



FINAL PUBLISHABLE SUMMARY

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THE PATHWAY PROJECT:
The Pathway to Inquiry Based Science Teaching
January 2011 – December 2013

Executive Summary

Following the recommendations of the "Science Education Now: A renewed Pedagogy for the Future of Europe" report (Rocard, 2007) , the PATHWAY Supporting Action brought together experts in the field of science education research and teachers' communities, scientists and researchers involved in pioneering scientific research, policy makers and curriculum developers to promote the effective widespread use of inquiry and problem based science teaching techniques in primary and secondary schools in Europe and beyond (see non-European partners in Russia and the US).

The project has set the PATHWAY toward a standard-based approach to teaching science by inquiry, to support the adoption of inquiry teaching by demonstrating ways to reduce the constraints presented by teachers and school organisation, to demonstrate and disseminate methods and exemplary cases of both effective introduction of inquiry to science classrooms and professional development programmes, and to deliver a set of guidelines for the educational community to further explore and exploit the unique benefits of the proposed approach in science teaching. More than 10,000 teachers were introduced in the PATHWAY methodology in the participating countries. Numerous best practices were used to facilitate the introduction of the inquiry approach to real school environments. Numerous teachers have populated the project portal with materials that were developed for classroom use. More than 50% of the participants were involved in an extended evaluation process before and after the training, and after a period of 2-4 months following the implementation of the inquiry activities in the classroom. The PATHWAY project has developed the most active and engaged teachers community in Europe and it aims to continue this work by exploiting further the PATHWAY training framework. The core of the PATHWAY exploitation strategy is the European Science Education Academy (ESEA). The training framework that is delivered by the ESEA is focusing on science teachers and instructional leaders. Facilitating the PATHWAY main outcomes (a series of guidelines, scenarios of practice, tools and show cases from the numerous PATHWAY teachers) the programme can support participants to introduce innovative aspects in their school settings. The programme is offered in the form of webinars, interactive online sessions, 2 to 6 day lasting courses and field visits as well as observations in PATHWAY schools all over Europe.

Concept and Objectives

The publication of the "Science Education Now: A renewed Pedagogy for the Future of Europe" report (Rocard, 2007) brought the teaching science by inquiry vision to the top of science educational goals in Europe. In this sense, the Science in Society Work Programme supported selected actions to promote the more widespread use of problem and inquiry based science teaching techniques in primary and secondary schools.

The PATHWAY project proposed to move towards a standard-based approach that brings coordination, consistency and coherence to the improvement of science education.

In this sense, the main project's objectives were the following:

1) The development of a standard-based approach to teaching science by inquiry that outlines instructional models that help teachers to organize effectively their instruction:

This task was realized in the framework of WP2 and it was finalized by Month 8 (Milestone 2). The determination of the underlying principles that govern the proposed standardization approach was based on the concepts and the theoretical approaches deriving from recent educational research in the field. The proposed approach imparted a deep understanding of content, taught prospective teachers appropriate ways to motivate young minds, especially with the suitable use of technology, and guided them in active and extended scientific inquiry, and instilled a knowledge of – and basic skills in using – effective teaching methods in the discipline. The PATHWAY framework gave more emphasis on continuously assessing student understanding, supporting a classroom community with cooperation, shared responsibility and respect and working with other teachers from other disciplines to enhance the aims of the school curriculum. The project team attempted to demonstrate the pathway towards the generation of a common profile of the effective science teacher across Europe (the "practitioner of inquiry"), as an important step towards the development of strategies and programs that will produce teachers who are implementing effectively inquiry based instruction. The project team proceeded by analyzing this profile, to identify components which relate to the desired competencies as well as other components that do not.

Being more precise, a framework for identifying best practices in inquiry-based science education was defined in WP2, which provided an instructional model for the published final Best Practices in WP3.

2) To build a group of practitioners of inquiry who share leading practices and influence policy development:

Teachers with specific "change management" competences are required to operate successfully as change agents in their schools facilitating the implementation of inquiry based methods. To guarantee sustainability of the proposed approach, the gradual development of the community of teachers – change leaders (first locally, and then gradually nationally and at the cross-European level) was supported by a state-of-the-art Web 2.0 collaborative learning and knowledge exchange environment. This task was realized in the framework of WP4 and it was finalized by Month 36 (Milestones 3, 4 and 5).

3) To implement a large number of training activities that facilitates the effective introduction of inquiry to science classrooms and professional development programs:

Within this project, more than 10.000 science teachers throughout Europe were trained in the Pathway inquiry-based approach.

During the project implementation teachers communities had access to a unique collection of open educational resources (linked with the science curricula) that have proven their efficiency and efficacy in promoting inquiry based education and that are expanding the limitations of classroom instruction.

In order to guarantee a long term effect, an international workshop was organised in 2013 to define the framework for the development of the “European Science Education Academy” (ESEA) for promoting inquiry based teaching and learning in European schools and beyond. The aim of the ESEA is to create an international network of science centers, research centers, teacher communities, museums as well as policy makers and it builds on the outcomes of the PATHWAY project which are used as guidelines.

The PATHWAY training practices further populated the Central Information Provider (Scientix Platform) that was set up to centralize and disseminate best practices in IBSE.

4) To propose a methodology for designing, expressing and representing inquiry based educational practices in a commonly understandable way:

This task was realized in the framework of WP4 and it was finalized by month 36 (Milestones 3, 4 and 5). This offered the mean for describing the activities for teaching science by inquiry that the project team had identified, that was, the building of blocks of different scenarios which were identified as subject-domain independent “educational activities” that implemented a specific inquiry educational approach (for example Learning Cycle, Guided Research, Problem-Based Learning), properly assembled to either implement existing Best Practice Educational Scenarios from international success stories or to create new activities for teaching science by inquiry. These activities were organized in three main categories: school based activities, activities that promote school-science center and museum collaboration and activities that promote school-research center collaboration.

5) To further support the adoption of inquiry teaching by demonstrating ways to reduce the constraints presented by teachers and school management:

This task was realized in the framework of WP5 and it was finalized by month 36 (Milestones 3, 4 and 5). The PATHWAY project deployed a series of methods of effectively involving teachers in the inquiry instruction. In order to fully realize the potential of inquiry based education, the project team needed to address all potential fears and negative preconceptions related to the proposed approach adequately while assisting them in every step of the process. The task at hand was to manage this change in a uniform way, allowing teachers to realize the potential of the opportunity offered by the PATHWAY project, take ownership of their contribution and maximize the output for both the project and themselves. The consortium included institutions with significant expertise in designing effective professional development programs.

6) To deliver a set of guidelines for the educational community to further explore and exploit the unique benefits of IBSE:

This task was realized in the framework of WP3 and it was finalized by month 36 (Milestone 5, Deliverable 3.3). The PATHWAY approach asked for knowledge areas integration, effective and closes cross-institutional collaboration, and organizational change in the field of science education. This effort was documented analytically and systematically in “The Pathway to Inquiry Based Science Education”. The main objective of the work was to generate a structured set of recommendations and that formed a pan European roadmap for IBSE to sustain the development/deployment of science educational methods and content services that supported the access and expanded the reuse of it. Therefore Best Practices have been gathered from all participants and evaluated if they fit to the PATHWAY’s 10 features of inquiry.

The report “The Pathway to Inquiry Based Science Education” was made available both in conventional form and in electronic format on the project web site, and was communicated to the networks of the project members (mainly to Ministries of Education). It was translated in 8 languages and published in 10,000 copies.

The booklet is available for teachers or any stakeholder outside the PATHWAY program on the website: www.pathway-project.eu/content/pathway-booklet

7) To systematic validate the proposed approaches and activities in order to identify their impact in terms of the effectiveness and efficiency:

This task was realized in the framework of WP7 and it was finalized by Month 36 (Milestones 3, 4 and 5). The PATHWAY validation methodology (based on the VALNET framework - valnet.eun.org) offered a framework for validating the introduction of innovation at schools so that piloting and field testing results could have been analyzed systematically and then disseminated widely, thus ensuring rapid impact and widespread uptake. The key areas of interest of the proposed validation methodology were science pedagogy, organization issues (e.g. impact on the national curriculum), technology – tools, services and infrastructure, economic – value for money, added value, as well as cultural and linguistic issues. The project was implemented in schools, science teachers training centers, science centers and museums and research centers in different countries that allowed an ethnographic research and evaluation of different attitudes against the use of inquiry based techniques in different cultures providing thus ways for intercultural dialogue to improve these attitudes.

Main results

Towards a Standards-Based Approach to Teaching

WP2 concluded the standard-based approach to teaching science by inquiry that outlines instructional models helping teachers to organise effectively the instruction. In this sense, it provided an instructional model for the further development of the Best Practices in WP 3. The determination of the underlying principles that should govern the proposed standardization approach was based on the concepts and the theoretical approaches deriving from recent educational research on the field.

All tasks and corresponding deliverables have been completed in the first year of the project. In T2.1 “The Essential Features of Inquiry Learning” the project team has identified the essential features of inquiry learning, based on the initial assumptions presented in section 1.1.4.1 of the DoW. The project team carried out an extensive review of the literature on inquiry teaching and learning and on effective models for professional development. The review focuses both on research and on practice.

The process included the organisation of a series of workshops where science educators, science curricula developers, teacher educators, scientists, practitioners, specialists in cognitive psychology, sociology and learning sciences had been invited to participate to exchange experiences. Additionally, the project team has performed interviews with "prominent" figures dealing with inquiry oriented science education. For these interviews all partners were asked to use a template developed by USH and provide the data for the consortium. Task 2.1 resulted in D2.1 “The features of inquiry learning: theory, research and practice” (M4).

In T2.2 “The Pedagogy of Inquiry Teaching: Strategies for Developing Inquiry as part of Scientific Literacy”, the project team proposed a methodology for designing, expressing and representing inquiry based educational practices in a commonly understandable way. These activities were organised in three main categories: school-based activities, activities that promote school-science centre and museum collaboration and activities that promote school-research centre collaboration. Task 2.2 resulted in D2.2 “Essentials of IBSE pedagogy: Strategies for Developing Inquiry as part of Scientific Literacy” (M6).

In T2.3 “Designing Effective Learning Environments that Support Inquiry”, the consortium has defined the characteristics of learning environments that support teaching science by inquiry. The partnership explored the integration of physical and computational media for the design of interactive learning environments to support learning about complex scientific phenomena. This has set the basis for the design of interactive learning environments to integrate systems supporting alternative ways of interaction with simulation and modelling tools. Task 2.3 closed with D 2.3 “Effective learning environments for inquiry learning and teaching” (M6).

In T2.4 “The Profile of the Effective Science Teachers”, the partnership has performed a correlation survey on the existing training systems that promote teaching as inquiry. Additionally cases like teachers’ workshops and summer schools have been identified and

their role in the common training framework was studied. The aim of the partnership was to identify successful approaches (e.g. training systems and methodologies, training methods, summer workshops and schools) in teachers training and professional development. The profile of “the science teacher we want to have”, the effective science teacher’s profile was created within this task. Task 2.4 closed with D2.4 “Professional development of IBSE teachers: Considerations and strategies” (M6).

In T2.5 “Defining Best Practices in Inquiry Based Science Education”, Best Practices in IBSE were defined. This task ended with D2.5 “A framework for identifying best practices in inquiry-based science education” (M8).

Based on these results, the project team further elaborated a set of guidelines for the educational community in WP3.

Best Practices of Inquiry Based Science Education Methods and Activities

The consortium has delivered a set of guidelines for the educational community to further explore and exploit the unique benefits of IBSE. Therefore Best Practices have been gathered from all participants and evaluated if they fit to the PATHWAY inquiry activities. The Best Practices also facilitated the extended training procedure that the PATHWAY project implemented in WP5 and systematically validated in WP7.

This work was documented in “The Pathway to Inquiry Based Science Education”, the major outcome of the project.

The consortium presented a series of exemplary teaching practices, resources and applications that provide students with experiences that enable them to achieve scientific literacy, criteria for assessing and analysing students’ attainments in science and learning opportunities that school programmes afford. It furthermore supported the community of practitioners by presenting effective teachers preparation and professional development programmes.

In the framework of the project, the proposed Best Practices were organised in the four main categories:

- Effective Educational Activities based on Inquiry Based Approaches (school based)
- Educational Activities that promote school – science centre and museum collaboration
- Educational Activities that promote school – research centre collaboration
- Effective Teachers Preparation and Professional Development Program

In T3.1 “Effective Educational Activities based on Inquiry Based Approaches (school based)”, a series of case studies have been selected. They formed the basic pool of reference for the training activities in WP5. These cases have mainly been implemented for many years in the framework of training activities in Europe and they have already proven their efficiency and efficacy as IBSE resources.

The consortium increased the utility of these resources through coordination, systematic training and dissemination and effective teachers' community building. The proposed educational materials and methods offer a "feel and interact" user experience, allowing for learning "anytime, anywhere" by employing advanced and highly interactive visualization technologies and also personalised ubiquitous learning paradigms in order to enhance the effectiveness and quality of the teaching and learning process.

In T3.2 "Educational Activities that promote school – science centre and museum collaboration", activities that expand the limitations of the classroom and promote innovative approaches to science teaching have been selected to enrich the PATHWAY repository of exemplary models of inquiry based instruction. The case is emphasizing the important benefits that could arise from the use of the unique resources the science centers and museums have to offer to the everyday school practice.

In T3.3 "Educational Activities that promote school – research centre collaboration", additional activities that promote access to scientific resources and experiments have been selected. It highlights Best Practices with live scientific experiments and phenomena, ongoing research, and the personalities and stories of working scientists across Europe.

In T3.4 "Effective Teachers Preparation and Professional Development Programs", the consortium gathered Best Practices to promote and facilitate teachers' professional development in inquiry based science learning. A blended learning model allowed for flexibility without sacrificing efficiency. Several examples of effective professional development programs were presented in D3.1.

The tasks (T3.1-T3.4) were summarized in D3.1 "Best Practices of Inquiry Based Science Education Methods and Activities (Initial Version)" at the end of the first year, which was revised one year later in D3.2 and it presents the final outcomes of these tasks. It includes a series of exemplary teaching practices, resources and applications that provide students with experiences that enable them to achieve scientific literacy, criteria for assessing and analysing students' attainments in science and learning opportunities that school programmes afford.

The goals of the different tasks (T3.1-T3.4) were achieved by asking for Best Practice suggestions from all participants. These suggestions were collected in a template to compare their efficiency in inquiry science teaching. The best practices in the templates were then allocated to the four main categories. The template consisted of a short narrative description about the content of the Best Practice, the aims and main actions within the activity. Furthermore, a short overview chart is added to each Best Practice that can be easily judged by a teacher or other educational guide. In this chart data about the applicable age of the students, the time needed, curriculum connections and languages available can be found. 10 selected features categorise how the activity is connected to inquiry based science teaching.

At the end of the project, the last task (T3.5) of WP3 was completed: "The Pathway to Inquiry Based Science Education" report. Within this task, a structured set of guidelines and recommendations was developed as summarized in the final version (D3.3).

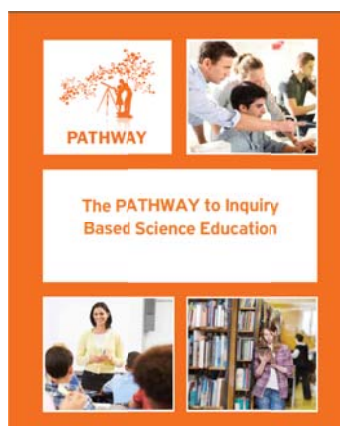
More specifically, it focussed on:

- a) how inquiry based techniques can be introduced in the school practice,
- b) how teachers can use the unique resources of science centres and museums in their lessons and
- c) how effective forms of collaboration between researchers and the educational sector (formal and informal) could create valuable and meaningful learning experiences for all, fostering exploration, discovery, curiosity and collaboration.

The document of D3.3 emphasized a new way of learning about science that reflects how science itself is done, on inquiry as a way of achieving knowledge and understanding about the world. It proposes new ways of interacting with scientific content and it demonstrates the results from the extended validation effort in the participating institutions and beyond. It briefly presents the project, its implementation, and its main outcomes, as well as discusses benefits and recommendations for the further application, improvement and integration of the project results in training policies and practices.

The report (D3.3) was made available both in conventional form and in electronic format and was communicated to the networks of the project members (and mainly to Ministries of Education). It was translated in 8 languages (English, German, Italian, Flemish, Greek, Bulgarian, Romanian and Spanish). It is published in 10,000 copies.

The booklet is available for teachers or any stakeholder outside the PATHWAY project on the project web site:



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Developing a Community of Practitioners of Inquiry

Within WP4, a group of practitioners of inquiry was established, in order to share leading practices and influence policy development. Therefore, teachers with specific change management competences were required to operate successfully as change agents in their schools facilitating the implementation and further diffusion of inquiry based methods in teaching practice. To guarantee sustainability of the proposed approach, the gradual development of the community of teachers – change leaders (first locally, and then gradually nationally and at the cross-European level) was planned. A number of engagement activities were organised (both face-to-face and online). WP activities were supported by a collaborative learning and knowledge exchange environment specially developed by the PATHWAY team. Also, various external tools were used to better engage a larger community according to the target audience preferences.

PATHWAY involved potential innovators in all project processes from the very start and keep them involved during the whole project lifetime. As part of T4.2, in 2011, a needs analysis was performed through the PATHWAY Visionary Workshops: 60 events with 1835 participants in 12 countries took place (outcomes are reported in D4.2). During 2012 and 2013 PATHWAY Practice Reflection Workshops were carried out locally in the countries providing IBSE training and teachers' support activities. The workshops sought to inform the consortium about the effectiveness of the training and implementation activities. They were an opportunity to reflect on the results of the training, helped to revise, if necessary, the PATHWAY IBSE model and to adapt the training accordingly. In total, 60 workshops have taken place in 13 countries (Austria, Belgium, Bulgaria, Finland, Germany, Greece, Ireland, Italy, Romania, Russia, Spain, Switzerland and UK) involving **1026** participants. Feedback on the PATHWAY methodological approach and training activities was received and the outcomes of the Practice Reflection Workshops can be used to improve further IBSE training and find how to support the IBSE adoption in the future (a summary and the complete reports are included as appendix in D5.4).

At the end of the project (in 2013), PATHWAY Summative Workshops were organised. This series of 16 closing events involved more than 250 participants as one of the means to recapitulate on the experiences and lessons obtained from implementation of the training activities. They were the participatory engagement tool in the final process leading to the proposition of the Pathway to Inquiry Based Science Education Report (D3.3). The complete reports are available on the PATHWAY BSCW.

All face to face activities were attended by the target audience and included active opinion and experience sharing, brainstorming sessions and discussions, thus fulfilling the overall goals of the WP4.

The work in WP4 was strongly related to the work in WP5 (Training Activities) and WP6 (Clustering and Networking) with a positive impact (i.e. exchange and collaboration) between the three WPs. The members of the PATHWAY local communities of practice (CoP) were mainly those teachers involved in training activities. In addition, interested people were reached through dissemination and invited to participate in sharing ideas, opinions,

teaching materials and practices with the local CoP in the participating countries. In each country, partners contributed with the necessary efforts to the creation and support of their local communities of practice. Furthermore, through the international training events various PATHWAY partners contributed to the creation and support of an international CoP. Several tools were designed for supporting the PATHWAY Community. The Community Support Workspace has been revised and, producing two new versions (D4.6 and D4.7 at months 24 and 36), it now contains a) the project BSCW platform with localized spaces for each of the participating country, allowing the use of a wide spectrum of Web 2.0 functionalities and used in various cases of PATHWAY training (both local and international events); b) connection to the PATHWAY-ASK-LDT (a Learning Designer Toolkit, described in D4.3) and the PATHWAY-ASK-LOM tool (a Learning Object Metadata Authoring Toolkit) that allow the creation and sharing of IBSE-based teaching materials (see D4.5); and c) a PATHWAY Repository of IBSE Scenarios was developed, which enables teachers and science museum educators to browse and share IBSE Scenarios and educational resources. These tools were linked to the main PATHWAY public access point (i.e. the PATHWAY website) and are described in detail in D4.7.

In addition, partners have adopted multiple approaches to reach and involve the target audience in a Community of Practice. These include: Social networking tools, such as facebook, twitter, several localised web sites (in Germany, Spain and UK), active users were also gathered around science contests organised in several countries (e.g. Greece, Germany), face-to-face meetings and brainstorming activities were organised for the most interested and active people. In order to keep the CoP alive, the consortium partners regularly stimulate the community by sending news, information, thought provoking experiences, etc. in the form of newsletters, mailing lists and so on.

As part of WP4 (T4.2) an online participatory engagement activity was launched in 2012 and was kept active throughout the 2012 and 2013 school years. The consortium developed a quiz for teachers and other stakeholders (about 900 people participated), which aimed to provoke and enable unconventional thinking about the future. Participants were also invited to visit the project website and to engage in the other project activities. The Quiz is available in 10 languages (<http://pathway.ea.gr/content/quiz>).

Training Activities – Diffusion of IBSE across Europe

The aim of this work package was to implement a large number of teachers training activities that facilitated the effective introduction of inquiry to science classrooms and professional development programmes. During the project implementation teachers communities had access to a unique collection of open educational resources (linked with the science curricula) that had proven their efficiency and efficacy in promoting inquiry based education and that were expanding the limitations of classroom instruction. PATHWAY brought together a network of educational communities, science centres and museums and research centres in Germany, Austria, United Kingdom, Ireland, Spain, Italy, Greece, Finland, Belgium,

Switzerland, Bulgaria, Romania and Russia in order to act as the pilot group for the project activities. The first task associated with the aforementioned goal of this WP was the formation of a concrete and detailed implementation plan that constitutes the methodological and practical guide of action for the whole period of large scale pilot implementation and validation on the field. This general implementation plan defined a concrete set of activities on the field, and the corresponding mechanisms for monitoring and corrective action. Moreover, the plan identified an implementation management structure and future reporting actions that ensured the implementation quality and determine the project's progress and was delivered in the first year of the project within the deliverable D5.1. Furthermore, PATHWAY has defined a set of planned implementation actions at their local and national level, taking into consideration the localisation of the actions in each country. Thus each group provided detailed plans on a per country basis analysing several key issues in each country: the current situation regarding science education, training of science teachers and the science curriculum. This set of localized implementation plans that was created and distributed at the end of the first year within the deliverable D5.2, also described the community-formation process on a local and national level and the interactions of these communities at an international level.

In the second half of the project, the following tasks were conducted in work package 5: T5.4 "Organisation of Implementation Activities at Local Level", T5.5 "Organisation of Implementation Activities at National Level" and T5.6 "Organisation of Implementation Activities at International Level". The outcome and results of these tasks were documented in the interim reports on implementation activities in the deliverables D5.3, D5.5 and D5.7 in December 2012 (M24 of the project). The final reports, including all training activities carried out in the participating countries of the PATHWAY project at local, national and international level from January 2012 to September 2013, were then documented in the deliverables D5.4, D5.6 and D5.8 at the end of the project.

The documents include the qualitative and quantitative aims of the project, like the variety of target audiences, approaches, methodological tools and themes implemented. In the final part of the document D5.4 practical recommendations for the inquiry training activities is given.

From January 2012 to September 2013, 19 institutions from 13 different countries have contributed to the development and implementation of 333 training activities for over 7.684 teachers at local level. In the same period and at national level the partners of PATHWAY conducted 24 workshops, 10 science contests, 5 seminars and 2 conferences at national level and altogether they attracted more than 2212 participants. In addition to that they also organized 4 international summer-schools on inquiry-based science education, 3 conferences and 3 international workshops, which altogether attracted 603 participants.

These results represent an amazing large-scale effort to disseminate Inquiry Based Science Education (IBSE) techniques throughout Europe. With this operation PATHWAY managed to reach thousands of science in-service and pre-service teachers and students, in the belief that the adoption of inquiry methodologies will help grow deeper thinking and more aware citizens.




All implementation activities were documented in a report template, developed by the WP 5 leaders, and through the project's website (www.pathway-project.eu). Compiled templates were collected in the project's BSCW (Basic Support for Cooperative Work) online platform: <https://fit-bscw.fit.fraunhofer.de/bscw/bscw.cgi>

The training activities included workshops, seminars, conferences, master-classes, summer schools and contests with the aim of disseminating and reinforcing the presence of an inquiry based approach to science teaching in schools.

Example for PATHWAY contest in Belgium:

(Template from D5.6 Final Report on National Implementation Activities)

Event code	10-05BE05
Title of the activity	Quantum Spin-Off 2012: How inquiry can lead to entrepreneurship
Status	Done
Country	Belgium
Workshop language	Dutch
Start Date	07-10-2011
End Date	31-08-2012
Organising Institute(s)	KHLim and University of Antwerp
Workshop coordinator	Renaat Frans
Activity description	IBSE contest
Implemented Best Practice(s)	Quantum Spin-Off: How inquiry can lead to entrepreneurship (Educational Activities That Promote School – Research Centre Collaboration)
Activity Type	National IBSE Contest for Teachers and students of the 3 rd stage of secondary education
Location	IBM - Brussels (HQ) - IBM Forum Avenue du Bourget/Bourgetlaan, 42 B-1130 Brussels
Total number of teachers	10 teachers - 136 students
Total number of schools	9
Brief description	The Kwantum Spin-Off contest is for students of the 3rd stage of secondary education (and their teachers). They study a patent that connects basic quantum physics research with nanotechnology. Based on that they set up a business plan for a company based on this patent. Kwantum Spin-Off shows the students modern physics on a very inquiry manner and it is showed how an innovative idea can lead to an application and even an enterprise. On this "spin-off" day the schools present their valorisation trajectory and their "spin-off" company to a jury. The jury awards the best trajectories with a price.
Learning outcomes	Inquiry Methodology for Modern Physics introduced by a contest between last year

	secondary school classes and their teachers.
Activity website	http://www.vakdidactiek.be/spinoff
Photos	  
Event agenda	<p>09u15 Welcome</p> <p>09u45 Introduction Jury</p> <p>10u00 Presentations of 2 classes of their Quantum Spin-off trajectory</p> <p>10u55 Pause</p> <p>11u05 Presentations of 2 classes of their Quantum Spin-off trajectory</p> <p>12u00 Lunch</p> <p>13u00 Presentations of 2 classes of their Quantum Spin-off trajectory</p> <p>13u55 Pause</p> <p>14u05 Presentations of 2 classes of their Quantum Spin-off trajectory</p> <p>14u55 Visit IBM Forum & Research IBM – Video Conference with IBM Zürich Lab</p> <p>15u45 Proclamation of the Results – Official Award Ceremony</p> <p>16u30 Reception</p> <p>17u00 End</p>

The following tables summarize the activities conducted in each country at local, national and international level organized per category, partners involved, type of activity/event, dates and number of participants.

Table of implementation activities at local level

Country	Partners involved in the implementation activity	Number of Events	Number of Participants
Austria	BMUKK	46	786
Belgium	KHLIM	19	591
Bulgaria	SHUMEN	17	500
Finland	HU	20	356
Germany	HUB, UBT, LUE	55	1139
Greece	EA, IASA, PI, ASPETE	59	1106
Ireland	DCU	26	376
Italy	MUST	24	429
Romania	CCDC	21	502
Russia	CITILE	18	675
Spain	UB	17	493
Switzerland	CERN	12	225
UK	UCAM, FUTURELAB	26	506

Note: The US partner, Shodor foundation, was not funded by the PATHWAY project but received its funding by the NSF. Thus the US numbers are not included in the list.

Table of implementation activities at national level

Country	Partners involved in activity	Type of Event	Date of Event	Number of Participants
AUSTRIA	BMUKK	Seminar	25/2-10/3 2013	6
		Seminar	29/4-11/5 2013	9
		Seminar	29/7-11/8 2013	8
				Total 23
BELGIUM	KHLIM	Contest	7/10/2011–1/8/2012	10
		Seminar	7/10/2011	10
		Seminar	10/11/2011	11

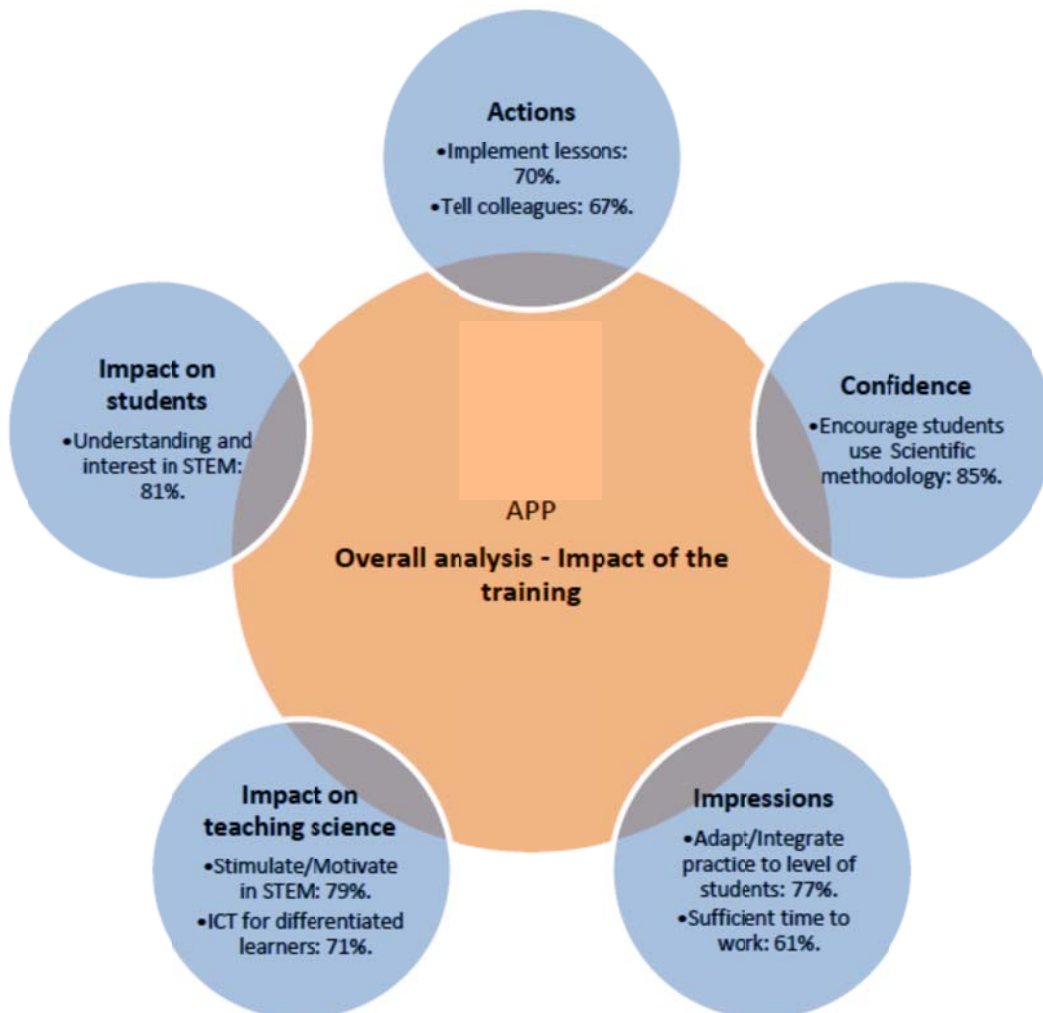
				Total 31
BULGARIA	SHU	Workshop	24-25/2/2012	24
		Workshop	28-30/9/2012	17
				Total 41
FINLAND	HU	Workshop	6/3/2012	30
		Workshop	10/5/2012	16
		Workshop	11/9/2012	20
		Workshop	5-12-19-26/4/2013	15-11-13-17
		Workshop	3-4-10/5/2013	39-35-27
		Workshop	10-11-12/6/2013	24-21-24
				Total 292
GERMANY	HUB	Workshops	2/6/2012	150
		Conference	15-20/7/2012	400
				Total 550
GREECE	EA	Contest	1/1-30/11 2011	43
		Conference	29/3-1/4 2012	100
		Contest	14-15/6 2013	28
	PI	Contest	22/6 2013	75
		Contests	13/5-4/10 2013	160+132
				Total 538
IRELAND	DCU	Workshop	13-14/2 2012	20
ITALY	MUST	Contest	30/4 2013	n/s
		Contest	21/11 2012	
ROMANIA	CCDC	Contest	25-28/5 2013	67
RUSSIA	CITLE	Workshops	1/4-15/6 2012	50
SPAIN	UB	Workshop	26/5/2012	27
		Workshops	23-24/11/2012	27-25-130
		Contest	1-30/4 2013	10
		Contest	1-30/4 2013	21
SWITZERLAND	CERN	Workshop	20/10/2012	34
		Workshop	15-18/11/2012	33
		Workshop	18-24/11/2012	19
		Workshop	10-13/12/2012	29
		Workshop	18-21/2/2013	40
		Workshop	26-31/5/2013	18
		Workshop	3-7/6/2013	16
		Workshop	23-28/6/2013	24
		Workshop	21-27/7/2013	39
		Workshop	24-31/8/2013	78
				Total 330
UK	UCAM	Workshop	14/9 2012	30

Table of implementation activities at international level

Partners involved in implementation activity	Type of Event	Date/Place of Event	Number of Participants
EA	Conference	27-29 Oct 2011, Athens, Greece	200
EA	Summer School	1-6 July 2012, Crete, Greece	27
EA, EUN	Workshop	15-16 Sep 2012, Brussels, Belgium	20
CERN	Summer School	1-21 July 2012, Geneva, Switzerland	42
SHUMEN	Conference	20-21 April 2012, Sofia, Bulgaria	42
CITILE	Conference	14-16 Oct 2012, Moscow, Russia	110
CERN, IASA	Workshop	8-9 July 2013, Geneva, Switzerland	51
HU	Workshop	14 March 2013, Trollhattan, Sweden	41
EA, UBT	Summer School	30 Jun - 5 July 2013, Crete, Greece	19
CERN	Summer School	30 Jun - 20 Jul 2013, Geneva, Switzerland	51

Impact of training activities

The following figure shows the impact of the PATHWAY training activities validated in an overall analysis in WP7 (*Deliverable “D7.5 Validation Report (Final)”*, p. 72):



Clustering and Networking

For clustering and networking, BMUKK was working with EPS (the co-WP6 leader) to develop the structure and mechanisms to disseminate the work of the partners in the PATHWAY project and highlight the collaborative working links that have been established between partners. BMUKK has clearly illustrated current relationships and demonstrated the possibilities of new connections and collaborations during the project lifetime and beyond. Within the developed Dissemination Plan (Deliverable D6.1) all contributions of partners were collected and the dissemination strategy was summarized. It was delivered in the first period of the project but gives the basic strategy and framework for all the dissemination, clustering and networking activities organized in the second period of the project. Specific measures were defined to support the dissemination and exploitation of the project results

and to contribute to their sustainability. According to this plan, all partners involved in WP6 organized their local, national and international clustering and networking activities, which included presentations, workshops, talks or distributing promotional materials at events, conferences, fairs and contests. The aim was to attract attention to an international audience and to distribute the importance of inquiry based science education over the world.

For example, PATHWAY promoted the project's results with oral presentations in conferences like ESERA (2-7 Sept 2013 in Nicosia, Cyprus) and eKNOW (24 Feb – 1 March 2013 in Nice, France). The presentations were also published in the conferences' proceedings. Upon the delivery of the first project results, papers were also submitted to scientific journals and magazines focusing on science education.

Reports of dissemination activities can be found in the deliverables D6.3c (Promotional materials including the chapter "How collaborations contributed to the PATHWAY project"), D6.4 (Presentations and Publications) and D6.5 (Proceedings of international conferences).

A PATHWAY website (www.pathway-project.eu) was established at the beginning of the project, which supported the community building and provided guidance, offered resources, news and forums for exchange of information on the thematic areas of the field.

The website acted - and still does - as an online reference point for project personnel, participants and people interested to initially access information about PATHWAY.

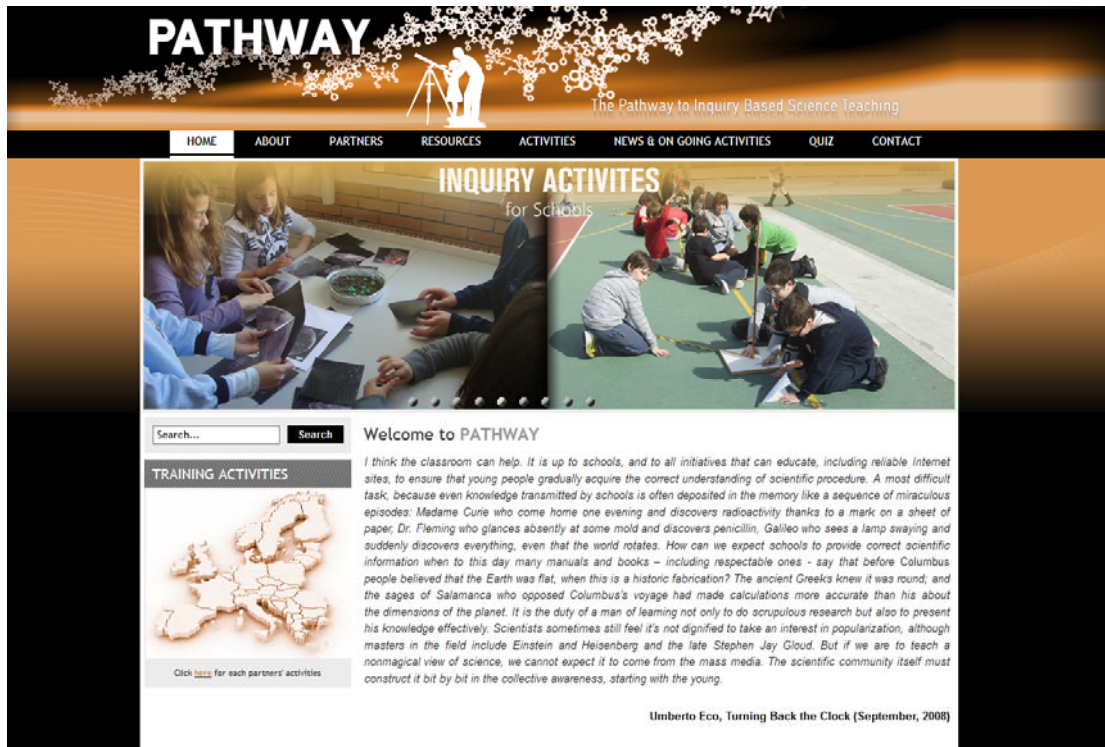
Moreover, there are four key areas accessible from the website, which are

- Inquiry Activities for Schools
- Connecting Schools & Science Centers
- Connecting Schools with Scientific Research
- Teacher's Professional Development

Users can also select between three main repositories depending on the type of activities they are interested in:

- School-Based IBSE Activities
- School-Research Center IBSE Activities
- School-Museum IBSE Activities

The overview and functionality of the PATHWAY website is presented in deliverable D6.2.



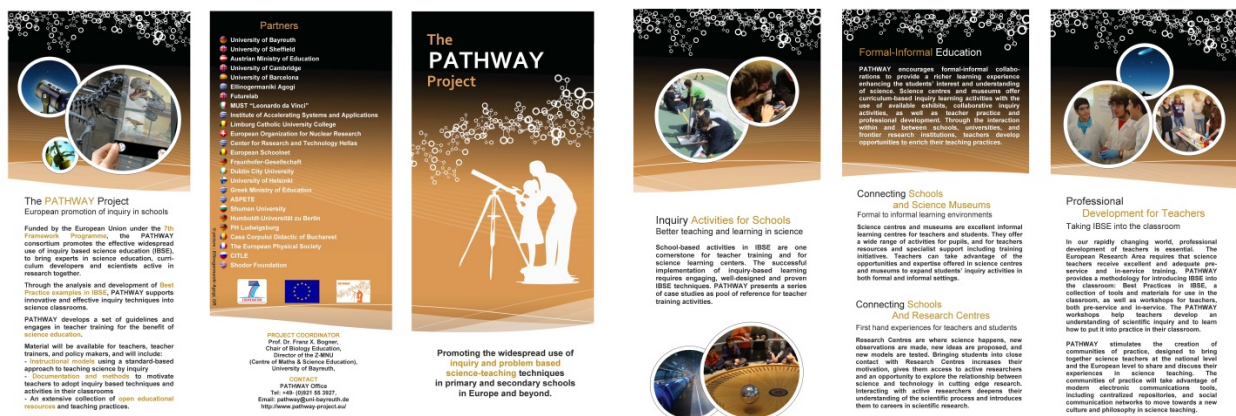
PATHWAY Website: www.pathway-project.eu

Some partners utilised also social media like facebook and Twitter to keep the PATHWAY community informed and to disseminate the project's results.

Furthermore, PATHWAY initiated the collaboration with the Central Information Provider (Scientix Platform: www.scientix.eu) at the beginning of the project, in order to disseminate the best practices in IBSE.

Besides the provided information on the internet, the project members developed and distributed printed dissemination material, which included posters, flyers, bookmark, newsletter as well as user guides and support materials for the implementation of inquiry based techniques in everyday school practice.

All the promotional materials (especially flyers and posters) and dissemination events were documented at the project platform BSCW which ensured that all partners had and still have access to all necessary dissemination material.



PATHWAY Flyer

The EPS developed together with EA and UBT a partner affiliation program and organised a separate international workshop to define the framework for the development of the European Science Education Academy (ESEA). The aim of the ESEA is to create an international network of science and research centres, teacher communities, museums as well as policy makers and to promote inquiry based teaching and learning in European schools and beyond. In total 22 participants (incl. 15 external experts) attended the workshop, taking place in Crete (1.-3 July 2013). The results can be found in the deliverable D6.6, an edited volume on “Inspiring Science Learning” presenting the ideas and the development process of the ESEA. It should be mentioned that the PATHWAY achievements provide the basically framework for further exploitation and elaboration by ESEA.

The final conference on Inquiry Based Science Education was organized by BMUKK, EPS and UBT and was hosted by BMUKK from 23rd to 26th of October, 2013 at the venue of a school in Bad Hofgastein, Austria. Five invited keynote experts enriched the conference with state-of-the-art talks. Several workshops were held and invited keynote talks were given to show and inform teachers, scientists, stakeholders and policy makers about the state of the art in inquiry based science teaching and learning.



PATHWAY Final Conference on Inquiry Based Science Education in Bad Hofgastein, Austria (23-26 Oct 2013)

Validation

The main aim of the work in this work package was the systematic validation of the proposed inquiry based approaches and activities in order to identify their impact in terms of the effectiveness and efficiency. According to the call this activity was independent. The PATHWAY consortium had allocated this task to European Schoolnet (EUN), the network of 31 European Ministries of Education. EUN has long experience in validating innovative approaches to teaching and learning.

As described in “D.7.1. Validation plan”, the focus of WP7 was on the collection of quantitative and qualitative feedback from the participants of PATHWAY activities, through a set of questionnaires. Since PATHWAY aimed to promote the effective widespread use of inquiry and problem based science teaching techniques in primary and secondary schools in Europe and beyond, the objective of validation was to assess the impact of the activities and determine whether initial hypotheses and objectives have been fulfilled. Specifically, validation was focused on the PATHWAY workshops of WP5.

In D7.1 we described the validation methodology, the workshops and target audience and the draft questionnaires that were used. The questionnaires have been tested and improved before the start of the full validation process in January 2012. As expected, localized validation plans were produced by M12, on the basis of localized implementation plans delivered at M10. Validation also formulated corrective recommendations which were integrated into the interim report at M24.

The purpose of the deliverable D.7.2 was to provide an overview of the validation procedures and feedback tools that we used to see the impact and uptake of the PATHWAY workshops. It contains practical information on the use of questionnaires as well as information on the collection of teacher’s feedback by each partner. Additionally, the regular reporting mechanism which helped address any issues as they appeared is described. It also included the online English version of the questionnaires that have been updated from “D.7.1. Validation plan” following tests with teachers and invaluable comments from partners.

To allow for in-depth analysis of the impact of activities, the validation was carried out around each workshop/activity at different times and in four steps: general teacher information, pre and post knowledge questionnaire and long-term impact questionnaire. The validation in PATHWAY had two evaluation cycles, one covering the workshops organized in 2012 and a second one with those organized in 2013.

EUN was in charge of analysing the data obtained from the validation questionnaires. As explained in D.7.1 and D7.2, it was necessary to have local validators who ensured the questionnaires are filled in correctly. For this reason, a structure has been set up whereas one person per country was in charge of supervising the validation procedure in that country, coordinating the local validators and liaising with EUN to report on the data obtained and/or inform of any possible issues encountered, and to make sure that any local characteristics of the workshops are incorporated and take into account in the validation exercise (local validation plans).

To ensure national validators can carry out their tasks, they needed to be trained in the validation methodology and questionnaires as well as provide feedback on translations issues and localization requirements. For this purpose, a set of meetings / discussions (both online and during management meetings) and a final face to face workshop were organized, as described in “D.7. 3 Training Workshops”, which gives an overview of the procedure followed to train the national validators as well as a description of the final workshop which took place in Brussels on the 1st and 2nd of December. As a result, a set of questionnaires to obtain feedback from the workshops’ participants have been designed as well as the protocol to obtain this information. The questionnaires have undergone extensive revision to ensure both the comprehension from the participants as well as to guarantee they will provide enough data to evaluate the impact of the PATHWAY workshops.

WP7 carried out the first full evaluation of 54 events organized by the PATHWAY partners during the period March-November 2012. These events included respondents to the pre-event and the post-event questionnaire and the event type had been identified. From these 54 events, ~ 1200 pre-questionnaires and ~500 post-questionnaires were analysed. This analysis resulted in Deliverable D7.4 Interim Validation Report. The data included in this report provided valuable input for partners in order to eventually improve the activities. It should be noted that all organizing partners also had access to the questionnaires raw data, but not to the participants’ identities. The conclusions of this report were spread over the results of the evaluation, as stated in the evaluation main goal, namely, monitoring the impact of the IBSME pathways. In particular it included: 1) Monitoring of the logistic aspect of the PATHWAY activities; 2) Measuring and understanding the impact on participating teachers; 3) Measuring and understanding the impact on teachers’ students; 4) Measuring and understanding the impact on teachers’ colleagues; 5) Monitoring the activities and formulating recommendations.

The consortium meeting and the following conference in Moscow in October 2012 were of significant importance for WP7. During the meeting, first results of the validation activities were formally presented and prompted a re-evaluation of the questionnaires to fit the conditions of the workshops better as well as to ensure a higher respondent rate. One of the major changes implemented following this meeting was the further simplification of the questionnaires. The initial set of questionnaires used for evaluation purposes included five questionnaires: Q1, Q2a, Q2b, Q3a and Q3b. The full questions can be found in deliverable D7.2 – Validation instruments and feedback tools. As mentioned, the questionnaires were simplified while preserving the main questions phrased the same way as in the initial questionnaire in order to ensure the data from the original questionnaires was compatible with the data obtained in the simplified questionnaires. The simplified protocol included three questionnaires/steps: pre-questionnaire (pre) including teacher information and pre-knowledge of IBSME, a post-questionnaire (post) obtaining information on post-knowledge of IBSME and a mid-term questionnaire (EUN) on knowledge of IBSME sent to participants a few months after filling in the post-questionnaire (i.e. a few months after they participated in a PATHWAY workshop).

The new questionnaires were sent out in all the “PATHWAY languages” at the beginning of 2013, including links to the partial reports for the partners to be able to check their status (i.e. number of respondents per event). The shorter questionnaires proved a success with tripling the number of respondents in five months, to those obtained during the whole previous year. Constant reviews of the data (in order to ensure no duplicates, correct functioning of the questionnaires, etc.) were carried out during this time.

During this period, the mid-term questionnaire was also launched. As expected, the response rate for this questionnaire was limited. In order to improve the response rate of this questionnaire as well as to complement the final report with case studies from teachers, a “competition” was organized. The email with the mid-term questionnaire to be filled in sent out to the PATHWAY workshops participants, included information on this competition. All participants that filled in the mid-term questionnaire and provided a case study would have the chance of being invited to the PATHWAY Final Conference (October 2013). 5 case studies were obtained this way, out of which 4 of the teachers were invited to the final conference. During the conference, EUN staff obtained 2 additional case studies. All 7 case studies are included in the final deliverable of WP7 (see also p. 31 of this document for exemplary case study).

A new complete analysis of the data obtained from March 2012 to end of May 2013 was carried out to see the status of the data and in order to present the results at the ESERA 2013 conference in September 2013. Out of 303 events reported, pre and post data was available from 232 of them. This time, ~ 3,700 pre-questionnaires and ~2,200 post-questionnaires were analysed: Three times more pre-questionnaires and more than 4 times more post-questionnaires than the previous report. At this time it was already possible to present overall results like typology of participants, overall impact of the PATHWAY workshops and some comparisons between types of events.

During the Final PATHWAY Conference in October 2013, the data was presented to the partners, including more advanced numbers of respondents. At this event, partners were confident we would reach the target number of 4,300 pre-questionnaires, 2,800 post-questionnaires and 600 mid-term questionnaires.

Once all questionnaires were closed, the complete data was re-evaluated one final time. The complete evaluation can be found in deliverable D7.5 Validation Report (Final). This report includes finally data from over 5,000 teachers. The PATHWAY event participants filled in 5,060 pre-questionnaires, almost 3,400 post-questionnaires and 430 mid-term questionnaires.

Such a drop in numbers is not unexpected, when participants need to complete questionnaires three times over a longer time span. However, taking into account a pre/post comparison (which is conveying the main PATHWAY messages), amazingly 3,400 tandems were reached. This result contributed to a marvellous statistical basis.

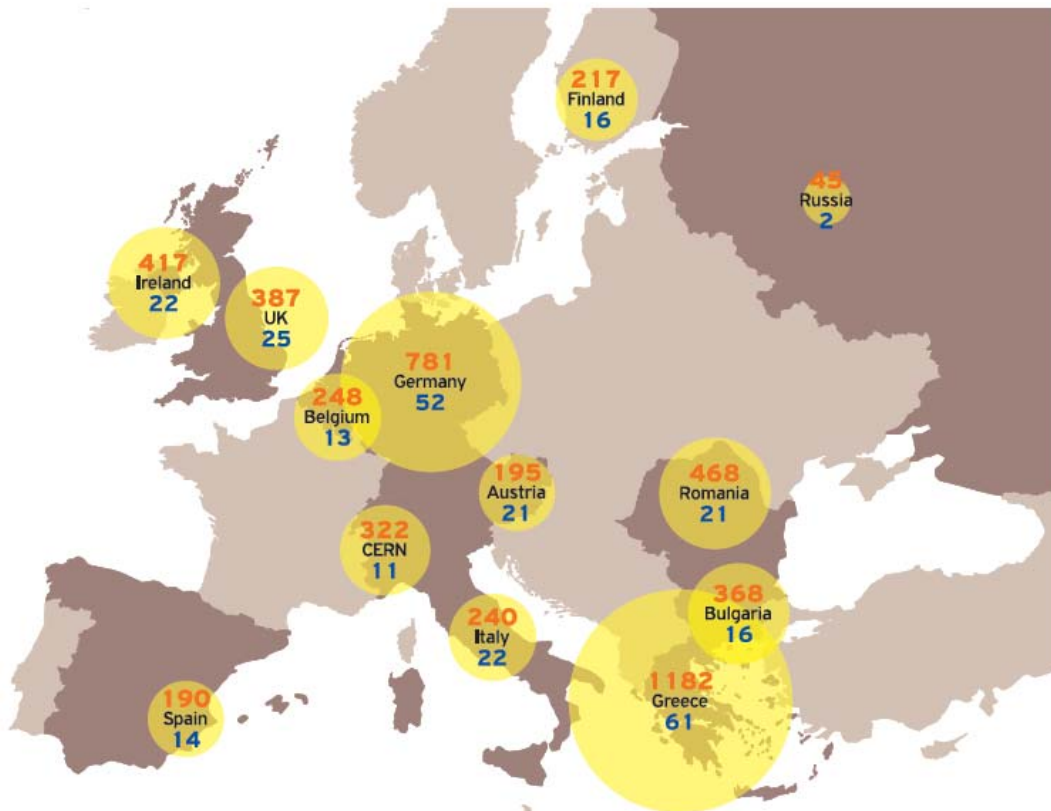
The steep drop of the midterm questionnaires was again not surprising, since this questionnaire was sent out months after the teachers had attended the events. Furthermore, it was not possible to send the mid-term questionnaire to participants of events finishing in autumn 2013 as insufficient time had passed after them for the

participants to be eligible for the final questionnaire. All in all, five times more data was obtained during the 3rd and final year of PATHWAY than during the 2nd year.

The following figure shows the numbers of training events where questionnaires were collected and the received numbers of pre-questionnaires for each participating country:



PATHWAY in Numbers



The final report has been structured so that the interested reader can locate the section of interest and read it independently of the rest of this document. The PATHWAY success is attested by the data provided and analysed in this final evaluation report. The added value of this EU project encompasses the amount and origin of trainees, the diversity of the trainees' formal and non-formal working areas and educational levels, the large amount of training events delivered in various formats and approaches, the quantity and quality of the pedagogical materials and methodologies that have been tested successfully, and the positive response and enthusiasm received from all stakeholders involved.

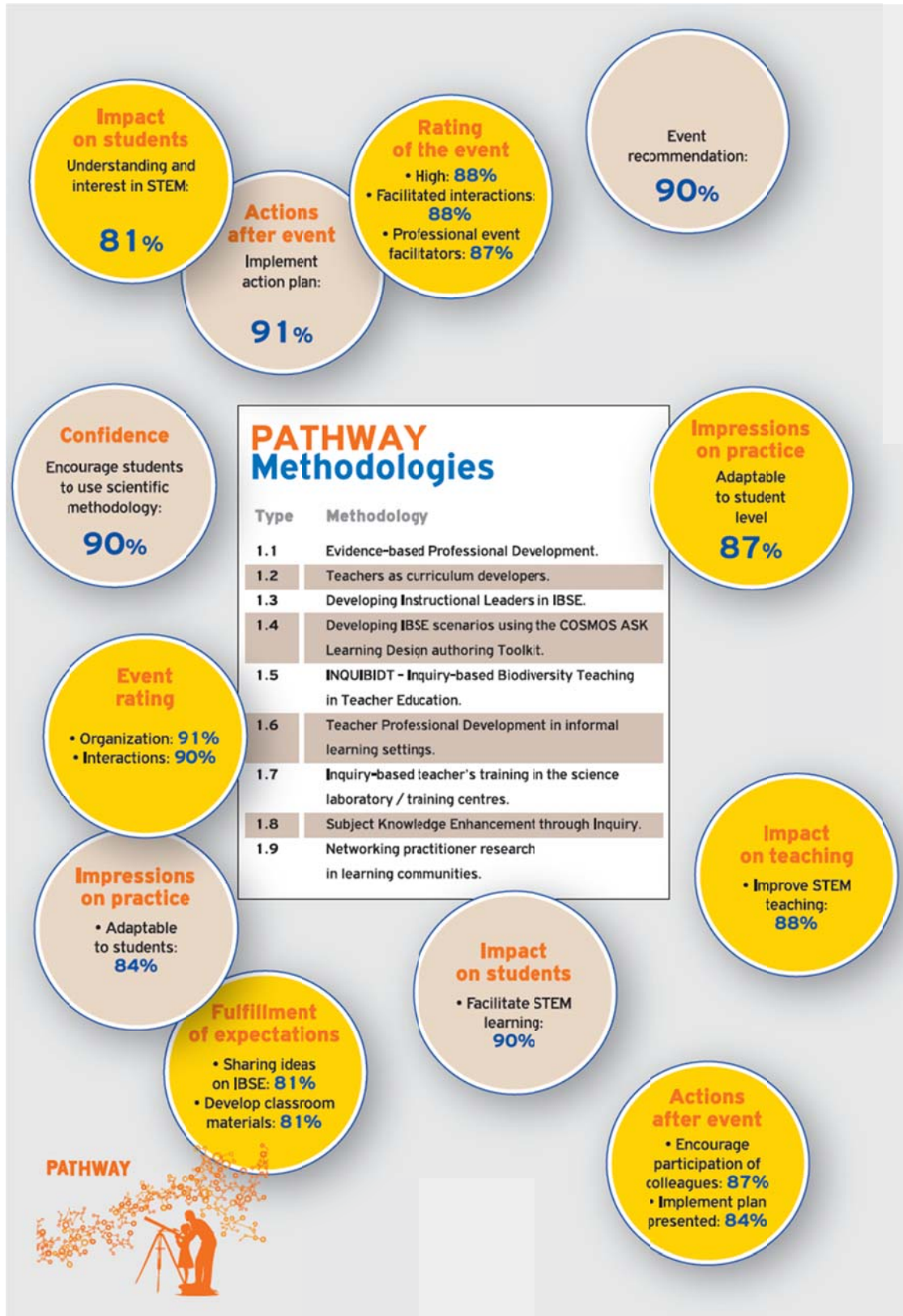
Overall conclusions from WP7

As far as WP7 is concerned, the main conclusions of the project are the following:

- The participation in PATHWAY events increases the teachers' knowledge base about IBSME as well as their attitude towards implementing these methodologies with their students and diffusing the practices among their fellow teachers.
- The relative scarcity of pre-event knowledge on the characteristics of IBSME methodologies is a good indicator for the necessity of projects like PATHWAY.
- Pre-service teachers welcomed PATHWAY events as an opportunity for learning about and also experiencing and practicing IBSME.
- Effects of the event type on the teachers' responses are found, including the use of ICT for dealing with differentiated groups of students.
- The vast amount of detailed data available for individual event types opens up the possibility to perform detailed inter-event type analysis for a large number of topics considered in the questionnaires.
- The teachers demanded more training time, as well as including further information about related European projects and also on the use of ICT.
- Teachers were quite pleased with the content of the training, even those teachers who already had some knowledge of IBSME.
- Teachers appreciated the possibility to take home practical and usable class-materials.
- The participants have shown a commitment to implementing the action plans developed during the events and many have started deploying them.
- The use of research-based instructional strategies has been shown to result in changes in teachers' practices.
- A mid-term evaluation exercise has allowed us to investigate also the mid-term persistence of the improvements made in the understanding of IBSME.

- The evaluation data can be used as a guide for the organisation of teacher training courses, and a simulation exercise showing one of many possibilities to do this has been included in the report.

The following figure provides an overview of the main results:



As a complement of the final WP7 report's sections, we have represented pictorially the average profile of participating teachers. Taking into account only the major characteristics indicated in the teachers' replies to the questionnaires, one finds an average pictorial overview which provides a simple instrument that can be used for basic analysis and comparisons. The diagram can be easily expanded to make it as comprehensive as desired, by including the most outstanding answers to other items in the questionnaires. In this way, intra-event type, inter-event type and cross-event type comparisons are quite easy to make.

In conclusion, apart from the contributions from the WP7 team that were expected from the planning of the whole PATHWAY project, the WP7 team has introduced four major original instruments:

1. A quantitative category-based analysis of the mid-term effects of the project (SOLO analyses) has been performed.
2. Average participant profiles in all major categories in the report, that can be used for analysis and intra-event type, inter-event type and cross-event type comparisons.
3. A simulation exercise is included about the use of the project's data for organising further teacher training events by the project partners or any other interested party.
4. A number of recommendations for evaluation teams participating in big projects like this one have also been included in the report.

From the amount of quantitative and qualitative data extracted from the evaluation exercise we may state that the projects' goals have been largely achieved. A major objective of the PATHWAY project was to promote and enhance the application of active T&L methodologies in the school, in particular IBSME. This message as well as the accompanying IBSME practice has reached the target. The seeds have been planted and have been shown to be already sprouting, and some areas for continuing efforts in teacher training and development as well as teachers' interactions and exchanges of resources have been earmarked.

The relative scarcity of pre-event knowledge on the characteristics of IBSME methodologies is a good indicator for the necessity of projects like PATHWAY. In fact, many pre-service teachers explicitly welcomed this PATHWAY event as an opportunity for learning about and also experiencing and practicing IBSME themselves.

The teachers demanded more training time, as well as including further information about related European projects and also on the use of ICT. They were happy with the contents of the training, even for those teachers where some knowledge on IBSME was already present. And, in particular, teachers appreciated the possibility to take home practical and usable class-materials. This item is frequently encountered in other projects. The added value of this EU project encompasses the amount and origin of trainees, the diversity of trainees formal and non-formal working areas and educational levels, the large amount of training events delivering various formats and approaches, the quantity and quality of the pedagogical materials and methodologies that have been tested successfully, and positive

response and enthusiasm from all stakeholders involved. The success of the PATHWAY project, as attested by the data provided and analysed in this final evaluation report, can be described succinctly in terms of the descriptors shown in the following figure:



Case study: Nicholas Makris' experience with PATHWAY (Greece)

"I am a primary school teacher and for the last three years I am also participating, as an external partner in developing science projects, in 1st All day Primary School of Portaria Magnisia, Near Volos - a city in the centre mainland of Greece. As an external school partner I help plan and implement projects about Physics and Mathematics in 5th and 6th grade (10 to 12 years old children). In parallel, I am about to finish my Master of Education in Modern learning environments in science and mathematics.

As a Master student of Education I was already familiar with the IBSE methodology but only from a theoretical perspective. PATHWAY has been a great opportunity for me to see and understand the IBSE methodology in practice. I now use the IBSE methodology as a teacher and external partner when I plan, develop and implement unique projects about science.

After completing the PATHWAY event I thought it was a great opportunity for me to continuously use the IBSE methodology in my lessons and in the lessons I implement.

The year just after the workshops, I also attended the PATHWAY summer school. Here I got inspired to implement a project about gravity and our solar system based on group work in all phases of my teaching interventions. I used ideas and information I had gained from the PATHWAY repository, summer school presentations and discussions with other summer school participants. In addition, when implementing the project, the kids had to work in teams to discuss their opinions, make and test hypothesis, argue their thoughts and ideas, solve open problems, measure, make experiments, and in general think and act as a scientist. (Pictures attached below from this project). My experience is that children love to work this way and find it enjoyable. For most of them it was the first time they had had the opportunity to work with others and solve open problems while interacting positively with their fellow student.

Since I attended the PATHWAY workshop I have been able to work with different science teaching perspectives and in parallel it has made me look and reflect about the nature of science from different perspectives. To be more precise I found the PATHWAY activity with the “mystery boxes” very inspiring because it effectively make the logic a science processes comprehensible for children. Since I first tried it in my classroom I realised that kids actually observe, set up hypothesis, discuss, listen, plan, test, and argue. The activity transformed them into scientists by incorporating the nature of science in their thoughts, skills and behaviours. That was a great opportunity and experience for me so enable in my teaching.

What was good about the workshop I participated in in Crete in 2012 was to existence different educators from several topics and their methodology. It gave me the opportunity to learn and teach new subjects. Another positive experience was the interactive teaching environment which the educators offered in all lessons. This interactive teaching environment helped all of us to express our opinions and learn about the other participating’s perspectives. The only drawback from the event was the duration of the workshop: participants attending the afternoon lessons did not profit effectively of the last workshops because the day had been too long.

Overall I have recommended what I learned in PATHWAY to all of my colleagues.”

This report is one out of seven case studies presented in the Deliverable “D7.5 Validation Report (Final)”, p. 245-247.

Long term impact and exploitation

Dissemination activities

PATHWAY aimed to promote the widespread use of the “Inquiry Based Science and Education” (IBSE) approach to teaching and learning science in primary and secondary schools in Europe and beyond. In order to diffuse IBSE, PATHWAY partners have organised various types of training activities in accordance with the three main axes of the project:

- A standard based approach to teaching science by inquiry using instructional models;
- A series of methods to motivate teachers to adopt IBSE techniques;
- A collection of efficient IBSE-based open educational resources and teaching practices.

With these materials and methodologies, PATHWAY improved school science teaching and empowered current and future teachers with a rich approach like IBSE, one of the most promising teaching and learning research-based practices.

In order to profit not only from the short term effect of the training activities but to guarantee sustainability of the proposed approach in the long run, within the WP responsible for Clustering and Networking specific measures were defined to support the dissemination and exploitation of results. Hence, the PATHWAY consortium employed a variety of dissemination, awareness as well as exploitation strategies that target to reassure the dissemination of project’s activities and outcomes at national, European level and beyond. Furthermore it provided the mechanisms for effective community building and active participation in order to encourage a better sharing of experience among practitioners across Europe.

The following dissemination activities have been performed by the project members:

- **PATHWAY Website**

A website (www.pathway-project.eu) was established at the beginning of the project, which supported the community building and provided guidance, offered resources, news and forums for the exchange of information on the thematic areas of the field. Moreover, the website acted as a focal hub and repository source for the entire consortium, target groups and the wider community.

The website was used extensively to upload news, announcements of events, images and/or videos from training activities and to download documents as well as to post ideas, feedback and organizational details. The PATHWAY portal that is available within the website was exclusively used for accessing (either uploading or downloading) educational material and learning activities.

The website is organized into the following sections:

- Welcome page

- Information about the project
- Information about the project partners
- Overview of the available resources
- Information about training events that will occur or have taken place in various countries
- Related news and ongoing activities (this section is directly linked to the BSCW platform that PATHWAY partners used to communicate)
- A quiz on inquiry-based teaching
- Contact details

- **Dissemination Workshops**

Dissemination Workshops were organized in the framework of major international or national events (e.g. EDEN conference, summer schools, CERN teachers' seminars). During these events the project's results were communicated to the main stakeholders.

- **Annual Conferences**

During the life cycle of the project three international conferences were organized. The aim of these events was to bring together experts and practitioners to share experiences and views on the specific field. The following conferences were held:

- 1) 5th Education Conference "Designing the School of Tomorrow"**

Athens, Greece (14.-16.1.2011)

Following the Kick-off Meeting, this conference was organized in the context of the 50th anniversary of EA and included sessions and seminars led by representatives of PATHWAY partners.

- 2) International Scientific and Practical Conference
"Science Education in the School of the Information Age" (SESIA)**

Moscow, Russia (14.-16.10.2012)

This conference was organized in cooperation with the Russian Ministry of Education and Science, the Federal Institute of Education Development, the Russian Academy of Sciences, the Russian Academy of Education, the Moscow State Department of Education and the Moscow Institute of Open Education (Project partner 24, merged with CITLE). The SESIA served as a multi-disciplinary forum for the discussion and exchange of information on the

research, development and applications on all topics related to Science Education in the general education area.

3) PATHWAY Teacher Conference

Bad Hofgastein, Austria (23.-24.10.2013)

The PATHWAY Teacher Conference took place in Bad Hofgastein, Austria, together with the final consortium meeting (25.-26.10.2013). The international conference focused on the achieved goals, towards a standard way to Inquiry Based Science Education (IBSE) that PATHWAY had accomplished. Best Practices of teaching Inquiry in school and in informal learning settings, as well as Best Practices on professional developments were presented and promotion material distributed to the teachers. The PATHWAY partners organized altogether nine workshops which were performed in three parallel sessions and attended by teachers who were mainly from Austria but also from Italy and Belgium.

- **Production and distribution of information and dissemination material**

This included posters, flyers, a bookmark, a newsletter as well as user guides and support materials for the implementation of inquiry based techniques in everyday school practice.

- **Presentations and publications of the project's achievements**

The consortium presented the project's results in numerous conferences and workshops in Europe and beyond. For example, PATHWAY was promoted by oral presentations at the ESERA (2-7 Sept 2013 in Nicosia, Cyprus) and the eKNOW conference (24 Feb – 1 March 2013 in Nice, France). The presentations were published in the conferences' proceedings. Upon the delivery of the first project results, papers were submitted to scientific journals and magazines focusing on science education. A list of the main presentations and publications is included in the core of the 2. Periodic Report.

- **Preparation of promotional videos**

Several videos, presenting the unique opportunities of the inquiry based approach and the corresponding training activities, were produced. They introduce the PATHWAY approach and show the workshops of the summer schools as well as the teachers' involvement in training activities. Moreover, the network of the European Science Education Academy (ESEA), which was developed within the project, is presented in a video as well. The videos are available on the website: <http://www.pathway-project.eu/content/pathway-short>

Exploitation of project's results

Besides the described dissemination activities that took place during the project it is now of special importance how to further exploit the project's results and how to effectively disseminate the acquired knowledge.

The key outcome of the PATHWAY project, "The Pathway to Inquiry Based Science Education" booklet, which analytically summarizes the developed Best Practices on IBSE, provides the basis for the project's exploitation. In this framework, the aim of the PATHWAY project was not only to substantially populate and contribute the Central Information Provider (Scientix Platform: www.scientix.eu) that has been developed to support the widespread of IBSE in Europe, but also to provide and make available to all European science teachers a common framework for the design, development, organization and sharing resources, methods and tools that promote teaching science by inquiry.

The following concrete measures for an effective, further exploitation have been implemented:

- Development of an international partner affiliation program: **The European Science Education Academy (ESEA)** for promoting inquiry based teaching and learning in European schools and beyond was established. It builds on the outcomes of the PATHWAY project like the developed Pedagogical Framework (D2.5), the Best Practices (D3.3) and the Guidelines for Teachers (D. 4.3). The aim of the ESEA is to create an international network of science and research centres, teacher communities, museums as well as policy makers and to promote inquiry based teaching and learning in European schools and beyond.

The ESEA has already invited international experts to two scientific workshops. In 2013, the ESEA was founded and the first workshop was taking place in Crete (1-3 July 2013). A second workshop, discussing the Action Plan for 2014-2015, followed at the University of Bayreuth, Germany, on 6 March 2014.

For more information please see the official ESEA website: www.eseaworkshop.org

- **Edited Volume on "Inspiring Science Learning"**: The content of this publication derives from the ESEA workshop in Crete (1.-3 July 2013) and includes contributions from experts working on relevant science education issues around the world and helped the project team to gain an overview of currently deployed initiatives in relevant areas. Furthermore, it gives an opportunity to promote the project results to interested communities. In this context should be mentioned that the PATHWAY achievements provide the basically framework for further exploitation and elaboration by ESEA.

This edited volume on "Inspiring Science Learning", presenting the ideas and the development process of the ESEA, was submitted as deliverable D6.6 to the European Commission at the end of the project.

- **Clustering activities and Networking:** The partnership tried, taking advantage of the well-established partners' dissemination channels, created an effective communication and collaboration with European Teachers Associations, ESERA (European Science Education Research Association) and ECSITE members. The partnership considered networking and clustering activities as major factors of the viability and the effectiveness of the results of the proposed work and collaborated closely with other projects funded by Science in Society like Natural Europe, Cosmos, Fibonacci, Proconet or Science Center to Go.

Grown out of CERN's participation in the PATHWAY project, the **Art@CMS** initiative was established (<http://artcms.web.cern.ch/artcms/>). This is an education and outreach initiative of the CMS experiment at the Large Hadron Collider (LHC), the world's largest and most powerful particle accelerator at CERN. The initiative has set up school based projects and art collaborations with a common goal: to reach out and speak to new and larger audiences via multiple and participatory channels, different from those traditionally used for scientific outreach events, by fostering creative synergies between scientists, students, educators and artists from around the world. Central to Art@CMS is the design and implementation of extended learning activities through which students can experience how big science works but they can also understand and appreciate the value of scientific work in large research infrastructures for informing responsible citizenship in a knowledge-based society.

Art@CMS is envisaged to act as a bridge between PATHWAY and the forthcoming EU projects under the Responsible Research and Innovation umbrella.

- Development and distribution of **“The Pathway to Inquiry Based Science Education”**: The consortium developed a structured set of guidelines and recommendations on how inquiry based techniques can be introduced in the school practice, how teachers can use the unique resources of science centres and museums in their lessons and how effective forms of collaboration between researchers and the educational sector (formal and informal) could create valuable and meaningful learning experiences for all, fostering exploration, discovery, curiosity and collaboration.

The report “The Pathway to Inquiry Based Science Education” briefly presents the project, its implementation, and its main outcomes, as well as discusses benefits and recommendations for the further application, improvement and integration of the project results in training policies and practices. This report was translated in 8 languages (English, Flemish, German, Italian, Swedish, Greek, Bulgarian and Spanish) and published in 10,000 copies. It was made available both in conventional form and in electronic format on the project website:

www.pathway-project.eu/content/pathway-booklet

Project consortium

The PATHWAY consortium was represented by 25 partners from 15 countries:

1. University of Bayreuth, UBT (Germany), Coordinator
2. University of Sheffield, USH (UK)
3. Bundesministerium für Unterricht, Kunst und Kultur (Federal Ministry of Education, the Arts and Culture), BMUKK (Austria)
4. University of Cambridge, UCAM (UK)
5. University of Barcelona, UB (Spain)
6. Ellinogermaniki Agogi, Research and Development Department, EA (Greece)
7. National Foundation for Educational Research/FUTURELAB, NFER/FUTURELAB (UK)
8. Museo Nazionale della Scienza e della Tecnologia Leonardo da Vinci, MUST (Italy)
9. The Institute of Accelerating Systems and Applications, IASA (Greece)
10. Katholieke Hogeschool Limburg, KHLIM (Belgium)
11. European Organisation for Nuclear Research, CERN (Switzerland)
12. Centre for Research and Technology-Hellas, CERTH (Greece)
13. European Schoolnet, EUN (Belgium)
14. Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung, FRAUNHOFER (Germany)
15. Dublin City University, DCU (Ireland)
16. University of Helsinki, HU (Finland)
17. Institute of Educational Policy, IEP (Greece)
18. School of Pedagogical and Technological Education, ASPETE (Greece)
19. University of Shumen, SHUMEN (Bulgaria)
20. Humboldt-Universität zu Berlin, HUB (Germany)
21. Ludwigsburg University of Education, LUE (Germany)
22. Casa Corpului Didactic Cluj, CCDC (Romania)
23. European Physical Society, EPS (France)
24. Centre of Information Technologies and Learning Environments, CITLE (Russia)
25. Shodor Education Foundation, SHODOR (USA)



PATHWAY – The Pathway to Inquiry Based Science Teaching

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