large scale across Europe. Furthermore, the impact of the professional development courses being offered for teachers within the project PRIMAS was evaluated. The model for professional development based on phases of analysis, implementation and reflection used as a basis for the professional development courses proved to be successful. PRIMAS met the challenge of effecting a degree of change in teaching practice with respect to IBL implementation.
The analysis of the data collected in both surveys showed that all over Europe, there are teachers who have had at least initial experience with IBL and who are keen to learn more about it. There is a strong belief that IBL has the potential to overcome learning problems and to motivate students. The high potential and high expectations among the teachers across Europe provide an excellent base for the implementation of a more student-centred pedagogy as intended by PRIMAS. However, with respect to the present status of practising IBL, the work

of WP9 made the differing IBL approaches between the countries and the subjects visible. The orientation towards IBL is significantly country dependent, whereas the implementation of IBL into daily teaching practice depends significantly on the subject. Science teachers report using more IBL than mathematics teachers do. Interestingly, there is a strong interaction with the country. In some countries, mathematics teaching seems to be more static, more defined und more sequential, thus allowing little room for IBL.
Teachers address many problems that hinder a broad uptake of IBL. A three-factor structure for the items which refer to problems when implementing IBL was evident. The difficulties that teachers report on can be subsumed in the following factors: systemic restrictions, classroom management and resource restrictions. These three factors were also found in the open question about difficulties that hinder the implementation of IBL. There are big differences within the countries taking part in the PRIMAS project in respect to judging the relevance of systemic and resource restrictions. Therefore, a successful implementation of IBL across Europe has to identify and address the very different issues found in the various member nations – and this was a key part of the PRIMAS approach.
A multi-faceted perspective of an inquiry-based teaching and learning culture was developed in cooperation with the Consortium members (see also WP1 and WP3 reports). This approach represented the broad theoretical foundation for developing the questionnaires. Besides the process of inquiry, there was also focus on having a meaningful context and on students being activated. We were able to show that this definition is sustainable. Based on the first order factors describing teaching practice focusing on IBL we specified a second-order factor model to calculate the so-called IBL-index. This second-order factor model was empirically affirmed. It enabled us to calculate an IBL-index. Through this index we were able to report the status of IBL and also changes in its implementation.
The analysis of the student data showed clearly that there is a need for projects like PRIMAS. Students, especially girls, show a low interest in the school subjects of chemistry, mathematics and physics. We were able to show that frequency of IBL is significantly correlated with the interest of the students. A logical conclusion is that the implementation of IBL will have a positive effect on the interest of the students in the medium term.
One aim of WP9 was to evaluate the country-wide/European-wide implementation of inquiry-based learning (as intended by our project). A pre-post survey was conducted to attain that goal. Our analysis of pre-post data showed that teaching practices changed significantly. After the professional development courses, the IBL-index indicating the frequency of IBL in classroom practice increased significantly. Further, positive student developments could be proven. Therefore, we were able to prove that our efforts not only reached the teachers, their students were also aware of these changes. We characterise this as a great success.

Part IV: THE POTENTIAL IMPACT AND THE MAIN DISSEMINATION ACTIVITIES AND EXPLOITATION OF RESULTS

PRIMAS aimed to effect change across Europe in the teaching and learning of mathematics and science at school by supporting teachers to develop IBL pedagogies so that in turn, students could gain first-hand experience of scientific inquiry. Our objective was that a greater number of students would have a more positive disposition towards the further study of these subjects and the desire to be employed in related fields. Based on our multi-level dissemination plan that

was addressed to teachers and important stakeholders, over the projects lifetime a maximum impact was achieved! Considering the main strands of PRIMAS, in the following – both on a cross-national basis as well as on a national basis – potential impacts, main dissemination activities and the exploitation of the results are described.

Provision of high quality support for, and training of, teachers and multipliers

The training of a large set of PRIMAS multipliers in each partner country with specialised knowledge and skills in the PD of teachers and IBL can be considered as an important contribution to the future. With the support of PRIMAS PD modules and other existing resources, multipliers can continue the dissemination of IBL methodologies beyond PRIMAS, thus contributing to an improvement in the teaching of science and mathematics across Europe.
Moreover, the big scale dissemination of PD courses carried out within PRIMAS has enriched teachers' teaching repertoire and beliefs. As a consequence, they are now better prepared to engage their students in the IBL process that will lead to a more meaningful learning, increased motivation and a more positive attitude towards scientific careers in the future. Besides these factors, many of these teachers will promote changes towards IBL within their schools and other colleagues they collaborate with.
Furthermore, the creation of national infrastructures for the dissemination of PRIMAS courses has led to the reinforcement of existing networks and/or the creation of new ones. These networks will ensure the dissemination of IBL pedagogies beyond the lifetime of PRIMAS, and can also promote new actions in relation to IBL. Specifically, the fact that in many countries we have worked closely with school authorities and Ministries of Education has a potential impact on their future policies, orienting them towards IBL (cf. chapter below on informing a wide range of policy makers about how they can support the required changes).

Selection of high quality materials and methods

The PRIMAS resources – like PD materials, classroom materials, guides for PD providers and supporting actions for teachers in promoting IBL, as well as the PRIMAS final publication – were (respectively are) being adapted and used by all partner countries in teacher education and national PD projects. The sustainability of this use is established through national networks, accredited courses for teachers, the trained multipliers (see above) and networks between teacher training colleges (see WP4 and WP5 reports).
Internationally, the use of the resources is sustained by new projects on IBL. For instance, the PRIMAS units for PD are being adapted and used in the USA to support the development of formative assessment lessons (http://map.mathshell.org.uk/materials/lessons.php). Furthermore, part of the PRIMAS classroom materials are also being used as an input of high quality IBL materials to be further adapted to other needs in the recently started EU-project mascil (http://www.mascil-project.eu).

Disseminating the PRIMAS ideas: addressed to teachers and out-of-school parties

During PRIMAS lifetime, a significant number of dissemination events took place in all partner countries. During these events, a large number of parents, students, policy-makers, community members, media representatives and researchers were informed about IBL and PRIMAS - and encouraged to get involved in the project. Until the end of PRIMAS, more than 360 dissemination

activities with more than 26 000 face-to-face contacts were conducted (cf. list of dissemination activities in ECAS).
PRIMAS adopted a multilevel approach and provided all partners with various tools and strategies (as they appeared in the International Guides about supporting actions in the form of framework for actions and cases studies; cf. WP 5 and WP6). Thus, PRIMAS succeeded in involving and informing not only teachers, but also engaged out-of-school target groups in the teaching and learning of school mathematics and science and gained acknowledgment for the significance of IBL in contemporary teaching and learning.
A significant number of the participating teachers of the dissemination activities continue to work with PRIMAS materials. Furthermore, WP5 and WP6 related actions have acted as the seeds for forthcoming initiatives and following projects that engage teachers, parents, and other out-of-school target groups in the teaching and learning of mathematics and science. Also by means of the project work, high-level policy makers, some very influential teacher and parent organisations and associations, and media representatives have been approached and informed about PRIMAS and IBL. Again, many of these groups and individuals will continue disseminating the benefits of IBL and will further disseminate PRIMAS materials and ideas. It is expected that the concrete outcomes of the PRIMAS dissemination activities and successful stories will facilitate wider benefits. These include improvements in teacher's inquiry-based teaching strategies, students having more positive attitudes towards maths and sciences – and attaining deeper, practice-oriented knowledge in these subjects, parents better understanding the role of maths and sciences in their children's daily and future lives, - and how IBL can support this and improved relationships between parents, teachers and schools.
On an international level, there were two main, joint endeavours of the PRIMAS Consortium: First, the PRIMAS Brussels Event 'Towards Europe *2020* – Inquiring minds – innovative pedagogies in mathematics and science education' on how to sustain innovative pedagogies and, second, the PRIMAS final conference on the changing requirements of teaching and learning in schools in our dynamic, knowledge-based society. The *PRIMAS Brussels Event* was held in June 2011 and marked a highlight in the international-level networking and impact of PRIMAS. The event not only attracted a broad range of visitors from across the EU – thus making it possible to inform and discuss with these groups – it also fostered our relationships and impact at the international level, most notably with policy makers. Last, but certainly not least: it created several new contacts and partnerships. The *PRIMAS Final Conference* was held in November 2013 and crowned the international-level networking and impact of PRIMAS. The achieved aim of this event was to outline a vision of our young people's educational needs in order to better prepare them for life beyond our classrooms. The conference also showed what PRIMAS has achieved towards this end. The circle of participants embraced important educational levels of different areas. This diversity factor helps ensure that the PRIMAS work and vision will be sustained – not only in the minds of those who attended, but also through the information they share about the conference and its message with their colleagues and constituents. As a result, we are pleased to point out the overwhelmingly positive audience response to the PRIMAS Final Conference. Many participants praised the opportunities they had to experience inquiry-based learning on their own, and gain fruitful insights into the benefits IBL provides, especially in regards to tackling the challenges of the future. Perhaps most importantly, the final conference clarified the necessity of anchoring approaches like inquiry-based learning in educational systems (and in the end, the societal level). This, as conference participants agreed, is essential to counter the changing requirements

of the future in which young people need to be equipped with problem solving skills, and competences for self-directed learning and exploring new knowledge.
PRIMAS also received good media coverage (including TV, press, online media, etc.) and various publications appeared about the project. Most of the publications were initiated by local partners to inform select groups (through suitable journals, such as those for teachers, etc.) about the project and its offers. The range spans from special issues of regular publications to newsletter contributions. A list of selected publications is available in the Annex of this report. In the following, we report on some key communication strategies and dissemination activities:
PRIMAS began publishing its own *international newsletter* in 2011. (Previously, there were newsletters sent internally to the panels). Five editions were sent to more than 300 readers.
The PRIMAS *international website* (www.primas-project.eu) was maintained and regularly improved in close collaboration with Management. In the second half of 2011, the PRIMAS website underwent a major re-launch. One of the most important improvements was that it now caters more specifically to the needs of the various target groups (ranging, for example, from parents to teachers to policy makers) and was substantially enlarged in content and scope. New media have also been strengthened with a Prezi, a film (in English) on PRIMAS that was created for the final conference. Video versions of the film are also available in several languages. Furthermore, several PRIMAS partners are running a *national PRIMAS website*, which is also beneficial for the transnational dissemination of the project. The success of investing in an extensive communication strategy can also be seen in active contacts that diverse groups now seek with the project after having made acquaintance with it – and through the publicity the project has received in other countries (e.g. a publication in Sweden, teachers all over the world are using the PRIMAS YouTube-channel, request from the University of Cambridge and the ORBIT Project, Africa Adaptation). In addition, we set up a *website to inform about the final conference* of PRIMAS. Here, we provided general information about the PRIMAS project and the event, details about the speakers and programme, and online registration. The website remains available after the conference and will be extended with the conference proceedings. The website is available under: http://primas-conference.ph-freiburg.de/.
A variety of factors have contributed to the success of the PRIMAS dissemination activities. It is a combination of all of these factors that has made PRIMAS the success it is today. Among these factors are: (a) The professionalism, dedication, commitment, and strong collaboration between the WPs; (b) The involvement of all key stakeholders in all countries; (c) The flexibility of the International Guides to cater to the specific needs of the school, the parents and the students in partner countries, (d) The successful collaboration with other research initiatives, and; (e) The good publicity and outreach work. As PRIMAS goes into its new phase (after the formal end of the project), we aim to extend its reach to a larger number of schools, teachers, students and parents across the partner countries - and those beyond the PRIMAS consortium.

Informing a wide range of policy makers about how they can support the required changes

PRIMAS aimed to inform policy development in national and international settings in relation to the education of young people in mathematics and science in ways that support the implementation of IBL practices in compulsory schooling. Referring to this, the work of PRIMAS, or more precisely the work of WP2 and WP7, made a substantial impact in terms of directly informing policy makers both nationally and internationally. This aim was accomplished through the published deliverables (Analyses of national policies and education policy

contexts relevant to the dissemination of inquiry-based pedagogies and comparisons of national education contexts) and presentation of these analyses in a variety of forms. Importantly, this informed the ongoing project work and direction, especially that of the international consortium and at national levels, the respective NCPs. The latter, in all project nations, involved a range of policy makers, who in their different ways, became advocates and/or ambassadors for IBL in general, and for PRIMAS in particular.

It is challenging to quantify the impact that this has made to date. However, partners report that there is clear evidence in the consortium nations of policy development both prior to, and during PRIMAS that should support the introduction, and sustain the ongoing use, of inquiry-based pedagogies in mathematics and science. Because of the project's involvement with policy makers during its lifetime, it is likely that policy makers at national, regional and local levels are now better informed in many different ways about how policy might better support IBL

Beyond the lifetime of the project, it is even more challenging to predict potential impact, as we know from experience the gestation period of impact is considerably longer than the lifetime of a project such as PRIMAS. Findings in complex fields, such as policy, require time to seep into consciousness and become part of an accepted discourse. However, because of PRIMAS high quality contributions, we fully expect that over time, there will indeed be a legacy. Also PRIMAS work was carried out within a careful, theoretically informed and systematic framework, and this adds a valuable contribution to the field of mathematics and science education policy. In particular, it complements the published contextual and background information in the Eurydice reports on mathematics and science (EACEA/Eurydice 2011), and the Eurypedia website. Therefore, it is to be expected that over time, future iterations of policy will be more widely informed – and have positive impact at national – and European-wide levels.

Evaluating the project activities: making the effects of PRIMAS visible

PRIMAS work had substantial impact during project lifetime. Thus far, our evaluation of the effectiveness of our activities has shown that the four past years of efforts have helped make great inroads towards achieving the goal of implementing IBL in maths and science classes on a wide-spread basis in the European Community.

By means of our project-evaluation, we were able to show that teaching practices changed significantly across all European partner countries. The model for PD based on phases of analysis, implementation and reflection was proven to be successful. Besides, it could be detected that through the PRIMAS PD courses, mathematics and science education improved. Our analysis of the data of the pre-post survey showed that teaching practices changed significantly. After the PD courses, the IBL-index indicating the frequency of IBL in classroom practice increased significantly. Therefore, we were able to show that PRIMAS efforts reached both teachers and students, which demonstrates the high impact our courses had. It is reasonable and advisable to continue with the work of the projects on a national and an international level.

Likewise from the summative research, it can be deduced that PRIMAS made a number of essential contributions to a widespread implementation of IBL in schools. At the same time, the case study research showed that systemic factors, biographical-background and deeply-rooted believes and behavioural patterns can impede a broad unfolding of innovative pedagogies like IBL in mathematics and science teaching. Considering these factors is important for future projects and to achieving the most successful and wide-spread IBL implementation possible in maths and science classes.

Highlighting PRIMAS effects on a country-specific level

As we have shown, PRIMAS has made significant impact on the more wide-spread uptake of IBL across Europe. In the following, we present PRIMAS-related actual and potential effects, the main dissemination activities and the exploitation of results from the perspectives of the 12 PRIMAS partner countries.

Cyprus
The PRIMAS project sought to address underachievement and negative attitudes in mathematics and science, and students' unwillingness to pursue careers in these disciplines by changing the attitudes and practices of schools, parents and children, specifically through promoting an inquiry-based approach in the teaching and learning of mathematics and science. A large number of schools, teachers, students and parents have been involved in PRIMAS activities. In Cyprus, the project has reached more than 500 teachers and 2000 students (and their parents); these numbers are large in and of themselves - but become even more impressive when one considers the small size of Cyprus. More than 100 teachers and 1500 students participated in the PRIMAS PD courses and worked with the PRIMAS materials. The project was implemented and reached more than 80 schools spread all over Cyprus. After successfully implementing the PD courses and workshops at foundation stage in the 2nd year of project lifetime, the workshops were then rolled out to a larger number of schools and teachers. The impact of PRIMAS can be acknowledged at a number of levels. First, a significant number of high-level policy makers have been informed on PRIMAS objectives and the benefits of implementing IBL related activities in school mathematics and science. Further, through scientific publications a large number of researchers, policy makers and teachers were informed on PRIMAS actions in Cyprus. Second, at the teacher level, the majority of participating teachers reported positive change in their attitudes and strategies towards a more IBL-oriented teaching practice. Third, teachers and students also reported improvements – in some cases dramatic – in students' engagement and investigation skills in mathematics and science. Finally, a significant number of parents were informed on PRIMAS and IBL. PRIMAS activities served as a venue for better engaging parents in their children's learning in mathematics and science. It is expected that these concrete outcomes will facilitate wider benefits that include improvements in teachers' inquiry-based teaching strategies, students' attainment and consolidation of knowledge and more positive attitudes towards mathematics and science, parents' better mathematics and science understandings, and improved relationships between parents and teachers and schools.
Denmark
PRIMAS has had, and will continue to have, widespread success in Denmark. The impact of PRIMAS in the milieu surrounding upper secondary school education in mathematics and science has been achieved through close collaboration and synergies with other projects. The national PRIMAS team is cooperating with the national network of Danish Science Upper Secondary Schools (DASG) through which professional development courses in inquiry-based science teaching in subjects related to green technology have been promoted and offered. Regarding mathematics, the team is collaborating with a project funded under the EU social fund (STAR), through which professional development courses in inquiry-based mathematics teaching focused on problem oriented project work in mathematical modelling are promoted and offered. In both kinds of PD courses, the participating teachers functioned and will continue to function as multipliers, or ambassadors, for inquiry-based teaching in mathematics and science in upper secondary schools in Denmark. This is ensured on the one hand through publication of the teachers' report of their experimental teaching experiences developed in the course, which have been made public through a webpage; and on the other hand through the participating teachers cooperation with colleagues at their schools. The Danish upper secondary school system promotes such cooperation through the curriculum requirements of interdisciplinary teaching and group organised project work in mathematics and science. Regarding primary, middle and lower secondary school (grade K0-K9), and teacher training, the impact of PRIMAS has been achieved through the national team's close collaboration with the government's advisors for science and mathematics. The national team has conducted school-based professional development within schools in Denmark. Together, these initiatives have ensured the success of PRIMAS at primary, middle and lower secondary school in Denmark. The Danish team has published research results of PRIMAS in leading international journals, as well as in national journals for teachers. Through these, results from PRIMAS will be exploited in present and future projects in Denmark related to inquiry-based and innovative teaching.

Germany
In Germany, PRIMAS achieved a new attitude to the use of open tasks and IBL. It became apparent that a lot of teachers who worked with us either as multipliers or as classroom teachers, are more willing to use IBL and open tasks than before. Based on their work in PRIMAS, they have learnt how to deal with the classroom challenges related to the implementation of IBL in day-to-day teaching. We are especially pleased that many of these teachers wish to work with us in future, for example within the new mascil project. In Germany, IBL was promoted through many PD initiatives, talks at teacher conferences, through a national material database with tested tasks for school lessons, through publications in teacher journals and newspaper articles. Also IBL was promoted within pre-service education. By PRIMAS end, more than 600 students were reached by pre-service teacher training activities in Germany. The PRIMAS materials, such as reports/guides, PD materials and tasks will be used as references whenever there are questions about IBL and open tasks. Through a very good on-line placement of the German PRIMAS-website and wide publicity, many German teachers know this website and refer to it when preparing lessons with open tasks. Through diverse dissemination activities (like students' competition: 'How much maths can you find in cereals?') we could reach a lot of German students directly. They received the opportunity of gaining insight into the IBL tasks working with IBL in a student-centred way. The award ceremonies by the winner schools have illustrated how much students like this way of working and how much they learn by lessons with open tasks. Our conviction that our work is very important for the development of students' competences and interest in mathematics and science has been confirmed. Also, a successful evaluation of the PRIMAS PD courses contributed to the development of an international strategy of efficient PD courses for teachers. We aim to work further on the development of the efficient PD courses in the German context by using the achievements of the PRIMAS evaluation.
Hungary
At the end of PRIMAS, we are highly optimistic about the attainable and still sustainable outcomes the project induces. There are static and dynamic contributions that enrich the Hungarian educational system. Particularly our 36-hour long accredited PRIMAS PD programme received highly favourable responses from high-level stakeholders. There are currently 8000 accredited programmes in Hungary (many of them have never been launched or tried out).Our PRIMAS programme represents a balanced amalgamation of theory and practice, not only from its content, but also due to the multipliers' commitment and contribution. Consequently in the reaccreditation process of the numerous offerings, our PD programme serves as an exemplary one. The PD modules in Hungarian and the tasks developed by us and the PD course participants represent another value of the project. A third value is the special issue of the journal *Iskolakultúra* (published in December 2010) which contains articles that have already received many citations and are embedded in course descriptions and BA, MA and PhD theses. The dynamic components refer to the changing content of our pre-service and in-service courses. We, the university staff, could well realise that having been involved in active group work during the PRIMAS meetings we ourselves started to apply more active instructional methods, e.g. the World Café method we learnt during our project-meetings.
Malta
During the project, the collaboration achieved between the University team from the Department of Mathematics, Science and Technical Education and the multipliers was noteworthy. This was appreciated on both sides as was clear in our last meeting with multipliers held in December 2013. During the course of the project, two of our multipliers were promoted to Assistant Directors at the Department of Curriculum Management, within the Directorate for Quality and Standards in Education, Ministry for Education and Employment. At present, two key positions within the Ministry for Education are vacant; namely that of General Director for Quality and Standards in Education and that of Director for the Department of Curriculum Management. Notwithstanding this, it is likely that once these posts are filled, we will be in a position to discuss ways in which the Department of Mathematics, Science and Technical Education and the Directorate of Curriculum Management can work together to plan future PD courses for Mathematics and Science teachers which are long term and suitably evaluated. This would be a considerable achievement, since the PRIMAS PD was the first ever and, to date only professional development course for teachers in these subjects which was carried out over a long term. Our dissemination activities with teachers were also received favourably. In fact, as a result of our last meeting with multipliers in December 2013, the University PRIMAS team is planning to work with the multipliers towards organising a one-day event for teachers of Mathematics and Science to promote IBL. The date has not yet been set, but we have agreed it should be within the first four months of 2014.

We have had very good feedback about the PRIMAS materials from the multipliers and from the teachers in the project. In particular, the PD modules have been found to be very useful to engage teachers in trying to move beyond the transmission approach to teaching towards more student centred approaches. Another useful outcome is the production of local videos of lessons of Mathematics and Science. This is certainly another activity that we intend to encourage to go on beyond the project. The dissemination of materials through the national web-site was effective and the Department of Mathematics, Science and Technical Education is working towards relocating the materials we used to another web-site.

Netherlands

PRIMAS had impact in the Netherlands on various levels. First of all, we were able to implement some of the PD-resources in the initial science & mathematics teacher education to advocate the importance of inquiry-based teaching and to provide strategies for pre-service teachers. In addition, pre-service teachers own instructors know about the other topics addressed in our resources and are able to use - or be inspired - by them, during their own work with the pre-service teachers.

The PRIMAS PD-resources were also taken up by teacher trainers for in-service professional development courses. Especially at the regional science education support centres at universities (*Beta-steunpunten*), we managed to create awareness for our PD-resources. During – and after - PRIMAS, several of these institutions offered IBL courses for science and mathematics teachers in their region.

PRIMAS helped us to further strengthen school networks in the region of Utrecht, raising awareness for possibilities for professional development on inquiry-based learning. We even continue to work together with some schools on topics of PRIMAS resources that were not addressed during project lifetime.

PRIMAS also helped us to put IBL on the policy-agenda. The policy members in our national consultancy board and our presentations at national conferences raised awareness for IBL and showed implementation strategies for innovation. We are still visible for policy-people (like from *Platform Beta Techniek*), as they now regularly consult us in relation to inquiry-based innovations in science and mathematics education.

Finally, all PD-resources and many classroom materials are available in Dutch for teacher trainers and for teachers who look for innovative ideas and want to further develop their practices. Several well-known teacher-websites have linked to the PRIMAS resources.

Norway

The ideas, implications and the first results of PRIMAS have been disseminated at several national conferences and events for mathematics and science teachers and teacher educators in Norway. At the political level, the project is well known: nationally within the STEM and IBL community – see 'Building Bridges' event; and locally in the Trondheim region. The team there has developed a close relationship with the Trondheim *kommune* (community) school authorities. Through our network of teacher educators, teachers and schools, PRIMAS has been disseminated to other regions of Norway. A concrete example is that PRIMAS materials have been used to run teacher professional development courses in a community that neighbours Trondheim, viz. Melhus, and in Mo i Rana (where one of the multipliers worked).

Through our pre-service teacher training courses in both mathematics and science education, PRIMAS has been disseminated to the next generation of maths and science teachers who were educated in our University college, and these pre-service teachers have also used the PRIMAS ideas and materials in their teaching practice, making the impact of PRIMAS fairly large in our area.

Initial results from our case studies and interviews with our multipliers show that (1) The ideas of PRIMAS and the use of IBL have gained considerable impact in the participating schools; and (2) That IBL-oriented pedagogies have become, to a larger extent than before the project started, an integrated part of mathematics and science teaching in the region.

The mathematics and science educators working with PRIMAS have gained considerable experience and have become well-known for high-quality, research-based teacher education and development of IBL methods in the subject areas. This firmly establishes HiST as a major contributor to research and development in mathematics and science teacher education in Norway. Our work with PRIMAS has made HiST a visible and influential part of the national mathematics and science teacher professional development community, something which has made it a suitable partner for one of the main TPD projects in Norway, FYR (within the framework of the mascil project).

Romania

The impact of PRIMAS in Romania can be measured on several levels. PRIMAS succeeded in creating a local community, which is currently involved in using IBL methods, in thinking about

development of new materials and in transforming traditional contents into really student-centred IBL activities. The size of this community is quite hard to estimate, but as an indicator, we mention that the Facebook page with albums of the final conference had 9428 visitors in 4 days (with 178, 727 page views). PRIMAS results were also presented in several regional and national newspapers, and during radio and TV interviews. On the level of supporting teachers, PRIMAS had (and still has) a major impact due to the national collection of materials, the edited volumes (both in Romanian and Hungarian). During the lifetime of the project, a major focus was maintained on the quality of the teaching materials and PD courses and on the support provided to the teachers. This significantly increased PRIMAS impact as compared to other local, national or international projects. The outcomes, the PD modules, the national and international collection, the edited volumes are all incorporated in the content of a three-semester, accredited PD course that will run in the next four years. Moreover, some multipliers initiated their own IBL courses independently of the Babeş-Bolyai University, so the intellectual capital accumulated in PRIMAS will be used intensively in the next period in order to produce further changes. The dissemination on local level included a large number of face-to-face activities in schools, publications on national level and presentations on some conferences about teaching. The PRIMAS team also participated in the organisation of several regional competitions, where PRIMAS ideas were presented and IBL problems proposed. Student feedback was highly positive. We consider this an encouraging starting point in changing the style of these contests. As a final conclusion on behalf of the PRIMAS academic team and of the group of multipliers, the PRIMAS project was quite challenging in many aspects, but it was also highly stimulating and motivating. Many new ideas appeared and some of these will be implemented and developed in the near future. The positive feedback obtained from students participating in the activities, from their parents and from teachers involved in the CPD courses clearly shows that the PRIMAS project brought real changes in the lives of numerous people. This is an excellent start for a change on a wider level.

Slovakia

PRIMAS achieved great success in Slovakia. The main project activities were the PD courses and a mathematical contest called 'B-day'. 114 teachers attended the PRIMAS PDs in Slovakia. A major success was that not only courses for maths teachers were offered in Slovakia, but also ones for physics, chemistry and/or biology teachers - and one course with a multidisciplinary approach (ecology). Multipliers used the PRIMAS modules, translated them into the Slovak language and enriched the modules by subject-specific IBL tasks. All courses were accredited by the Ministry of Education of the Slovak Republic.

The mathematical contest called 'B-day' was launched in Slovakia in 2011 and repeated in 2012 and 2013. More than 130 students participated in the contest each year. The idea of the contest - solving open problems in teams of three or four - was new in Slovakia and very welcomed by students and their teachers. The B-day community consists of university teachers, researchers, PhD students, pre- and in-service teachers and students.

The translations of the PRIMAS modules and materials into the Slovak language enrich the current scientific literature for PhD students and researchers and also update IBL vocabulary in this scientific field.

During PRIMAS lifetime, project and IBL ideas were spread not only at the Constantine the Philosopher University in Nitra, but at all universities where study programmes for future teachers in mathematics and sciences are running in Slovakia. Also PRIMAS created significant impact in practicing teachers' education and influenced teachers at about 200 schools in Slovakia. At the end of the project, national radio and journals were reached. In future, further project-related articles and interviews will be published. Moreover, in future the national PRIMAS web-page will be an important communication channel which will be used for both teachers and out-of-school target-groups.

Spain

PRIMAS can be considered to be a very successful project in Spain. Numbers show that we reached more 270 teachers with our PD strategy. If we add those teachers that have the opportunity to gain some insight into IBL (for instance, teachers that attended some sessions in the training of multipliers phase, or teachers working as advisors within the teachers' centres), more than 350 teachers have benefitted from PRIMAS thus far.

Through our collaboration with existing initiatives in Úbeda, Atarfe and Jerez, hundreds of people (apart from teachers) have had the opportunity to get in touch with IBL pedagogies and a renewed way of teaching and learning mathematics and science in school.

We also integrated PRIMAS ideas successfully in our work with pre-service teachers at the University of Jaén and the Pablo of Olavide University in Seville. Additionally, we disseminated IBL and our IBL-oriented research on several national and international conferences.

Furthermore, we established a very successful collaboration with the Regional Ministry of

Education, which allowed us to transmit to policy-makers the importance of IBL. Also with the National Ministry of Education, collaboration will be extended in the future.
Successful collaboration with many teachers' centres, teachers' associations and other professional development providers were established. They are key actors in our system, since they offer the PD that the majority of in-service teachers follow. We have been successful in creating a network with teacher advisors in many teachers' centres, also with experienced teachers and multipliers that collaborate with them. They will continue spreading IBL after PRIMAS, organising new courses or integrating PRIMAS modules within their own teacher training materials.
As explained in the Spanish analysis of the context (cf. WP2), PRIMAS coincided with a period in which our educational system was demanding this kind of methodologies. Since the publication of a competency-oriented curriculum in 2007, and the mediocre results of our students in PISA, there was a need for renewing traditional pedagogies. IBL is a methodology that increases students' motivation towards mathematics and science, makes students' learning more meaningful and develops their competences beyond using standard and routine procedures. In short, IBL matches perfectly with the kind of mathematics and scientific education that Andalusia would like to have in the future. Sadly, PRIMAS also coincided with a period with salary cuts for teachers and a deterioration of their working conditions. Since teachers' professional development is not compulsory in Andalusia, and it takes part in the afternoon, teacher participation in courses depends highly on their motivation. PRIMAS was successful in attracting teachers, but according to the opinions expressed by advisors working at the teachers' centres, numbers might have been even higher in a 'normal' (non-crisis) situation.
Finally, we would like to stress the importance of continuing in our effort. An extend support is needed for any educational change to happen. PRIMAS national team will continue with this effort through: (a) a new FP 7 project; (b) promoting new courses based on PRIMAS; (c) Integrating IBL in our work with pre-service teachers; (d) keeping the contact with the Ministry of Education (regional and national), the teachers' centres network, teachers associations and other PD providers; (e) making IBL a central topic in our research and scientific publications.

Switzerland

The impact of PRIMAS implementation in Geneva on the teaching of mathematics and sciences will be of durable length. We have forged sustainable links between teacher trainers at university, teachers from basic schools at all levels, the official institution – and also parents. We have also acquired expertise in popularising the teaching of mathematics and sciences and have created a real partnership with a television team and museum. In this regard, we have developed a website attached to Swiss TV on popularising mathematics and science and organised an exhibition at the Geneva Science Museum (*Musee d'Histoire des* Science). The website aims to make sciences and mathematics more fun and offers interviews, programmes and regularly some puzzles in mathematics and sciences. In collaboration website partner, we created a 45-page brochure on mathematics. It presents succinct information about a few mathematicians and recreational problems relating IBL to real life. Furthermore in the Museum of History of Science, we organised an exhibition called *Les jeux sont faits – Hasard et probabiltés* (Games, hazard and chance), which was a huge success. In this exhibition visitors, such as students and their teachers, were able to do some experimentation and solve puzzles about statistics and probability. This exhibition was opened from 1 February 2012 until 7 January 2013.The reflection that we had through PRIMAS helped us reorganise our pre-service courses which are now more IBL orientated and also, due to the specific case of Geneva, more in accordance with the new curriculum and textbook. Moreover, we had an exceptional opportunity to collaborate with all the maths and sciences teacher trainers. Over the lifetime of PRIMAS, in Switzerland more than 300 teachers and multipliers and more than 440 pre-service teachers were reached.

United Kingdom

The most significant achievement of the English partners was the design and development of the seven PD modules (in cooperation with PRIMAS partners) that clearly show how IBL can be enacted effectively in secondary classrooms. These video-based units are now available across Europe, thanks to PRIMAS, and a version is now also appearing in the US.
To understand the dissemination models used in the UK, one has to understand a little of the context. Over the past four years, the UK coalition government has decentralised educational provision and dismantled most previously existing professional development structures for teachers. Local authority advisers and consultants have lost jobs and many have returned to school teaching or have set up private training companies. Since 2010, more than 3444 schools, including more than half of secondary schools, have taken on academy or free school status, which allows them to operate largely outside of the supervision of local education authorities, as well as granting extra freedoms over the curriculum and teachers' pay, conditions and PD. Currently, new regulators for these schools are being suggested. In addition, the government has rewritten the national curriculum and completely redefined qualifications, including the GCSE, taken by

everyone.
When we were originally planning PRIMAS, we sought to use existing national structures for disseminating IBL, such as the local authorities. This proved impossible for the above reasons. We therefore sought partners and additional funders to set up alternative models for PD. Some early ideas failed, such as a proposed Masters Course for teachers, and a Science Learning Centre course. They simply did not attract the interest of busy teachers. Instead we devised three clear models – which are named in the following – that provided sustained and successful PD, with very different levels of external support. They were underpinned by the PD materials developed for PRIMAS: The Lesson Study model, the linked training event model and the self-sustaining model (Detailed information on the models is provided in the main S&T results/foreground, WP4).
We are convinced that each of these models will continue beyond the life of PRIMAS. We have additional funding from the Nuffield foundation to support the first.
Finally, we believe that PRIMAS has also enabled us to influence the government's rewriting of the national curriculum and the GCSE specifications, albeit in limited ways. Both Geoff Wake and Malcolm Swan were involved in consultations.
The impact of PRIMAS in the Greater Manchester area has been to provide opportunities in a systematic and sustained manner for teachers and trainee teachers to collaborate in local schools in the development of more sustained enquiry based learning contexts, mainly in science teaching. This activity has led to the development of enquiry based learning cultures in five schools, and to activity in a less-sustained manner in another 30 schools.
This has been happening at a time when inspection and accountability regimes in England have been calling strongly for more IBL, but where resources for such development have been lacking. The dismantling of the teacher development systems in 2010 left a space which PRIMAS has been able to use and where those teachers involved have found encouragement in developing their capabilities in this vital area.

The activities that were carried out within PRIMAS are significant examples of successful, wide dissemination of the PRIMAS concepts and ideas to show sustainability and prove that PRIMAS is not a 'one-off event', but is well on the way to being strategically integrated into other relevant activities and networks being used to enlarge the impact and sustainability of the project.
All project partners are strongly committed to the PRIMAS vision. Therefore, one of our main concerns is to sustain project achievements using, among other means, materials and publications. To this end we developed the PRIMAS Final Publication that addresses the project's main target groups: teachers and teacher trainers. This colourfully illustrated booklet aims to support those who actively participated in PRIMAS as they continue to purse IBL methods in their daily classroom practice. The PRIMAS Final Publication is also a reader-friendly, informative booklet for anyone interested in learning more about inquiry-based learning and its potential benefits for teachers, students, and as we strongly believe, society at large. Also the publication includes numerous tasks for different school levels and first-hand reports by teachers who used these tasks in their classrooms. The publication can be downloaded from the international PRIMAS website.

Part V: THE PRIMAS PROJECT – FURTHER INFORMATION

Website and key links

Further information about the PRIMAS project can be found on the international website at: **www.primas-project.eu**

Interested readers may also visit directly the pages with condensed project information including a video on the aims and work within PRIMAS, the main reports and guides published so far in the project, as well as the latest editions of the PRIMAS newsletter.

A Prezi was also created which gives an overview of PRIMAS aims, professional development modules and classroom materials.

PRIMAS Consortium partners and PRIMAS countries

University of Education Freiburg	Germany
University of Geneva	Switzerland
Utrecht University	Netherlands
University of Nottingham	UK
University of Jaén	Spain
Constantine the Philosopher University in Nitra	Slovakia
University of Szeged	Hungary
Cyprus University of Technology (until 31/12/2012)	Cyprus
University of Malta	Malta
University of Roskilde	Denmark
University of Manchester	UK
Babeş-Bolyai University	Romania
Sør-Trøndelag University College	Norway
IPN Kiel	Germany
Edex-Educational Excellence Corporation Limited (from 1/1/2013)	Cyprus

Selected publications (non-scientific) in print and online media

The various PRIMAS project publications included here do not have a scientific background. They serve informational purposes and were published locally and internationally in diverse types of media.

- **October 2009**: UNIversalis-Zeitung: 'Zwischen Forschung und Praxis' (Germany).
- **October 2009**: Diario Jaen, Jueves 1 de octubre 2009: 'Gran participation de la UJA en dos proyectos europeos' (Spain).

- **January 2010**: Badische Zeitung: 'Freiburger Professorin wirbt für besseren Mathematikunterricht' (Germany).

- **February 2010**: Badische Zeitung: 'Fördergelder für die PH, Ziel: praxisnaher Unterricht' (Germany).

- **February 2010**: Informationsdienst Wissenschaft: 'Start des Forschungsprojekts PRIMAS: Veränderung der Unterrichtskultur in Mathematik und den Naturwissenschaften' (Germany).

- **February 2010**: TV Südbaden/Kanal8: 'Projekt soll Schüler für Mathe begeistern' (Video) (Germany).

- **February 2010**: Badische Zeitung: 'Der Lösungsweg ist das Ziel' (Germany).

- **February 2010**: SWR4 Baden-Württemberg: Radio Interview (Audio) (Germany).

- **February 2010**: Utrecht University Newsletter: Article about the start of the PRIMAS project: http://www.science.uu.nl/betanieuws/2010.02/eusubsidie.htm (Netherlands).

- **March 2010**: Staatsanzeiger: 'Schüler sollen im Mathematikunterricht künftig praxisnahe Probleme lösen' (Germany).

- **March 2010**: Constantine the Philosopher University in Nitra Newsletter: http://www.ukf.sk/dokumenty/ouniverzite/nascas/2010_3_web.pdf (Slovakia).

- **April 2010**: Constantine the Philosopher University in Nitra Newsletter: http://www.ukf.sk/dokumenty/ouniverzite/nascas/2010_4_5_web.pdf (Slovakia).

- **April 2010**: FiF Newsletter: 'Im Porträt: Prof. Dr. Katja Maaß – Lieber Mathe lernen!' (Germany).

- **September 2010**: Dorier J-.L. (à paraître): 'La démarche d'investigation en classe de mathématiques – une première approche prospective', Actes du colloque de l'AREF, Genève (Switzerland).

- **December 2010**: Iskolakultúra journal special issue: 'A PRIMAS project': http://www.iskolakultura.hu/iol/csikos.pdf (Hungary).

- **January 2011**: Largeur: 'Le raisonnement scientifique est en perte de vitesse': http://www.largeur.com/?p=3321&print=1 (Switzerland).

- **January 2011**: Constantine the Philosopher University in Nitra: Stretnutie konzorcia medzinárodného projektu 7RP PRIMAS: http://www.ukf.sk/udalosti/1796Stretnutie-konzorcia-medzinarodnehoprojektu-7RP-PRIMAS (Slovakia).

- **January 2011**: Europäischer Informationsbrief Bildung & Beschäftigung, Ausgabe 1-2 2011: Ankündigung der Tagung zu 'Wissensdurst - innovative

Pädagogik in der mathematischen und wissenschaftlichen Lehre'(Germany).

- **May 2011**: Scientix Portal: Announcement of the conference 'Towards Europe 2020: Inquiring minds innovative pedagogies in mathematics and science education' (Germany).

- **May 2011**: Newsletter Wissenschaft in der Gesellschaft, Ausgabe 3/2011: 'Veranstaltung des SiS-Projekts PRIMAS am 27. Juni 2011 in Brüssel' (Germany).

- **May 2011**: Ecent conference report: Article about PRIMAS workshop 'Onderzoekend leren' (Inquiry-based learning): http://www.ecent.nl/artikelen/view.do?supportId=2297 (Netherlands).

- **June 2011**: Babes-Bolyai University News: Press release on the PRIMAS event 'Towards Europe 2020: Inquiring minds – innovative pedagogies in mathematics and science education': http://news.ubbcluj.ro/comunicate-de-presa/towards-europe-2020-inquiring-minds-innovative-pedagogies-in-mathematics-and-scienceeducation/ (Romania).

- **September 2011**: SimpleX portal: Tábor Bonchidán: http://simplexportal.ro/galeriak/tabor-bonchidan (Romania).

- **September 2011**: Szabadsàg: Matematikáról másképpen, Bonchidán: http://szabadsag.ro/szabadsag/servlet/szabadsag/template/article%2CPArticleScreen.vm/id/63513 (Romania).

- **September 2011**: Didaktika. Pedagògusok Virtuàlis Tanàrija: Tábor Bonchidán: http://didaktika.ro/hirek/109-tabor-bonchidan (Romania).

- **Oktober 2011**: Szekelyhon: Több mint kilencven ifjú matematikus Csíkszeredában: http://www.szekelyhon.ro/magazin/tobb-mint-kilencven-ifju-matematikus-csikszeredaban (Romania).

- **November 2011**: Reference in Eurydice Report (Germany).

- **November 2011**: Udarhelyi Híradó: About the conference in Odorheiu Secuiesc (Romania).

- **November 2011**: A MAGYAR TUDOMÁNY NAPJA ERDÉLYBEN 2011. Matematika és informatika alkalmazásokkal. http://www.cs.ubbcluj.ro/~darvay/eme/mtne2011/ (Romania).

- **November 2011**: Netradičná matematická súťaž. https://www.ukf.sk/udalosti/2212-Netradicna-matematicka-sutaz (Slovakia).

- **December 2011**: PRIMAS Project of the Month, German Federal Ministry (Germany).

- **December 2011**: Mathsline: Maltese schools participate in PRIMAS project (Malta).

- **Since autumn 2011**: ProCoNet Website with PRIMAS introduction (http://proconet.ph-freiburg.de/)

- **January 2012**: Sci-News : Q &A – Maltese schools participate in PRIMAS (Malta).

- **March 2012**: Vyhodnotenie tímovej matematickej súťaže B-DAY: https://www.ukf.sk/udalosti/2313-Vyhodnotenie-timovej-matematickej-sutaze-B-DAY (Slovakia).

- **April 2012**: Schwarzwälder Bote - Villingen-Schwenningen: 'Das Ziel ist die Freude an der Mathematik': http://www.schwarzwaelder-bote.de/inhalt.villingen-schwenningen-das-ziel-ist-die-freude-an-der-mathematik.b65c1012-0db3-4b84-ba41-cd9f9b6cbef5.html (Germany).

- **April 2012**: Vyhodnotenie tímovej matematickej súťaže B-DAY: https://www.ukf.sk/dokumenty/ouniverzite/nascas/NasCas_2012_4.pdf (Slovakia).

- **April 2012**: Südkurier Online – Villingen-Schwenningen: 'Kinder und Lehrer sollen das Lernen lernen': http://www.suedkurier.de/region/schwarzwald-baar-heuberg/villingen-schwenningen/Kinder-und-Lehrer-sollen-das-Lernen-lernen;art372541,5483430 (Germany).

- **June 2012**: Badische Zeitung – Bad Säckingen: 'Mathe kann schön sein': http://www.badische-zeitung.de/bad-saeckingen/mathe-kann-schoen-sein--60665764.html (Germany).

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Pictures of the final Consortium meeting and the Final Conference

PRIMAS Consortium Meeting December 2013 in Brussels: Working group phase after a plenary session.

PRIMAS Consortium Meeting December 2013 in Brussels: the PRIMAS Consortium with the International Consultancy (ICP) and Expert Panels (IEP).

PRIMAS ICP and IEP members: Internal working group phase of the ICP and IEP members of PRIMAS.


PRIMAS Final Conference, December 2013 in Brussels: Some impressions of the conference.


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