The Fibonacci Project

DISSEMINATING INQUIRY-BASED SCIENCE AND MATHEMATICS EDUCATION IN EUROPE

SEVENTH FRAMEWORK PROGRAMME

PROJECT FINAL REPORT

Grant Agreement number: 244684

Project acronym: FIBONACCI

Project title: The FIBONACCI Project - Large-scale dissemination of inquiry-based science and mathematics education

Funding Scheme: Coordination and support action (coordinating)

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[1] Usually the contact person of the coordinator as specified in Art. 8.1. of the Grant Agreement .

[2] The home page of the website should contain the generic European flag and the FP7 logo which are available in electronic format at the Europa website (logo of the European flag: http://europa.eu/abc/symbols/emblem/index_en.htm logo of the 7th FP: http://ec.europa.eu/research/fp7/index_en.cfm?pg=logos). The area of activity of the project should also be mentioned.

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ABBREVIATIONS USED

IBSE	Inquiry-Based Science Education
IBME	Inquiry-Based Mathematics Education
IBSME	Inquiry-Based Science and Mathematics Education
MST	Mathematics, Science and Technology
RC	Reference Centre
TC	Twin Centre
Centre	RC, TC1 or TC2
CT	Common Topic
PD	Professional Development
CPD	Continuing Professional Development

A. PUBLISHABLE SUMMARY

THE FIBONACCI PROJECT:

Disseminating inquiry-based science and mathematics education in Europe
January 2010 – February 2013

EXECUTIVE SUMMARY

The ambition of the Fibonacci Project was to contribute to the dissemination of inquiry-based science and mathematics education throughout the European Union, in ways that fitted with national or local specificities. It defined a process of dissemination from 12 Reference Centres to 25 Twin Centres, based on quality and a global approach. This was done through the pairing of Reference Centres selected for their extensive school coverage and capacities for transfer of IBSE and/or IBME with 12 Twin Centres 1 and 13 Twin Centres 2, considered as Reference Centres-in-progress. Started on 1st January 2010 for a duration of 3 years, the project was coordinated by the French *La main à la pâte* programme, with a shared scientific coordination with the University of Bayreuth (Germany).

It is somehow paradoxical that a project based on the indefinite expansion of the Fibonacci sequence would stop only after the third generation of Fibonacci centres. Intellectually seducive on paper, the Fibonacci model also passed the test of the field: all the Fibonacci centres delivered, most of the time exceeding the set targets, in terms of teacher professional development in IBSE and/or IBME and, through its twinning mechanism and associated support system for teachers and teacher educators, the project proved to be very effective in disseminating IBSE and IBME across Europe.

Indeed, one of the cornerstones of the Fibonacci project's large scale dissemination of inquiry-based science and inquiry-based mathematics education process was the twinning. From the beginning of the project, 12 Reference Centres were twinned with 12 Twin Centres 1 and 13 Twin Centres 2, which received tutoring and support for 2 years, thus gaining expertise and, in the case of TC1s, becoming able to start tutoring another centre themselves. The twinning proved to be a very effective way to build the capacity of teacher training organisations in delivering quality continuing professional development in IBSE and IBME, and a powerful dissemination tool of good practice and peer-learning at European level. The level of satisfaction of the Fibonacci partners regarding the twinning is such that 80% of the Fibonacci centres have declared their willingness to continue collaborating with their twinned partners beyond the lifetime of the project.

It is in the final phase of the project, between June 2012 and February 2013, that the Fibonacci model genuinely came into its full dimension, with the Twin Centres 3 expanding the network to over 60 teacher support centers, thus demonstrating the multiplying power of the twinning process, and the structuring and catalytic effect of the systemic and holistic approach fostered by the project.

The substantive collaborative work done on the 5 common topics and during the 5 related training sessions also came into fruition with the publishing of 5 booklets, complementing the 3 background resources perfected by the scientific committee, which are now offering a consistent view of inquiry for science and mathematics.

The most innovative elements of the Fibonacci project, i.e. the twinning process, the local community boards, the results of the 5 cross-cutting topics groups, the theoretical background on IBSE and IBME provided by the scientific committee, or the development of various forms and models of CPD, come as valuable foreground, disseminated through various publications and media, and up for exploitation by all interested science education centres in Europe and beyond. Some observed spin-off effects, like the impact on pre-service education or the certification of CPD, are a clear indication of both of the positive impact of the project and of the way forward. More investment in now needed in quality CPD content, CPD certification and teacher mobility across Europe.

Summary description of project context and objectives

★ Context, objectives and summary description of the project

The Fibonacci project was based on two previous projects, Pollen and Sinus-Transfer, mentioned in the Rocard report *"Science Education NOW!" (2007)* as reference projects for Europe. These projects have successfully implemented IBSME in a large number of European cities and regions, and, along with other projects, have paved the way for a broader dissemination of IBSME methods and objectives. The ambition of the Fibonacci project was to contribute to the dissemination of such approaches throughout the European Union, in ways that fit with national or local specificities.

Its main objective was to implement a large scale dissemination strategy for IBSME in Europe based on a European network of Reference Centres, namely institutions with high recognition in science and mathematics education. It defined a process of dissemination from 12 Reference Centres to 25 Twin Centres. This process was to be done through the twinning and tutoring of a Reference Centre of 2 Twin Centres, a Twin Centre 1 and a Twin Centre 2, which were considered as Reference Centres in progress. The project would result in a blueprint for a transfer methodology valid for further Reference Centres in Europe.

Three pillars constituted the core structuring elements of the project:

- Inquiry-based science and mathematics education for scientific literacy
- Local initiative for innovation and sustainability
- A twinning strategy for IBSME dissemination.

The project covered both the primary and secondary school levels.

It started in January 2010 and lasted 3 years. The target was to involve a minimum of 2,500 teachers and 45,000 students by the end of the project.

Supervised by a high level scientific committee, the project was coordinated by the French programme *La main à la pâte (French Academy of Sciences, Écoles Normales Supérieures of Lyon and Paris)*; the scientific coordination was shared with the University of Bayreuth (Germany). The project was endorsed by major scientific institutions such as Academies of Sciences.

The consortium included 25 members - the Reference Centres and the Twin Centres 1, along with the project coordinator - and 13 associate members - the Twin Centres 2. In total, 37 centres from 24 countries were involved in the project.

From 2012, 25 new centres, the Twin Centres 3, joined the project, expanding Fibonacci to almost all of the European countries.

The project was funded by the European Union under the 7th Framework Programme for research and technological development.

Three "Basic Pillars" to guide the work of partners

Three "Basic Pillars" were to guide the actions of partners throughout the lifespan of the project.

Pillar 1: Inquiry-based science and mathematics education for scientific literacy

Inquiry pedagogy goes beyond the learning of concepts and engages students in identifying relevant evidence and reflecting on its interpretations. By learning through inquiry, students are expected to develop concepts that enable them to understand the scientific aspects of the world around them through their own thinking, using critical and logical reasoning about evidence that they have gathered. Teachers lead students to develop the skills necessary for inquiry and the understanding of science concepts through their own activity and reasoning.
In order to guide the work of partners, nine "Basic Patterns" were formulated as touchstones for achieving a change in teaching and learning through inquiry. These patterns were analogous to the successful concept developed within the German *SINUS-Transfer* programme, and were of similar

inspiration than the 10 principles developed by *La main à la pâte* in France, which had framed the *Pollen* project:

1. Developing a problem-based culture
2. Working in a scientific manner
3. Learning from mistakes
4. Securing basic knowledge
5. Promoting cumulative learning
6. Experiencing subject boundaries and interdisciplinary approaches
7. Promoting the participation of girls and boys
8. Promoting student cooperation
9. Promoting autonomous learning.

Teachers were to be considered as experts in teaching, capable and responsible for further developing and improving their own classroom practice. These "Basic Patterns" were expected to help them frame their work and share their thoughts and ideas with their colleagues.

Pillar 2: Building on local initiatives for innovation and sustainability

Local and regional initiatives were to be at the core of the projected reform of science and mathematics education in Europe. Indeed, on the basis of the experience acquired during the *Pollen Project*, the potential for innovation within local initiatives as opposed to delocalised initiatives was known to be strong because of its reduced scale, the greater concentration of actors, and the better integration into local policies. Local initiatives were also known to allow the capitalisation of resources from different actors inside and outside the different formal education systems, progressively involving the whole local community in a joint effort. Finally, working on a small scale would allow schemes and tools to be tested before replicating them on a larger scale.

Pillar 3: Implementing a twinning strategy for dissemination of inquiry pedagogy

Dissemination within the project was to be neither top-down nor bottom-up, but rather a transfer of semi-formalised practices and experiences that had reached a satisfactory level of recognition, expertise and sustainability on a local scale. Successful strategies inspired by RCs would be replicated in TCs. In order to achieve this, each RC would be twinned with two TCs. Concretely, twinning activities would involve visits of members of the TCs to the RC on the field, on-site and distance tutoring from experienced members of the RC in order to support the TCs' emerging initiatives, and exchanges of good practices among the centres through common projects and sharing resources. Twinning activities would focus both on implementation strategies and on pedagogical content.

★ The model for dissemination: the Fibonacci sequence

The key actors of the strategy for large-scale dissemination designed within the project were to be the Reference Centres (RCs): local teacher support centres coordinated by entities of diverse types (universities, teacher education institutions, schools, science museums, science academies). Reference Centres would be responsible for spreading to other centres throughout Europe 1) a common pedagogical approach to inquiry-based science and mathematics education, and 2) successful strategies for designing Continuing Professional Development (CPD) programmes and providing material and logistic support to teachers, taking into account specific local needs and possibilities. Each teacher support centre would involve a group of local schools and teachers and develop a local network of partners to support these actions.
In order to accomplish dissemination of the pedagogy and the strategies for its implementation, each RC would be linked to two Twin Centres (TCs): a TC1, with some expertise in these two areas, and a TC2, with no expertise at all but with a clear interest in acquiring it. The RCs would be in charge of supporting the TCs to develop the necessary competencies to become, in turn, RCs. This support was to be provided through field visits and tutoring and training activities throughout the three-year life-span of the project. TCs would be provided with start-up guidance, advice and tools for developing their own teacher support strategy for implementation of inquiry pedagogy. Drawing from the results of the *Pollen* and *SINUS* projects, it was estimated that it would take two years for a TC2 to acquire the necessary expertise to become TC1, and for a TC1 to become an RC with a full capacity for dissemination.

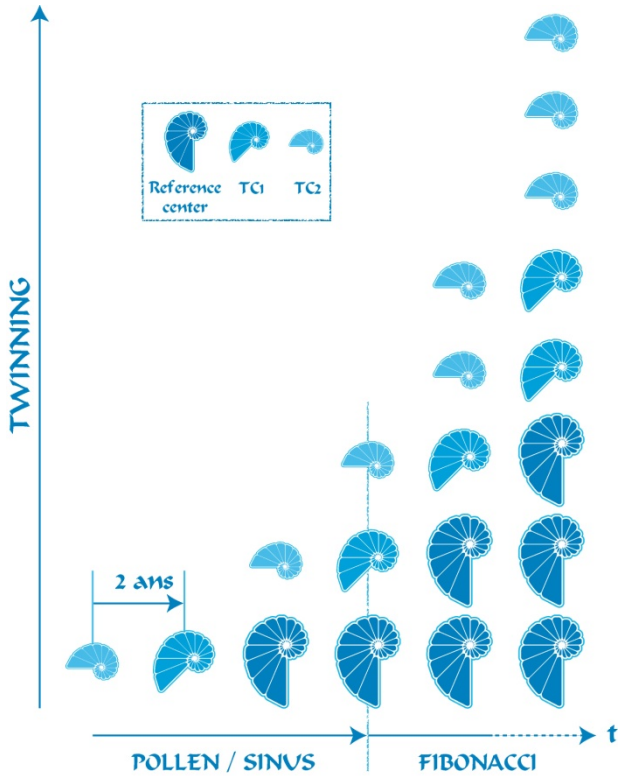
At the beginning, the *Fibonacci* project included 36 partners:

- 12 RCs, most of which had been involved in the *Pollen* or *SINUS* projects, were selected on the basis that they already coordinated a structured and on-going initiative for supporting teachers in taking inquiry-based science and/or mathematics education into the classroom at a local, district, county, or regional level. They were the initial matrix for dissemination of inquiry pedagogy in Europe.
- 12 TC1, who were selected on the basis that they already had some experience in inquiry-based science and/or mathematics education projects and who were willing to start up their own initiative according to the principles of the *Fibonacci Project*. They would be twinned with an RC after a first field visit, during which they would identify common interests.
- 12 TC2, with no experience in inquiry-based science or mathematics education projects, were selected by the RCs themselves at the beginning of the project through a competitive application. The criteria for selection included interest and perspectives for dissemination of inquiry-based pedagogy at a local and national level, official links with a national or regional institution involved with science of mathematics education, the relevance of its strategic plan for the introduction and dissemination of inquiry pedagogy, and the involvement of educational or scientific authorities in the project.

By the end of the project, the TC1s were expected to have acquired the necessary expertise to become RCs, and the TC2s would have become TC1s. A new group of 24 TC3, selected by the RCs on the same criteria than the TC2, was to join the project at the end, and visit an RC (which could be a previous TC1) at least once.

Leonardo of Pisa (c.1170–c.1250), also known as Fibonacci, has often been considered the most talented mathematician of the Middle Ages. In his book, *Liber Abaci*, he posed and solved a problem involving the growth of a hypothetical population of rabbits based on idealised assumptions. The solution was a sequence of numbers which came to be known as the Fibonacci sequence: the number of existing pairs of rabbits at a given month is the sum of the two previous numbers of pairs in the sequence: 1, 1, 2, 3, 5, 8, 13, 21… The Fibonacci number sequence was chosen to represent how mass dissemination of an educational reform could be conceived and planned: a small number of RCs would disseminate inquiry pedagogy and strategies for its implementation to the same number of TC1s and TC2s, and later to twice as many TC3s, thus accomplishing an integrative growth similar to the one described in the Fibonacci sequence (see ***Fig. 1***).

Fig. 1: The Fibonacci sequence



This was of course conceived as an ideal dissemination scheme which then had to be adapted to concrete actors and situations. Although, from the start, the differences between the RCs, TC1s and TC2s were not always clear-cut, this three-level structure was useful to organize systematic peer-mentoring between centres in which people with different levels of expertise could share knowledge.

★ Phases

The Fibonacci project was divided into the phases of launching, twinning, training & tutoring and dissemination.

★ Expected final results, potential impact and use of the results

Three types of impact were expected.

1. A network of Reference Centres in IBSME and a dissemination process for Europe

• Based on the RC, the dissemination process was designed as a progressive transfer to TC1 and TC2, the TC progressively becoming RC. At the end of the project, 12 RC and 12 TC1, which would have converted themselves into RC, would have the resources to disseminate their expertise at a European level. 12 TC2 would become TC1. 24 TC3 would join the project in a new phase of dissemination. 60 tertiary education institutions throughout Europe would thus be involved.

The dissemination process would result in a blueprint for a transfer methodology valid for further Reference Centres in Europe.

• An innovating model for scientific education reform and scale up was to be set up: at the end of the project, TC1 and TC2 were expected to have improved and deepened their experience about IBSME in classroom teaching and learning in the framework of Fibonacci. They should be able to disseminate their expertise at different levels: successful teacher PD and support, teamwork of involved teachers; PD/tutoring expertise and protocols proposed to TC 3; expertise of coordinators and tutors to deal with TC3 PD and to spread the project at local and regional level.

This model was to be popularized among stakeholders and policy-makers through the two European conferences.

2. Local impact on direct beneficiaries: teacher educators, teachers and pupils

The implementation and consolidation of innovative, inquiry-based science and mathematics education activities, the development of a sustainable framework to ensure the involvement of local actors, as well as the European events and activities organized in the project was to benefit the teacher educators, the teachers and the pupils.

The teacher educators from in-service and pre-service PD institutions were expected to especially benefit from the project in terms of PD skills and methods.

At the end of the project, a minimum of 2,500 teachers and 45,000 pupils from primary and secondary schools should be involved.

The number of pupils was expected to reach a total of 46,500, with the following breakdown:

- 12 RC x 25 classes x 25 pupils (average) = 7,500 pupils (for 3 years)
- 12 TC1 x 20 classes x 25 pupils (average) = 6,000 pupils (for 3 years)
- 12 TC2 x 10 classes x 25 pupils (average) = 3,000 pupils (only for 2 years)

3. Spreading excellence, exploiting results, disseminating knowledge

This was to be sought through different actions: communication, wide dissemination to interested non-participating parties, European and national networks, Greenwave Europe, the European training sessions and the European conferences. Two other results were expected:

• The guidelines on the 5 major topics related to IBSE and IBME.
This set of documents was expected to provide an operational definition of IBSME taking into account the diversity of cultural and institutional contexts, as well as concrete steps towards its local implementation.

• A feasibility study for the creation of a European Network of Reference Centres.
Capitalising on the project results, it was meant to deliver a complete document for European stakeholders to consider the possibility and usefulness of creating a European network of reference centres for science and mathematics education, with the capacity to follow up and foster initiatives in all member countries.

★ Fibonacci centres' objectives:

Short-term objectives:

- to structure a more consistent and more efficient local and regional educational community of partners,
- to develop and test a CPD strategy which could lead to a noteworthy improvement of teachers' practices and skills in the classrooms,
- to test a dissemination process of this strategy for getting in touch with more stakeholders of the education system.

This was done with the **long term aim of**:
- improving the quality and the efficiency of pupils' science and technology learning process,
- implementing within the educational system some useful elements of external professional cultures, based on a better knowledge of: what is inquiry, how researchers work, what is a project, what are the working rules in industrial teams, how to manage work with outer support... this improvement being based on meeting and concretely working with some representatives of these fields.
- launching a development for many more years than the project duration, given the huge amount of people needing to get in a CPD process.

★ The project partners

The European coordination of the project as well as the science coordination was taken on by *La main à la pâte* (Paris), and the mathematics coordination by the University of Bayreuth. A scientific committee of acknowledged experts in science and mathematics education was to provide partners with the necessary scientific background on inquiry pedagogy in science and mathematics. An external evaluator, *Educonsult*, worked closely with the partners to provide them with formative feedback throughout the implementation of the project and evaluate its impact on the different stakeholders. The full list of Fibonacci partners is given in ***Fig. 2,*** and ***Fig. 3*** shows their localisation in Europe. Throughout the text, the project partners will be referred to by the name of the city they are located in.

Fig. 2: Full list of teacher support centres with coordinating institution and their level of expertise (RC, TC1, and TC2)

City	Country	Coordinating Institution	Level of expertise
AABENRAA	Denmark	University College South Denmark	RC
ALICANTE	Spain	University of Alicante	TC2
AMSTERDAM	Netherlands	Hogeschool van Amsterdam	RC
ANTWERPEN	Belgium	Dienst Katholiek Onderwijs	TC1
AUGSBURG	Germany	University of Augsburg	RC
BAD BERKA	Germany	Thuringer Institut fur Lehrerfortbildung	TC2
BAYREUTH	Germany	University of Bayreuth - Mathematisches Institut - Lehrstuhl für Mathematik und ihre Didaktik	RC

BELFAST	UK/Northern Ireland	Queens University	TC2
BELGRADE	Serbia	Vinca Institute for Nuclear Sciences	TC1
BERLIN	Germany	Free University of Berlin	RC
BRUSSELS	Belgium	Free University of Brussels	TC1
ÇANKAYA-ANKARA	Turkey	Academy of sciences - TUBA	TC2
CESKE BUDEJOVICE	Czech Republic	University of South Bohemia	TC1
DUBLIN	Ireland	St Patrick's College	TC1
GLASGOW	UK/Scotland	University of Glasgow	TC2
HELSINKI	Finland	University of Helsinki	TC1
KLAGENFURT	Austria	University of Klagenfurt	RC
KOBENHAVN	Denmark	Aarhus University - Centre for Science Education	TC2
KOLN	Germany	Cologne and Bonn Chambers of Commerce and Industry	TC2
KRAKOW	Poland	Jagiellonian University - Instytut Fizyki UJ	TC2
LEICESTER	UK/England	University of Leicester	RC
LISBON	Portugal	Ciencia Viva - National Agency for Scientific and Technological Culture	TC1
LJUBLJANA	Slovenia	University of Ljubljana	RC
MAGURELE	Romania	National Institute for Lasers, Plasma and Radiation	TC1
NANCY	France	PRES of the University of Lorraine	TC2
NANTES	France	Nantes Graduate School of Engineering	RC
NAPLES	Italy	National Association of Science Teachers (ANISN)	TC2
PATRAS	Greece	University of Patras	TC1
SAINT-ÉTIENNE	France	ARMINES/St Étienne Graduate School of Engineering	RC
SANTANDER	Spain	University of Cantabria	TC2
SILKEBORG	Denmark	VIA University College	TC2
SOFIA	Bulgaria	IMIBAS - Institute of mathematics and informatics - Bulgarian Academy of sciences	TC1
STOCKHOLM	Sweden	Royal Swedish Academy of Sciences	RC
TARTU	Estonia	University of Tartu	TC1
TRNAVA	Slovakia	University of Trnava	RC
VIENNA	Austria	Pädagogische Hochschule Wien	TC2
WALFERDANGE	Luxemburg	University of Luxemburg	TC1
ZURICH	Switzerland	University of Zurich - Institut für Erziehungswissenschaft	TC1

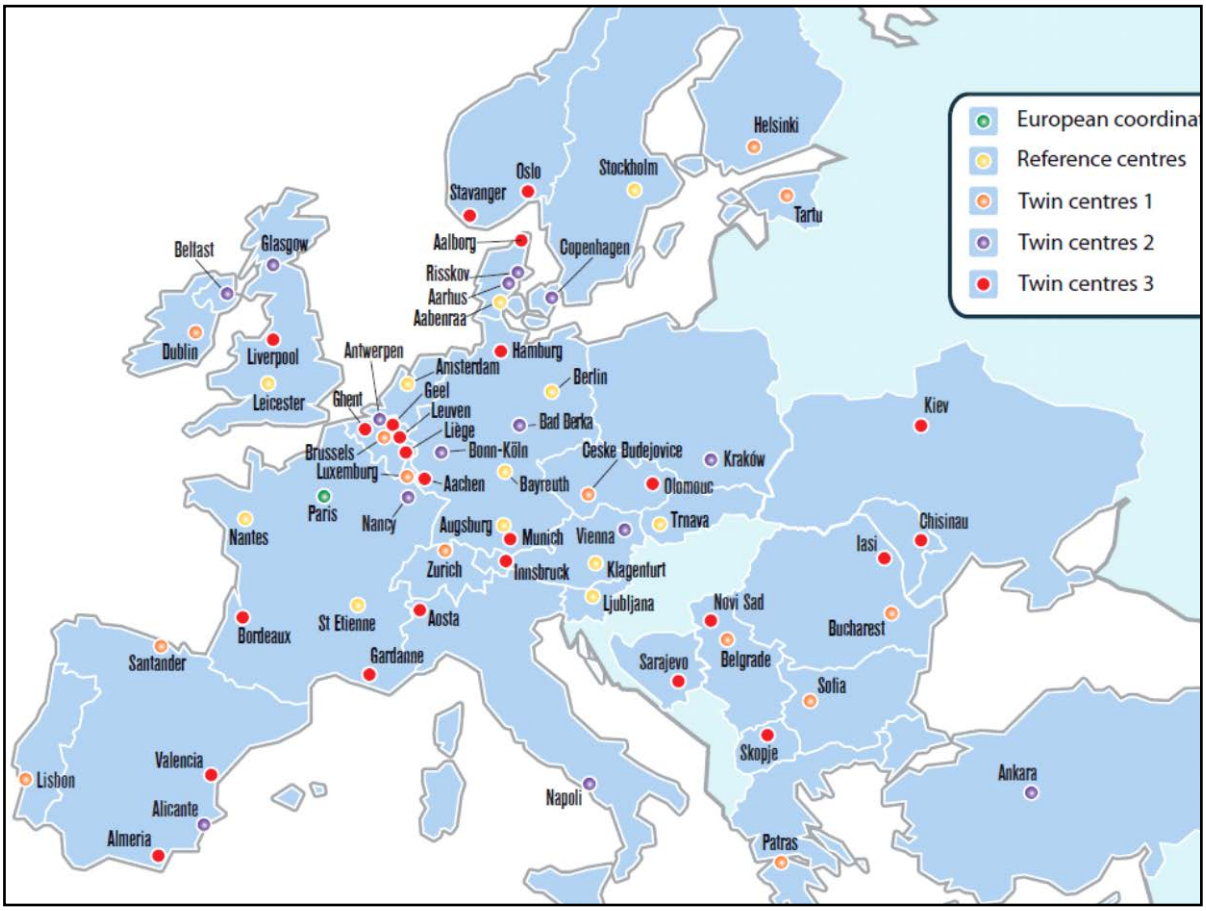
List of TC3 (joined the project in 2012):

City	Country	Coordinating Institution
AACHEN	Germany	RWTH Aachen, Lehr- und Forschungsgebiet Didaktik der Mathematik (device- and research-field didactics of mathematics)
AALBORG	Denmark	Aalborg University - Department of Learning and Philosophy
ALMERIA	Spain	University of Almería
AOSTA	Italy	Assessorato Istruzione e Cultura-Regione Autonoma Valle d'Aosta / Didattica delle scienze sperimentali, educazione ambientale
BORDEAUX	France	Cap Sciences - centre de culture scientifique
CHISINAU	Republic of	Organization for Reform and Development in Educational

	Moldova	System, ORDSE
GEEL	Belgium	Katholieke Hogeschool Kempen vzw
GHENT	Belgium	Artevelde University College Ghent
HAMBURG	Germany	Universität Hamburg - Fakultät 4 - Erziehungswissenschaft, Psychologie und Bewegungswissenschaft
INNSBRUCK	Austria	Pädagogische Hochschule Tirol
KIEV	Ukraine	Institute of Gifted Child of the National Academy of Pedagogical Sciences of Ukraine
IASI	Romania	Alexandru Ioan Cuza University of Iasi, Faculty of Psychology and Education Sciences, department of Education sciences
LEUVEN	Belgium	KHLeuven, University College Leuven
LIÈGE	Belgium	ASBL Hypothese / Haute école HELMo
LIMASSOL	Cyprus	Cyprus Centre for Environmental Research and Education (CY.C.E.R.E.)
LIVERPOOL	United Kingdom	Liverpool Hope University
MARSEILLE	France	Direction des services départementaux de l'éducation nationale des Bouches du Rhône - CRDS de Gardanne
MUNICH	Germany	ISB (State Institute for School Pedagogics and Education Research)
NOVI SAD	Serbia	Faculty of Sciences, University of Novi Sad
OLOMOUC	Czech Republic	Faculty of Education, Palacký University
OSLO	Norway	The Norwegian Centre for Science Education
SARAJEVO	Bosnia-Herzegovina	Foundation "Education in Action"
SKOPJE	Macedonia	Faculty of Natural Sciences and Mathematics at the University "St. Cyril and Methodius"
STAVANGER	Norway	University of Stavanger
VALENCIA	Spain	Dpt. Didàctica de les Ciències Experimentals i Socials – Universitat de València

Fig. 2: Localisation of partners throughout Europe

THE FIBONACCI NETWORK



★Transversal activities among partners

As a complement to twinning and mentoring, three other forms of common work among partners were to be carried out: reflexion on five transversal topics, European Conferences linking research and practice, and a collaborative project for teachers and their students.

→ Topic groups: developing a better understanding of inquiry, organizing European Training Sessions, and developing resources

Five transversal topics were selected to advance the understanding of inquiry pedagogy and its implementation through collaboration among groups of partners:

1) Deepening the understanding of inquiry in mathematics
2) Deepening the understanding of inquiry in natural sciences
3) Implementing and expanding a Centre for Science and/or Mathematics Education (CSME)
4) Integrating inquiry across the curriculum
5) Using the external environment of the school

Each topic group was expected to develop a better understanding of its topic, which involved converging towards common strategies and methodologies. Each topic group would organise a European training session aimed at reflecting on, sharing and disseminating good practices and resources on their particular topic. Training sessions were expected to bring together 60 participants including representatives from partner institutions and key actors exterior to the project. The topic groups would maintain a constant back-and-forth dialogue between their reflection and classroom work: the topic group's activities were expected to guide the work conducted with the classes in each centre, and the work in the classroom was expected to provide the necessary field work for each topic.

At the final phase of the project, each group produced a resource on their topic, providing recommendations and good practices based on the three-year experience of implementation[3].

→ *European Conferences: networking and linking research and practice*

Two European Conferences, open to outside participants, were to be held in the framework of the project:

- ***Raising Awareness about Inquiry-Based Science and Mathematics Education in Europe*** (21-22 September 2010, University of Bayreuth, Germany).
- ***Bridging the Gap between Scientific Education Research and Practice*** (26-27 April, 2012 University of Leicester, UK).

The main goal here was to raise awareness of the project objectives, particularly amongst the scientific community, and to explore strategies for improving inquiry-based science and mathematics education through research and evaluation of innovative practice.

→ *Greenwave: a European project for teachers and their students*

Based on the platform and pedagogical project developed by Discover Science and Engineering/Discover Primary Science (Ireland), the Greenwave project (www.greenwave-europe.eu) deals with the fact that every year a green wave can be seen moving across Europe in springtime, as different species bud and come into leaf. Classes involved in the *Fibonacci Project* were invited to participate in this project by posting on the website the species they spotted which act as very early indicators of the arrival of spring and as nature's clock.

★ Project website

Information on the project and numerous resources are freely available at:

ww.fibonacci-project.eu

[3] The *Fibonacci Companion Resources* presented in Chapter 7 are the outcome of the work of the topic groups.

THE FIBONACCI PARTNERS

European coordination & scientific coordination for science		Scientific coordination for mathematics		Members of the Scientific Committee
France	École Normale Supérieure, Paris / La main à la pâte (Academy of Sciences)	**Germany**	University of Bayreuth	**France – Paris 7 University – ARTIGUE Michèle** **UK – King's College, London – DILLON Justin** **UK -** University of Bristol – HARLEN Wynne France – Academy of Sciences – LENA Pierre

TWINNING BETWEEN THE CENTRES

Reference Centres *Consortium members*		Twin Centres 1 *Consortium members*		Twin Centres 2 *Associate members*	
Austria	Universitaet Klagenfurt	**Finland**	Helsingin Yliopisto	**UK/Scotland**	University of Glasgow
Denmark	Professionshojskolen Syd University College	**Portugal**	Ciencia Viva - Agencia Nacional Para A Cultura Cientifica E Technologica	**Spain**	Universidad de Alicante
France	ARMINES / Ecole Nationale Supérieure des Mines de Saint-Etienne	**Belgium**	Université Libre de Bruxelles	**Italy**	Associazione Nazionale Degli Insegnanti Di Scienze Naturali (A.N.I.S.N)
France	Ecole Nationale Supérieure des Techniques Industrielles et des Mines de Nantes	**Greece**	University of Patras	**France**	PRES de l'Université de Lorraine
Germany	Freie Universitaet Berlin	**Luxemburg**	Université du Luxembourg	**Germany**	Industrie- und HandelsKammer Bonn/Rhein-Sieg und zu Köln
				Turkey	Türkiye Bilimler Akademisi (TÜBA)

Germany	Universitaet Augsburg	**Switzerland**	Universitaet Zuerich	**Denmark**	NAVIMAT, Nationalt Videncenter for Matematikdidaktik, University College UCC
Reference Centres *Consortium members*		**Twin Centres 1** *Consortium members*		**Twin Centres 2** *Associate members*	
Germany	Universitaet Bayreuth	**Bulgaria**	Institute of Mathematics and Informatics of the Bulgarian Academy of Science	**Germany**	Thüringer Institut für Lehrerfortbildung, Lehrplanentwicklung und Medien
		Spain	Universidad de Cantabria		

Netherlands	Universitaet van Amsterdam	Romania	INLFPR	**Belgium / Flanders**	Dienst Katholiek Onderwijs Vzw
			twinning open to several TC1 which have interest in the ICT pedagogical tools and the related expertise developed by Universitaet van Amsterdam		

Slovakia	Trnavska Univerzita v Trnave	**Romania**	INFLPR - Institutul National De Cercetare Dezvoltare Pentru Fizica Laserilor Plasmei si Radiatiei	**Austria**	Pädagogische Hochschule Wien

Slovenia	Univerza V Ljubljani	**Serbia**	Institut Za Nuklearne Nauke Vinca	**Poland**	Uniwersytet Jagielloński

Sweden	Kungliga Vetenskapsakademien	**Estonia**	Tartu Ulikool	**Denmark**	VIA University College

United Kingdom	University of Leicester	**Ireland**	St Patrick's College Drumcondra	**UK/Northern Ireland**	Queen's University Belfast

Associate partner for the Greenwave Europe project		**External evaluator**	
Ireland	Forfas / *Discover Primary Science and Maths*	Belgium	Educonsult

Main S&T results/foregrounds

1. Conceptualizing Inquiry in Science and Mathematics Education

The 'Rocard Report' was useful in bringing a long-established pedagogical and epistemological approach to science teaching into the realm of educational politics. But the popularity of inquiry pedagogy, added to this new political reality, exposed it to a variety of interpretations. Project partners were conscious from the start that a loose definition of inquiry prevailed in Europe, which meant that the type of teaching practice designated by this term often varied from one context to another and that some of the existing approaches to inquiry lacked rigorous conceptualization.

Providing partners with a careful conceptualization of inquiry-based science and mathematics education was thus one of the main tasks of the project's scientific committee. It involved coming to terms on an operational definition of inquiry pedagogy for science and mathematics inspired on the general pedagogical principles shared by the project partners[4]. It also involved building bridges between two distinct, yet interdependent epistemologies: the natural sciences and mathematics.

2. Resources for understanding inquiry and implementing it in the classroom

Giving teachers easy access to the resources necessary for inquiry-based teaching is fundamental (although not wholly sufficient) for inquiry to happen in the classrooms. Without the resources, setting up an inquiry-based activity may become so burdensome for teachers that discouragement is very likely to follow. Teachers need both teaching guides and modules that propose activities especially conceived for inquiry-based teaching. Giving teachers access to these resources is yet another challenge that requires substantial planning and monitoring.

Experience in many areas of change in education is that participation in developing new procedures or materials by those who have to implement them is a most effective way of encouraging commitment to change. When groups of teachers work together with researchers or developers they can be creative and experimental in a safe environment, learn from each other, combine ideas, and achieve ownership of the emerging practices.

In order to support the effective implementation of inquiry pedagogy in science and mathematics throughout Europe, the *Fibonacci Project* produced two complementary sets of resources. The *Background Resources* define the general principles of inquiry pedagogy and of its implementation in science and mathematics education. They are addressed to a public of teachers and teacher educators and tackle the pedagogical, didactical, and epistemological implications of such an approach.

The *Background Resources* evolved gradually throughout the three-year life-span of the Fibonacci Project from a set of documents originated in the framework of the Pollen and SINUS projects. They are one of the outcomes of the fruitful dialogue generated by the project among the science and mathematics education communities in Europe. Although they are theoretical documents, grounded on the findings of education research, they take account of the needs identified on the field during the three years of implementation of the *Fibonacci Project* in the 32 different partner countries.

The *Companion Resources* are based on the collaborative work of four groups of ***Fibonacci*** partners. They provide practical information, instructional ideas and activities, and evaluation tools for the effective implementation of inquiry pedagogy in science and mathematics in schools. This collection of booklets underwent a strict editorial process supervised by the project's scientific committee. There are cross-references among them and to the *Background Resources* where pertinent.

Protected by a Creative Commons licence, all of these booklets are available for free download on the Fibonacci website, in the Resources section. They can be reproduced, distributed, and even modified

[4] These pedagogical principles shared by the project partners refer to the nine "Basic Patterns" of the SINUS project.

(i.e. translated or complemented), as long as it is non-profit, as long as credit is given concerning the original document, and as long as the new document is licensed under the same conditions. Many reprints, translations and adaptations of the *Background Resources* by individual Fibonacci partners are already under way. All translations and adaptations will be made available on the *Fibonacci* website.

Together, the *Fibonacci Background and Companion Resources* convey a clear and shareable definition of inquiry pedagogy and define a common inquiry-based proposal for science and mathematics education without forgetting the important epistemological differences among these two disciplines.

Resources for Implementing Inquiry in Science and Mathematics at School

Target readers: teachers, teacher educators, CSME coordinators, and other actors concerned with the implementation of inquiry-based pedagogy in science and mathematics at a local level

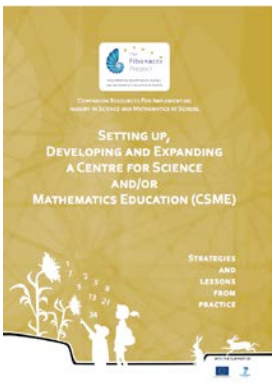
Background Resources

Companion Resources

Available for free download at www.fibonacci-project.eu, in the *Resources* section.

3. A resource for developing a teacher support centre

A special resource was produced in the framework of the *Fibonacci Project* in order to support future implementation of the strategy described in the previous sections by local stakeholders. The booklet *Setting up, Developing and Expanding a Centre for Science and/or Mathematics Education (CSME*), developed through close collaboration among 10 *Fibonacci* partners (Amsterdam, Bayreuth, Belgrade, Berlin, Brussels, Glasgow, Klagenfurt, Ljubljana, Nantes, and Trnava), the *Fibonacci* European Coordination (Paris), the four members of the *Fibonacci* scientific committee, and the project's external evaluator (*Educonsult*), aims to support entities interested in setting up, developing and expanding a teacher support centre. The booklet provides an organisational framework with strategies, recommendations, and lessons learned through implementation during the three-year life-span of the project in seven strategic areas. It also provides examples of how these strategies and recommendations were successfully implemented and adapted to specific cultural, political, and educational contexts through nine selected profiles from centres involved in the *Fibonacci Project*. An overview of the strengths of the other centres that took part in the project is also provided, thus giving the reader the opportunity to identify and contact potential collaborators.



4. Local initiatives for innovation and sustainability

Rather than assuming that all contexts are the same – and thus that one solution fits all – in the *Fibonacci Project* it was assumed that different learning environments require different solutions. This is the reason why local teacher support centres (RCs and TCs) were at the core of the project's dissemination strategy. The centres worked on various levels: providing continuous professional development for science and/or mathematics teachers, developing resources and giving teachers access to them, creating and promoting teacher networks, and involving the local community in all of these initiatives. By designing its own strategic plan, each centre tackled each of these fronts by making the best possible compromise between three variables: 1) its local needs; 2) educational research findings concerning what works best; 3) the financial and human resources at hand. The various strategic work areas of each teacher support centre are briefly described in what follows. Examples of successful initiatives developed by the centres within the project, compiled by *Educonsult* (the project's external evaluator), are given in boxes.

Box 1	**Examples of CPD programmes developed by the teacher support centres**
In **Aabenraa**, the teacher support centre is operated by University College South Denmark, who has an impressive material store for teachers and is connected to a national network of Centres for Educational Resources. In Denmark, inquiry-based instruction is already imbibed in the educational system. Thus, the core of Aabenraa's CPD strategy was adapting existing resources from the centres to inquiry-based practice and providing punctual support to individual teachers upon request for teaching specific subjects through inquiry. In **Nantes**, the teacher support centre is operated by an engineering school (École des Mines de Nantes). Most teachers already have at least some knowledge of inquiry-based practice from their previous training. A CPD strategy based on providing in-class support by engineering students was	

successfully set up.

In **Trnava**, the teacher support centre is operated by Trnava University, whose school of education has a long experience in constructivist approaches to science teaching. The educational system is extremely conservative and thus teachers are still formed to implement transmission approaches. In order to respond to this situation, a long-term, 120-hour credited teacher course in inquiry-based science education was designed and successfully implemented.

In teacher support centres with little experience in CPD for inquiry-based instruction, the need for a reliable strategy for diagnosing the specific needs of each group of teachers came up early in the project: although conducting interviews or surveys among teachers was an option, this was often not sufficient, particularly when teachers were completely new to inquiry-based teaching and thus did not have the elements to assess their own teaching in the light of this particular teaching model. A *Diagnostic Tool for CPD Providers*, especially adapted to diagnose the needs of teachers for implementing inquiry pedagogy in science, was developed and tested in classrooms of five different partner countries, with the involvement of teachers, teacher educators, and science education researchers. The tool is part of the *Fibonacci Companion Resources* and can be downloaded free of charge at the project website.

5. Development and distribution of pedagogical resources at a local level

Giving teachers easy access to the resources necessary for inquiry-based teaching was stressed as fundamental (although not sufficient) for inquiry to happen in the classrooms. Without the resources, setting up an inquiry-based activity may become so burdensome for teachers that discouragement is very likely to follow. Teachers need both teaching guides and modules that propose activities especially conceived for inquiry-based teaching. Giving teachers easy access to these resources is yet another challenge that requires substantial planning and monitoring. **Box 4** provides some examples of successful initiatives for distributing resources at a low cost.

Box 2	**Examples of successful initiatives for giving teachers access to resources**

A structured national network of Centres for Educational Resources

The Danish Centres for Educational Resources have been giving teachers access to resources since the 1930s. Their function is to build up a collection of teaching resources intended to be on loan to educational institutions, to provide information and offer guidance to teachers regarding the teaching resources in their collection, and to support teachers in developing their personal teaching resources. The centres host a complete collection of up-to-date school handbooks and related material covering the educational needs of the schools and institutions they serve. The collection includes a large selection of audiovisual learning materials and multimedia resources. The schools served by the centres have weekly deliveries of materials, which have been booked through an online platform or on the phone. The teacher support centre in **Aabenraa** relied on the Centres for Educational Resources present throughout the national territory to disseminate inquiry-based practices in science and mathematics by adapting the existing material to an inquiry-based approach.

Free or low-cost access to resources

Some centres, such as **Paris**, have developed a great deal of inquiry-based science teaching resources which are free of translation fees, provided an agreement of use for non-profit purposes is signed. The teacher support centre in **Belgrade** was started with practically no financial support thanks to the possibility of accessing the French materials for free. Other centres, such as **Bayreuth**, translated a selection of their resources to English and made them available for free download on the Internet.

Experience in many areas of change in education is that participation in developing new procedures or materials by those who have to implement them is a most effective way of encouraging commitment to change. When groups of teachers work together with researchers or developers they can be creative and experimental in a safe environment, learn from each other, combine ideas, and achieve ownership of the emerging practices. **Box 3** provides an overview of the resources produced by the *Fibonacci* teacher support centres.

Box 3	Overview of pedagogical resources produced locally by the teacher support centres

All centres produced resources with and for their teachers in their native languages. Some centres, such as **Naples**, **Klagenfurt**, and **Sofia**, produced a considerable amount of publications. Local resources take many different forms: DVDs or films showing how inquiry-based education is applied in concrete classroom situations (**Aabenraa**, **Berlin**, **Ljubljana**, **Saint-Etienne**, **Stockholm**, **Tartu**), pedagogical kits for teachers, description of CPD offers delivered by a particular centre (**Amsterdam**, **Bucharest**, **Dublin**, **Nantes**, **Trnava**, **Nancy**, **Saint-Étienne**, **Tartu**, **Vienna**), research publications on the impact of inquiry-based teaching on teachers and students (**Augsburg**, **Krakow**, **Leicester**, **Ljubljana**, **Patras**).
Further, each centre developed a website in its own language. In several cases, teachers can upload materials on the website after undergoing a quality check by the centre, making it available to other teachers. In some cases blogs were also created.

6. Creation and promotion of local and national teacher networks

A qualitative change in teaching practices requires time and depends largely on group effort. A teacher's mid and long-term willingness and capacity for conscious engagement in transforming their teaching is a key factor to ensure sustainable change[5]. Support, exchange, and co-assessment systems enable teachers to share and compare their practice, their thoughts, and their individual skills, and thus to consciously engage with others in the transformation of their teaching. And, most importantly, it enables teachers to remain the primary drivers of their own careers.
The *Fibonacci* teacher support centres promoted various forms of successful teacher networking. **Box 4** provides a few examples.

Box 4	Examples of teacher networks created by the teacher support centres

Different forms of cooperation among teachers
The SINUS project's teacher networking model, under the coordination of **Bayreuth**, inspired the networking model of the *Fibonacci Project*. The model is based on various forms of close cooperation and networking among teachers at all different levels of the national school system. Cooperation among teachers takes place within the department of a school and also beyond each individual school. Exchanges of ideas and experiences on a state level and supervision and support on an interstate level promote and strengthen cooperation with local implications. In addition, teachers cooperate both in an intra and inter-disciplinary manner.
The long-term CPD course developed in **Trnava** includes various forms of cooperation among the teachers involved. For example, trainers visit teachers in their classrooms and analyze their lessons with them, and participants attend open lessons given by expert teachers with follow-up discussions.
'Multiplier' teachers
Bayreuth, **Ceske Budejovice**, **Klagenfurt** and **Tartu** worked with 'multiplier' teachers: expert teachers especially trained to support less experienced teachers in their classrooms. This built powerful learning communities. Occasional meetings of all the teachers involved in the project at a local or regional level also enhanced networking across schools. Learning communities also developed within schools as a result of the project. In **Dublin**, **Augsburg**, and **Belgrade**, teachers who benefited from the CPD provided by the centre acted as multipliers towards some of their colleagues. In **Luxembourg** and in **Zurich**, structured strategies for teachers to share the expertise acquired through their participation in the *Fibonacci Project* with all the other teachers from their school were developed.

7. Community involvement

An educational initiative such as establishing and developing a teacher support centre is necessarily inscribed in a specific local context at a neighbourhood, city, and/or district level. This context must be carefully examined and associated to the centre through local partnerships. Local partners are crucial

[5] Gather Thurler M. and Bronckart, J. (2004). *Transformer l'école.* Brussels: De Boeck.

because they provide different types of support to the centre as well as contributing to opening the school to its environment by linking science and mathematics activities with daily life situation and professional contexts. Partners can be academic or municipal authorities, academic or scientific, public or private organisations (universities, museums, research centres or laboratories, enterprises, businesses, industry, associations, cultural centres, etc.), and/or individuals concerned with science and/or mathematics education (i.e. the pupils' parents).

With the *Fibonacci Project*, each teacher support centre developed a community board at a local, regional or sometimes national level, in which all stakeholders were represented, to support and help to make the work of the centre sustainable. This allowed resources from inside and outside the local education system to be capitalized, and tools and strategies developed within the project to be tested at a local level before replicating them on a larger scale. Examples of successful community boards developed within the *Fibonacci Project* are given in **Box 5**.

Box 5	**Examples of successful community boards**

In **Berlin**, the "TuWaS!" project runs on the basis of an impressive local network involving many different types of partners from the private and public domains who each contributed in a different and creative manner to the success of the *Fibonacci Project*. Support does not always mean money:

- The co-founder of TuWaS!, the Brandenburg Academy of Sciences and Humanities, provides knowledge and the support of renowned scientists, as well as a political connection. The academy also hosted two conferences on inquiry-based science education.
- Early on, TuWasS! was supported by the TSB Technologienstiftung Berlin, which funded teaching material for technology topics and provided the salary for the head of the material centre. In addition, it helps to promote TuWasS!.
- The Senate Department of Education, Youth and Science contributes with financial support and knowledge of the school system. They funded the acquisition and adaptation of teaching materials and allow teachers to work part time for TuWaS!, while being paid by the school system.
- TuWaS! Is also supported by companies. For example, GO! EXPRESS & LOGISTICS, which specialises in secure transport of time-critical shipments, delivers and picks up the teaching materials without charge. Companies also helped to buy some of the teaching material.
- The Berlin chapter of the Junior Chamber International provided funds to pay for the professional development of teachers. In addition, young volunteers (*freiwilliges ökologisches Jahr*) work for the project by helping to adapt the material and organise public events.

In **Brussels**, **Dublin**, **Helsinki**, **Leicester**, and **Ljubljana**, the creation of community boards resulted in strong interactive networks of universities, national and local decision-makers (ministries and town councils), academies of science, companies, heads of schools, researchers, teacher educators etc. They all joined together to enhance the quality of CPD activities and to support their sustainability.

However, the external evaluator stresses that stimulating the local involvement by creating community boards that support the implementation of IBSME in the RC or TC was sometimes challenging. Although most of the centres had some kind of local involvement, only a minority of the centres have managed to conclude a formal agreement with the stakeholders involved. This last element should therefore require more attention towards the future, so as to involve not only representatives from education and from educational authorities but also from companies. The evaluators stressed that a strong CB is a key element to enhance the sustainability of the IBSE and IBME activities and should also be based on cooperation between stakeholders in education and in industry.

8. Twinning: educational change as inquiry

The strategy for disseminating inquiry pedagogy throughout Europe designed and tested within the *Fibonacci Project* was a transformational approach to change in education. Transformational approaches recognise that:

- Sustainable development in learning takes place when change is seen as inquiry by those concerned with the transformation[6]. Change in teaching practice, for example, is a matter of learning, and effective learning by teachers has the same qualities as for students. Just as students develop understanding through their own mental and physical activity, as described in the previous chapter, so teachers learn best when they take an active part in deciding how to transform their practice.
- Sustainable change in education takes place when policy makers, researchers and practitioners participate and learn together with integrity, recognising their shared goals of improving learning for all[7]. This implies changing practices at all the different levels of the educational system: classrooms, schools, teacher education institutions, local and national authorities. It also implies developing the necessary resources to support each of these actors in bringing about the desired changes.

Reference Centres (RCs) were chosen on the basis that they already coordinated a structured and on-going initiative for supporting teachers in taking inquiry-based science and/or mathematics education into the classroom at a local, district, county, or regional level. The RCs' main objective during the three-year life-span of the project was to disseminate their expertise on teacher support strategies to two different rings of less experienced centres: 12 Twin Centres 1 (TC1) and 12 Twin Centres 2 (TC2).

We describe hereafter the main types of twinning activities carried out during the Fibonacci project:

- **Partnerships built on the basis of common interests**

Dissemination of expertise from the RCs to the TCs occurred through a form of close cooperation called 'twinning'. Each RC worked closely with – was 'twinned' with – one TC1 and one TC2 from a different European country. Twinning partners were not chosen randomly: at the project inaugural meeting, each partner expressed its twinning preferences. Some twinned mainly on the basis of common linguistic and/or cultural references (e.g. *Saint-Étienne-Brussels*); others twinned together mainly because of common research interests (e.g *Leicester-Dublin*); some were motivated by sociological issues (e.g. *Berlin* approached *Ankara* because of the numerous Turkish population in Berlin). More generally, centres whose priority was maths were twinned together, as were those whose priority was science. Each group of RC-TC1-TC2 can be thought of as a 'cluster'. The configuration of each cluster is provided in **Table 2**.

Table 2. Cluster configurations: twinning partnerships among teacher support centres with different levels of expertise.

Reference Centre	Twin Centre 1	Twin Centre 2
Aabenraa	Lisbon	Alicante
Amsterdam		Antwerpen
Augsburg	Zurich	Copenhagen
Bayreuth	Sofia	Bad Berka
	Santander	
Berlin	Luxemburg	Köln
		Cankaya-Ankara
Klagenfurt	Helsinki	Glasgow
Leicester	Dublin	Belfast
Ljubljana	Belgrade	Krakow
Nantes	Patras	Nancy
Saint-Étienne	Brussels	Naples

[6] Hayward, L. and Spencer, E. (2010). The Complexities of Change: formative assessment in Scotland. *Curriculum Journal*, 21(2), pp. 161–177.
[7] *Op. Cit.*

Stockholm	Tartu	Silkeborg
Trnava	Magurele/Bucharest	Vienna

- **Horizontal cooperation: experienced and less experienced centres learning from each other**

Box 6	Examples of successful twinning strategies

Cluster *Aabenraa-Lisbon-Alicante*: development of a learning unit on sailing ships
At the beginning of the twinning process, this cluster decided to develop and implement learning units in cooperation. Together they searched for common and relevant contents that could inspire science and mathematics learning with an inquiry-based approach, and they found that all three countries (Portugal, Spain and Denmark) have long maritime traditions and that the schools in their networks were placed near harbours or coastlines. They therefore decided to develop a unit on sailing ships.
The learning unit was to be used both in CPD courses and by the teachers in their classes. Thus, teachers would face a genuine challenge during the CPD course: inquire into how to design a sailing ship, just as their students would later on. The learning unit was conceived so that teachers could adapt it to their particular classroom context, and also as an reference frame on which teachers could draw in order to develop their own learning units.
The unit on sailing ships was translated into Spanish, Portuguese and Danish and was introduced to teachers in a number of workshops during the four twinning visits. In the three countries, an ongoing process to adapt the unit to different age groups, to informal learning environments or for children with special needs was put in place.
The cluster's next aim is to create a community of practice involving teachers from the three countries. A blog was created (http://fibonacci-project-co-operation.blogspot.dk/) so that teachers could share their experience in implementing inquiry-based science and mathematics units in their classes.

Cluster *Ljubljana-Belgrade-Krakov*: didactic material, CPD workshops, regional networks
As a response to the teachers' requests, cooperation between partners in this cluster was centred mainly around the production of experimental kits and didactic materials and their distribution to teachers. Serbia was particularly active in translating resources for teachers, which benefitted Slovenian teachers as well. Twinning visits were the occasion for the three partners to exchange experiences on this topic.
CPD workshops for teachers and visits to schools and kindergartens involved in the project were organized in all three countries. A CPD workshop on "Fruits and vegetables" was designed by Slovenian teachers, developed further in Poland, and implemented in both countries in a new, richer version.
Cooperation within this cluster exceeded the project's frame: exchanges of young researchers between University of Ljubljana and Jagiellonian University were organized, and a topic group on physics education in South-East Europe was created in order to raise awareness on the necessity of implementing inquiry in this field. The group's first meeting was held in Ljubljana in September 2012, with attendance of representatives from the three partner countries. This initiative was a continuation of the activities of the Serbian partner, who had already organised five annual South-East European Workshops on Primary Science Education (2005-2010) involving countries in the region that were not involved in the project.

- **Tutoring**

Each cluster developed a twinning strategy adapted to the local needs and capabilities of each of the centres that composed it and to their common interests. Twinning activities focused both on the understanding and practice of inquiry pedagogy, and on the strategies to implement it. Learning from peers at all levels of the school system was the key component of twinning. Concretely, this could involve trying out different approaches to teaching and to training teachers, building common teacher networks and learning communities, doing research, developing assessment tools and methods, exchanging ideas on how to introduce inquiry-based approaches in pre-service teacher education,

sharing strategies to work collaboratively with other local partners of interest (e.g. scientists, municipalities, science museums, etc.). Field visits where each TC1 and TC2 could visit their respective RC for several days and experience the implementation of inquiry pedagogy at the classroom, school, and local level were organized within each cluster.
From the second year of the project on, tutoring was a key component of twinning. After the first field visit, each RC organised tutoring sessions for its respective TC1 and TC2.

Examples of tutoring strategies within two clusters are presented in **Box 9**.

- **Field visits**

The transfer and sharing of experience and expertise in IBSE or IBME from RC to TC (and vice versa) has been strongly stimulated by organising two waves of very successful field visits during the lifetime of the project. These FV have proven to be a key element to stimulating cooperation and cross-fertilisation between the RC and TC as shown in the evaluation report addressing this pillar. The first wave of FV was in 2010 -2011 between RC, TC1 and TC2 and a second wave of field visits was organised when the TC3 joined the project in 2012 and could attend a similar field visit to an RC or TC.

During those field visits the RC invited interested TC, as well as other RC, to come and experience what they have been doing already for years in IBSE or IBME and how they were implementing the three pillars of the Fibonacci project. Practically speaking, these three to four day field visits focused on the strategy, the organisational framework and the type of pedagogy used in the RC, on the introduction to IBSE or IBME, on school visits, on class activities on IBSE or IBME, on the organisation of IBSE or IBME in CPD and pre-service teacher education, on the development of the Community Board and on how an RC or TC collaboration could be developed and implemented. The field visits have proven to be very intense and fruitful peer learning activities for all the participants. They have laid the basis of the strong Fibonacci network. The cooperation between RC, TC1 and TC2 were strengthened by mentoring activities by the RC for its TC1 and TC2 in the 2nd and 3rd year of the project.

The whole process of the successful RC – TC cooperation has been very well documented which has resulted in a blueprint for a transfer methodology valid for building further Reference Centres in Europe. This blueprint is described in detail in one of the five companion resources “Developing and Expanding a Centre for Science/or Mathematics Education” available on the website of the project. This document will prove very useful to organisations that want to become an RC event outside Fibonacci.

- **Continuing Professional development (CPD)**

The variety of CPD shows how creative and innovative the clusters of RC and TC have been. Various forms of CPD were organised ranging from short one day CPD (taster training) to long(er) CPD of 40, 70 or 120 hours mixing time attending CPD seminars and time making use of open and distance learning (blended learning). Demonstration sessions were also organised to show teachers the benefits of IBSE or IBME. The CPD focused either on basic training for IBSE or IBME or advanced training for science teachers who subsequently became “multipliers” or “expert teachers” at local or regional level. In many cases those CPD trainings have been recognised by ministries of education by introducing them in the official offer of CPD of the ministry of education and/or by giving credits to the teachers for their involvement in those CPD activities.

It is important to stress that in virtually all cases the CPD was followed by mentoring of the teachers who had been trained to support them during the implementation of what they had learned during the CPD.

- **Mentoring of teachers**

The follow-up or mentoring of teachers took different forms ranging from individual class visits (using an observation tool developed by Fibonacci), to Skype talks, to pair or peer teaching, co-teaching and

learning and to open lessons where groups of teachers attended a lesson of a colleague. Experienced teachers were paired up with other experienced teachers or with teachers with less or no experience, teachers were linked up with future teachers of pre service teacher education or teachers were teamed up with engineering students or with doctoral students who could support primary school teachers etc. This variety of forms and methods of CPD and mentoring has proven to be very useful.
Several Fibonacci partners have developed strong local and regional networks structured with regional coordinators who are in charge of mentoring and supporting the Fibonacci teachers trained during the CPD. Some of those teachers have gradually become multipliers themselves, playing a key role in those regional networks.

The organisation of teacher CPD, the training of expert or multiplier teachers, the support and tutoring given to the teachers involved and the promotion of teambuilding and teamwork amongst the teachers has definitely contributed to bringing about change in teaching practices concerning IBSME.

9. Spin-off: from in-service to pre-service

The key and major spin-off which was not part of the objectives in the application was the integration of IBSE and IBME in PRE-service teacher education. Although the application of the Fibonacci project focused solely on Continuous Professional Development (CPD) of teachers, many of the partners gradually involved PRE-service teacher education. It became gradually clear to many partners, especially the universities with departments of pedagogics and pre-service teacher education, that it was fairly easy for them to integrate PRE-service teacher education into the project. Materials, modules and approaches that had been developed for CPD were translated into Pre-service teacher education and future teachers were involved in some of those activities.

Thus several partners developed modules (in parallel to the Fibonacci CPD) to be used in PRE-service teacher education. In this way future teachers could also be introduced to IBSE or IBME as many RC and TC believe that IBSE or IBME has to be promoted both in pre-service and in-service teacher education and enhance continuity of innovation in science education. Towards the end of the project a special field visit was organised in Amsterdam in January 2013 focusing on Pre-service teacher education. A supplementary publication was also prepared focusing on this item. It highlights various initiatives within Fibonacci focusing on Pre-service teacher education.

Potential impact (including the socio-economic impact and the wider societal implications of the project so far), main dissemination activities and exploitation of results.

The *Fibonacci* sequence: a European network and learning community

The *Fibonacci Project* had 12 clusters in all, corresponding to the initial number of RCs. By the end of the project, nearly all TC1s had acquired the necessary expertise and experience to become RCs, which means that a teacher support system capable of insuring dissemination activities towards another centre was up and running.

According to *Educonsult*, the project's external evaluator, all centres increased their expertise and knowledge in inquiry-based education and enlarged their network or learning community. For most TCs, twinning led to an acceleration of the process of acquiring expertise, as well as gaining access to recent research on inquiry-based teaching and learning. At the same time, most RCs learned how to better promote and implement inquiry-based education and to disseminate the outcomes of what the RC had already accomplished. Twinning was a win-win situation for both partners. Further, most centres integrated inquiry pedagogy into pre-service teacher education by developing either optional or compulsory modules for future teachers, thus ensuring continuity between pre-service and in-service education. This enhanced the sustainability of the educational innovation.

The 25 TC3s were chosen among 34 candidate institutions who formally requested to join *Fibonacci*. TC3s had the opportunity to visit at least once the centre they were twinned with (an RC or a TC1).

More teachers, mores pupils, more classes than planned

Initially, the *Fibonacci Project* was scheduled to involve 2,500 teachers, 45,000 pupils, and 550 classes. By the end of the project 6,171 teachers, 302,000 pupils, and about 10,000 classes had been involved). The impact as to numbers is thus much larger than initially planned. This was possible because several centres managed to secure additional funding from their national, regional or local authorities.

Finally, many future teachers studying in pre-service teacher education were also beneficiaries of the *Fibonacci Project*. It is difficult to put a number to the extent of involvement of pre-service teachers, but it is likely to be several hundreds.

Bridges built between research and practice: 500 European teacher educators and hundreds of researchers ready to help out

500-600 teacher educators were involved in the various activities implemented during the lifetime of the *Fibonacci Project*. Researchers also took part, particularly on the occasion of the two European Bayreuth Conference the Leicester conference in April 2012.

6,000 European teachers more confident and motivated to teach science or mathematics through inquiry

The data presented in this section was recovered and analyzed by *Educonsult*, the project's external evaluator. Impact refers to the effect that the project's activities had on the beneficiaries: on the teacher support centres, on teacher educators, and on teachers and pupils. Impact can be evaluated at local, regional, national, or even European level. Although impact is best evaluated in the long-term, some elements of short-term impact of the *Fibonacci Project* are mentioned in this section.

The evaluation of the project's impact on the centres is based on qualitative data recovered during 2-4 day field visits to the 12 RC and to the 12 TC1 including participant observation of the centres' activities and interviews with the coordinators and some of the stakeholders. Questionnaires focusing on RC–TC cooperation and on the development and the implementation of the Community Board were also delivered at these occasions.

The impact of the *Fibonacci Project*'s teacher support strategies on teachers, pupils, and schools was measured through interviews with teachers and mentors and through questionnaires addressed to the teachers involved in the project, delivered at the beginning and at the end of the project. The questionnaires requested information on the teachers' personal characteristics (gender, age, experience with inquiry pedagogy, level of teaching, type of school) and asked them to assess their confidence in teaching in general and in teaching mathematics, science and technology in particular. In the post-questionnaire, four series of questions were added in order to assess the impact of the project on other aspects of their teaching, on the school, and the effectiveness of the mentoring activities. The evaluators also held regular meetings with the *Fibonacci Project*'s European coordination team and attended all the events organised in the framework of the project involving several partners, both at a European and at a national level.

As far as the impact of the professional development of the teachers is concerned the evaluators have noticed that the activities have mostly had the impact envisaged in the definition of Guskey[8]. The activities have enhanced the professional knowledge, skills, and attitudes of most of the educators. 80% or more of the teachers indicate that the CPD has stimulated their motivation for teaching and that it has increased their knowledge on how to make students work in a scientific manner by focusing on learning though enquiry. Three quarters of the teachers also indicate that they are now more confident to teach mathematics or science or technology and that it has strengthened their knowledge and skills on how to implement IBSE or IBME. The professional development has also improved the learning of students as can be seen in the analysis of the questionnaires in part 2 of this report. Moreover it has had an impact on educational structures and cultures. Sometimes this impact has been limited to the teachers and schools involved in the project but in some cases (Austria, Germany, Estonia, Finland, Ireland, Sweden...) the project has had an impact on the educational culture of and the approaches of teaching MST in the whole country or the regions involved in the project.

Box 7	**Quotes from teachers who participated in *Fibonacci* CPD programmes.**
"Overall, I have gained a lot professionally from my involvement in Fibonacci. I am now a more confident and effective science teacher. I found it very interesting interacting with teachers from other schools. I also greatly value the opportunities we were given to travel abroad and experience Fibonacci at work cross-culturally. Having said that, the whole project was much more demanding of my time and energy than I would have expected when I signed up for it. On a further positive note, I feel that my students have really enjoyed their science experience during the past two years. Inquiry has been a very positive force in my teaching and in my pupils' learning." "The Fibonacci Project has had a really positive effect on my teaching of science. I am really enthusiastic about teaching science and teach it much more frequently. Honestly, science was one of my least favourite subjects to teach and now it is one of my favourites." "For the first time in more than twenty years I felt that my eyes were sparkling again while I was teaching. The course has really given me a boost!"	

Confidence in teaching was taken as an indicator of the impact of the *Fibonacci Project* because there is significant research evidence that that when teachers do not feel confident in a particular curricular area, they tend to teach as little as possible of that subject and compensate by teaching more in high confidence areas[9].

There was a significant rise in teacher confidence as a result of the *Fibonacci* experience, particularly in some of the key aspects of inquiry-based teaching. When considering average ratings, the highest rise in teacher confidence (10%) was noted in encouraging students to think for themselves. Significant rise in confidence was also recorded on helping students to explain and make deductions from observations or results, encouraging students to make careful observations, and helping students to generalise from observations and results.

However, teachers rate themselves significantly less confident on a number of items after their *Fibonacci* experience, especially those concerned with assessing and counselling pupils and

[8] Guskey, T.,R. (2000). *Evaluating Professional development.* p. 16
[9] Harlen et al., 1995. *Confidence and Understanding in Teaching Science and Technology*.

evaluating inquiry-based education resources. Two possible reasons for this are that little attention was given to these aspects of teaching during the mentoring, and that teachers may have become aware of the fact that teaching differently also means assessing differently.

It is interesting to point out that teacher support had a higher impact on confidence for teachers under 30 years and over 50 years of age than it did on teachers between 30 and 50 of age. This being said, all age groups agree or fully agree that their participation in the ***Fibonacci Project*** stimulated their enjoyment in teaching science and mathematics. This is very important as one of the problems with the teaching profession is the high turnover of teachers. In the report of the Nuffield Foundation on Science education in Europe it was noted that although there is little data available on teacher retention apart from in England, these data show that 50% of teachers of all subjects who begin training leave the profession within five years[10]. Teachers who are motivated for teaching will be less likely to leave the profession.

During an interview one of the older teachers stated:
Pre-primary and especially primary school teachers, who usually have to teach all subjects, declared feeling more confident in teaching science and mathematics after the *Fibonacci* experience on almost all of the items surveyed. Lower secondary school teachers also felt more confident on most aspects of their teaching. Not surprisingly there was less impact on upper secondary school teachers, who are generally trained for the specific subjects that they are teaching.

300,000 European pupils starting to like learning science and mathematics

Given that more than 300,000 pupils were involved in the project, and that many were very young and did not speak English, it was decided to measure the impact of the project on the pupils through the teachers. The following data were collected through more than 1,000 questionnaires answered by teachers who participated in the *Fibonacci Project*.

All teachers, irrespective of the type of school they teach in, noticed that the new teaching approach they started to implement as a result of their participation in the *Fibonacci Project* stimulated students' interest and motivation for learning science and mathematics. This is very important in view of the Eurydice report *Developing Key Competences at School in Europe: Challenges and Opportunities for Policy*[11], where reference was made to academic literature and research proving that the level of motivation to learn mathematics and science is an important determinant of student achievement in school. This was confirmed by some Fibonacci teachers involved in the project who recorded the performances of their pupils during the lifespan of the project. According to these teachers the different teaching approach has had a positive impact especially on low-achievers and pupils who were struggling with MST subjects.

Over three-quarters of teachers reported their perceptions that their participation in the project had benefited their students. These benefits included ability to work collaboratively in groups and independently, working scientifically, finding different ways to solve problems and developing their understanding as shown in ability to apply knowledge in new situations. A majority of teachers, especially in pre-primary and primary education, stated that girls' interest in science and mathematics was enhanced as a result of the changes they introduced in their teaching. This is important because recent research as shown that most students develop their interest in and attitudes towards school science before the age of 14[12].

Teachers from urban schools perceived a greater impact on their pupils than those from rural schools or from schools in disadvantaged areas, with the exception of impact on language skills relating to discussing science and mathematics problems. This could be associated with presence of many non-native speakers in these schools. Indeed, during interviews in Berlin and Tartu, teachers in schools with a high proportion of non-native speakers remarked that their pupils' language skills had been

[10] Osborne, J.& Dillon, J. (2008). *Science Education in Europe: Critical Reflections. p. 24*
[11] European Commission (2012a). *Developing Key Competences at School in Europe: Challenges and Opportunities for Policy*.p. 46
[12] Osborne J., Dillon, J. (2008). *Science Education in Europe: Critical Reflections.*

enhanced through inquiry pedagogy. Collaborative learning and discussion might have enhanced these children's language skills.

Relevance to 8 EU competences for lifelong Learning

According to the external evaluator, Fibonacci activities have been relevant in view of European policies as they contribute to promoting and strengthening the EU 8 key competences for lifelong learning.
Indeed, the project has very clearly promoted the Mathematical competence and basic competences in science and technology, which was at the heart of the project. It has also strongly helped develop the competence "Communication in the mother tongue", as IBSE and IBME have always promoted cooperation, debate and exchanges between pupils. Furthermore, this competence has been promoted through cross- and interdisciplinary approaches where science and mathematics were combined with poetry, history, statistics, arts and design etc. It has enhanced the "Digital competence" as many activities, both in IBSE and IBME, have focused on using ICT (through equipment such as computer-directed sensors) in IBME and IBSE.

IBSE and IBME have also promoted the four transversal competences. Promoting IBSE and IBME has strongly contributed to promoting the competence "learning to learn", both at the level of the pupils, the teachers and the teacher educators. IBME and IBSE activities focusing on interaction, exchanges and debates on science and mathematics issues and problems between children have most probably promoted the social and civic competences of the children. As one head of a school in Nantes put it:

"Thanks to IBSE the children in our school in a deprived area have learned to argue and exchange with one another instead of using their fists to settle arguments".

It is clear that IBSE and IBME have promoted the competence "Sense of initiative and entrepreneurship", as children are invited to take initiative in their learning. Finally the project has also had an impact on the competence "Cultural awareness and expression" and this in various ways: links have been made between IBME and visual arts (Bayreuth and Bulgaria, IBME and dance (Bulgaria) etc. Concrete examples of this are the various publications focusing on mathematics and arts as the one called "Mathematik andersARTig" and produced in the framework of the Fibonacci project.

The only competence which seems to have been less promoted through the Fibonacci project seems to be the competence "Communication in foreign languages". It could have been promoted if there had been an opportunity to create links between teachers and/or pupils across Europe. It turned out that most of the teachers and pupils involved in the project were not able to communicate in a foreign language.

Section A: dissemination measures

First of all, it is worth reminding that the Fibonacci project being itself a dissemination project, most of the activities carried out during the project were intended to disseminate inquiry-based science education. The twinning process (see above p. 5 and p. 20 for details) was undoubtedly the main and most original dissemination measure implemented during the project, enabling to reach out to and involve 37 teacher training organisations (12 TC2s and 25 TC3s) outside of the project consortium, these new entities becoming in their turn dissemination players towards other institutions. This central mechanism was supported and complemented by various additional forms and tools of dissemination.

- **At European level**
  - *Fibonacci website*

Building on the Pollen and SINUS-Transfer platforms and users, the FIBONACCI website was a key instrument to disseminate the activities taking place in the centres. It was be used as a coordination and communication tool throughout FIBONACCI. The website was regularly updated by the Coordination. The design and the development of the website was assigned to the University of Bayreuth.

The FIBONACCI website was also the entry point for teachers wishing to participate in the *Greenwave project*, which was hosted and developed by FORFAS in collaboration with the Irish partner (SPD).

As there is free access to the website (except special virtual rooms or workspaces) it work as an instrument for spreading the ideas of Fibonacci and to bring interested groups (e. g. teachers, parents, students) in contact with Fibonacci.

- *Communication material*

A specific visual code was elaborated for the FIBONACCI project. A booklet was released in English on P1 to promote the project and broadly diffused. Flyers were published for important events, especially conferences.

- *Newsletters and Press releases.*

5 newsletters and 3 press releases were prepared by the Coordination and sent regularly to all participants, local decision-makers, partners and any other interested groups through a database of key-persons (stakeholders, scientists and decision-makers in science and mathematics education). This database was elaborated from the beginning of the project and progressively updated by gathering names and details from the 25 Consortium members as well as from supporting institutions. Parts of press releases and other dissemination documents were translated by the different partners, in order to reach teachers and administration in each country.

- *European conferences*

As part of the key activities of the project, two major European conferences have been held (in Bayreuth, September 2010, and Leicester, April 2012) bringing together key players in IBSE or IBME from all over Europe (with about 150 participants each). The objective was to disseminate further expertise and good practices in IBSE or IBME and make more stakeholders aware of the potential of

IBSE or IBME, as well as bridging the gap between scientific education research and practice. As the evaluation reports of those conferences have pointed out, these conferences have contributed to strengthening networking between IBSE or IBME practitioners and researchers across Europe and beyond. In this way they have also contributed to enhancing knowledge brokerage between researchers and practitioners which is very often too weak. They also helped to disseminate IBSE and IBME further across Europe.

- *Cross-cutting topics*

Throughout the project, the different RC and TC1 were successfully involved in five common working groups which focused on 5 key topics in IBSE or IBME: deepening the specificities of IBME, deepening the specificities of IBSE, implementing and expanding a Reference Centre, cross-disciplinary approaches in IBSE or IBME and using the external environment of the school in IBSE or IBME.

These working groups resulted in five European training seminars (ETS) from September 2011 to March 2012 which brought together RC and TC and other teachers and teacher educators to train them on those specific topics related to IBSE or IBME. Each session gathered about 40 to 80 participants, internal and external to the project.

Those seminars have stimulated the introduction of IBSE or IBME across many schools in Europe and have also strengthened networking between all the participants as to IBSE or IBME. The evaluation has pointed out that it was a pity that no more teachers (external to Fibonacci) had been able to attend those seminars and also recommended to repeat such ETS with support of the mobility grants within Comenius of the LLP programme.

This common work on those five cross-cutting themes (with the organisation of the five ETS) has resulted in the production of five companion resources or publications on each of the five topics. A lot of time was invested in developing quality companion resources. These documents will, no doubt, prove to be very helpful to teachers and teacher educators wanting to promote IBME and IBSE.

Last, it is important to stress that the 5 European training sessions organised on the 5 major Fibonacci topics also received participants external to the consortium. At least one-third of the participants (60 for each training session) did not belong to the initial Fibonacci network, in order to look for commitment of other parties.

➢ European and national networks

Each member of the consortium in the project was part of a broader network of partners who were involved in the project in order to spread issues and results. These networks and their members were associated to the major events of the project and contributed actively to diffuse and spread its outcomes among their members.
Of note was the participation of Fibonacci to the Scientix conference in 2011, which enabled to share the mid-term outcomes of the project with various FP7 project coordinators and allowed for fruitful exchanges between FP7 projects.

International networks like ESERA, IAP or Scientix took part in several Fibonacci events.

➢ Other forms of dissemination activities carried out at local/national level

This dissemination was done at several levels: the teachers and teacher trainers' level, mainly through workshops, training sessions and pedagogical resources and material; the academic and research level, through European conferences and participation of Fibonacci coordinators to other national or international conferences and colloquia; the political level, through the community boards created by each partner.

- ***Websites:*** almost all Fibonacci centres developed their own website in their national languages. These websites were updated regularly and are listed in the general Fibonacci website ("Centres" section).

- **Magazines:** A number of Fibonacci centres took advantage of magazines to communicate about their Fibonacci activities and disseminate some resources developed within the project. For example, INTOUCH is a monthly magazine that is published by the Irish National Teachers' Organisation (INTO) and distributed to all primary school teachers and personnel affiliated with primary education all over Ireland. Each month the magazine features a range of different education articles and features. From November 2011 to June 2012 INTOUCH featured Fibonacci articles which were written by Fibonacci teachers. Links to a selection of these articles can be found on the Irish Fibonacci website (www.Fibonacci_project.ie) and back issues can be downloaded from the INTO website (www.INTO.ie) Alison Gilliland head of the CPD unit in the INTO, was a member of the Fibonacci community board, and arranged for the Fibonacci article to feature in INTOUCH each month.

- **Peer-reviewed publications**
  See Template A1.

- **Books and other publications (including articles published in the popular press)**
  See template A.2

- **Whole Staff CPD:** A number of the Fibonacci teachers facilitated staff in-service workshops in their schools. During these workshops they provided their colleagues to engage with a number of the Fibonacci activities. As a result other non-Fibonacci teachers in the-participating schools are now using Fibonacci activities as an integral component in their school science lessons.

- **CPD DVDs:** Several Fibonacci centres, like Ecole des mines de Saint-Etienne and St Patrick's College, have produced DVDs intended for teacher professional development or institutional communication.

Box 8	**The use of video as a teacher CPD tool – St Patrick's College, Dublin**
The Irish (Dublin) example is indicative of how video can be used as a teacher CPD tool: over the past two years of the Fibonacci project, members of the Irish Fibonacci professional development team have been collaborating with the Irish National Teachers Organisation (INTO) www.into.ie to develop a National programme for Continuing Professional Development (CPD) on teaching Nature of Science in primary schools. As part of this collaboration the INTO co-funded the production of a DVD on teaching NoS through inquiry in primary schools. Two of the Dublin Fibonacci teachers were videoed teaching about different aspects of Nature of Science using innovative inquiry-based approaches. These lessons exemplified some of the innovative methodologies for teaching about NoS in primary classrooms that were developed over the course of the Fibonacci project. It is envisaged that the DVD will be used as a teaching resource for the National CPD programme.	

- ***Teachers' Resource Book:*** In some cases, like in Slovakia, resources that were developed by Fibonacci national centres, were compiled and edited for publication as a teachers' resource book.

- ***Pedagogical resources:*** it is not possible to make a list of the vast number and wide spectrum of pedagogical and scientific resources developed by the Fibonacci partners. These range from teaching sequences to teachers' manuals, but also comprise material kits (Slovenia, Saint-Etienne, Berlin, Tartu, Sweden) or specially developed dynamic worksheets or sensors. Most of them are available on the national Fibonacci websites, and could be made available more broadly, after being translated, via the Scientix portal.

- **Awards Ceremony:** in several countries (Switzerland, Slovakia, Ireland), awards ceremonies were organised for Fibonacci teachers. In Dublin, the teachers, who had participated in the Fibonacci Project since June 2010, were presented with their awards by Minister of State at the Department of Jobs, Enterprise & Innovation and Education & Skills, Sean Sherlock TD, at a ceremony in the College. Over 170 people attended this momentous event which included children, principals and parents from the 10 participating Dublin schools. In Zurich, Fibonacci teachers were awarded with bronze plaques. These ceremonies are important in terms of visibility for the project and recognition for the teachers. They give the opportunity to rally political support for science education. As Irish Minister of State at the Department of Jobs, Enterprise & Innovation and Education & Skills, Sean Sherlock TD said: *"Ireland has seen and continues to see significant investment from companies in the science, technology, engineering and maths (STEM) sectors and it is important that we encourage our future generations to embrace these subjects from an early age. A strong culture in any subject comes from getting the basics right. By teaching our children in a fun, interactive and different way, they can develop a real interest in STEM subjects that will stay with them. The Fibonacci Project has proved extremely successful and I congratulate all the teachers that took the first step to try something new. I hope that the momentum is maintained and that the Project continues to go from strength to strength around the country."*

- **Research**

Evaluation of impact of Fibonacci CPD programme on teachers and pupils were made part of research projects in several countries, like Greece, Sweden, Ireland and South Bohemia. In Patras, one post graduate thesis was completed and one PhD study is in progress, while two other PhD theses' results were used to inform the design of activities and tests.

In Belfast and Dublin, questionnaires were administered to all of the children participating in the Fibonacci project this academic year. Focus group interviews were conducted with children from all participating schools. In June 2012 exit questionnaires were administered to the Fibonacci pupils and interviews were conducted with as selection of children from each school. Interviews were also conducted with one teacher from each of the Fibonacci schools. The data gathered from the teachers and pupils over the course of the project has been analysed. The co-ordination team are currently writing up the findings for publication in peer reviewed journals. The first paper is focusing on the impact the Fibonacci Project CPD programme has had on Irish primary teachers' experiences of and attitudes towards teaching science. The second paper is exploring whether pupils' engagement with the Fibonacci CPD material has had an impact on their experiences and attitudes towards school science. The co-ordinators hope to have both papers written and submitted to peer reviewed journals by May and June 2013.

- **Science & technology and ICT**

Box 9	**Belfast: the value of video-based technology in science teaching and learning**

The use of video cameras and of video-based technologies to support collaboration and the exchange of science teaching and learning approaches was instrumental in Belfast. Teachers identified both positive and negative aspects of each of these.

Teachers in the Belfast cohort all agreed upon the value of using video, in general, in the classroom for science teaching and learning. It aided both teacher professional development and children's learning. Teachers became more proficient in the use of video cameras with which they claimed they had no prior experience. The use of video also allowed teachers to create new methods of assessment. They could use video clips as records of classroom practice and could return to the video to re-evaluate or re-address both child learning and their own practice. Teachers specifically identified the video as valuable in allowing them to become reflective practitioners as they could observe their own questioning skills, for example. Teachers could also look back at episodes of child learning and peer interaction and observe events they may have missed during the teaching of the lesson. They could explore more deeply group dynamics also. Video was also identified as valuable for child learning in that the clips could be replayed to the children who could then revise and revisit specific topics. Children enjoyed seeing themselves on camera and became more focused

in lessons where the camera was used. In some schools children began to use the cameras themselves, thereby enhancing their technological skills also.
The only negative aspect of the videos identified by one teacher was the difficulty she experienced in video editing for the purpose of presenting her work to the rest of the group.

Video-based Technologies
Teachers were introduced to Digital Interaction Video Enhanced Reflection (DIVER), a virtual learning environment where they could upload and discuss their video clips with other teachers within the Belfast cohort. Teachers initially discussed the value of such programs and how they could aid the dissemination of good practice. However, upon participation in the project teachers experienced many problems and issues with DIVER and no teachers used the program throughout the duration of the project. Teachers viewed DIVER as time-consuming, intimidating and confusing, requiring a lot of energy. Teachers felt that their planning and actual teaching of science was more important than discussing it online. They also experienced difficulties in accessing the DIVER program due to restrictions on school computers.
Overall, teachers labelled the DIVER program as not viable for long-term collaboration. They valued video both for child learning and their professional development but all agreed that virtual environments for disseminating and sharing these videos were ineffectual.
Some professional development programmes have successfully included various technology-related parts, such as: web-based virtual learning environments (VLE), online and electronic conferencing features. An important aspect of such technology is that it can overcome location and time constraints.
However, technology is only as good as the people who use it. It is vital that teachers are given adequate time and training to overcome challenges, such as lack of confidence in using ICT.
Teachers acknowledged the potential value of using video-based technologies but insisted upon the need for social interaction to best share experiences from the classroom.
The original aims of the project were to encourage the use of video and video-based technologies to enhance dissemination of science teaching and learning. Teachers enjoyed the use of Flip cameras to record their practice within the classroom and consequently use the footage for their own professional development, and to promote child learning. Through participation in the project, however, teachers described the best way to disseminate not as through the use of video-based technology but through providing time and contexts for direct social interaction. Video-based technology should not replace face-to-face interaction but should be used in conjunction with it, so as to enrich the dissemination process.

In **Flanders (DKO),** the use of sensors, which was central to the project, is now a hot item in lower secondary and the start is given for attempts in primary education.

The use of ICT was particularly relevant in centres focusing on mathematics, but not exclusively.

In **South Bohemia**, a set of inquiry-based worksheets and learning environments, freely available in the national Fibonacci website, was developed both for in-service and pre-service mathematics teachers. 3 articles focusing on IBME were published by the University of South Bohemia in the Electronic Journal of Mathematics and Technology, and in the North American GeoGebra Journal.

In **Amsterdam**, four secondary schools and 6 primary schools received funding for science equipment to support IBSE. The secondary schools received equipment for student investigatory projects and they concentrated amongst others on applying ICT in IBSE such as video measurement and modeling.

- **Conferences, Exhibitions, Films, Flyers, Interviews, Posters, Presentations, Press releases**

See template A2: list of dissemination activities

Use and dissemination of foreground: compilation of information and figures provided by the project partners in templates A1 and A2

A1 - Scientific publications:

1 - *Promoting science teaching and learning with IBSE* - Gostincar Blagotinsek Ana - Journal of Optoelectronics and Advanced Materials - vol. 3, no. 1 - National Institute of Optoelectronics – Romania - 01/03/2011 5-6 p

2 - *Fibonacci project - the Romanian approach* - Dan Sporea and Adelina Sporea - Journal of Optoelectronics and Advanced Materials - vol.3, no.1 - National Institute of Optoelectronics – Romania - 01/03/2011 - 25-34 p

A2 – Dissemination activities: 14 different types of activities:

- **Articles published in the popular press:**

20 articles
5 partners
Main audience: Medias and civil society

- **Conferences:**

42 conferences
14 partners
Main audience: Scientific community (higher education, Research), Civil society, Policy makers
Total size of audience: 3243 persons

- **Exhibitions**

10 Exhibitions
6 partners
Main audience: Scientific community (higher education, Research), Civil society, Policy makers
Total size of audience: 4105 persons

- **Films**

4 Films
3 partners
Main audience: Scientific community (higher education, Research), Policy makers, Medias

- **Flyers**

7 flyers
5 partners
Main audience: Scientific community (higher education, Research), Civil society, Medias
Total size of audience: 1400 persons communicated (other ??)

- **Interviews**

7 interviews
3 partners
Main audience: Scientific community (higher education, Research), Civil society, Medias
Total size of audience: 2000 persons communicated (other ??)

- **Posters**

9 posters
4 partners
Main audience: Scientific community (higher education, Research), Civil society, Policy makers, Medias
Total size of audience: 1232 persons communicated (other ??)

- **Presentations**

41presentations
11 partners
Main audience: Scientific community (higher education, Research) - Civil society - Policy makers – Medias
Total size of audience: 4575 persons communicated (other ??)

- **Press Releases**

5 press releases
3 partners
Main audience: Scientific community (higher education, Research) - Civil society - Policy makers – Medias

- **Publications**

107 publications
16 partners
Main audience: Scientific community (higher education, Research) - Civil society

- **Thesis**

1 Thesis
1 partner
Main audience: Scientific community (higher education, Research)

- **Videos**

3 videos
1 partner
Main audience: Scientific community (higher education, Research) - Civil society
Total size of audience: 1100 persons

- **Web sites/Applications**

18 Web sites/Applications
11 partners
Main audience: Scientific community (higher education, Research) - Civil society - Policy makers – Medias

- **Workshops**

94 Workshops
15 partners
Main audience: Scientific community (higher education, Research) - Civil society
Total size of audience: 3172 persons communicated

Section B: Exploitable foreground and plans for exploitation

- **General advancement of knowledge**

- **Conceptualizing Inquiry in Science and Mathematics Education**

The 'Rocard Report' was useful in bringing a long-established pedagogical and epistemological approach to science teaching into the realm of educational politics. But the popularity of inquiry pedagogy, added to this new political reality, exposed it to a variety of interpretations. Project partners were conscious from the start that a loose definition of inquiry prevailed in Europe, which meant that the type of teaching practice designated by this term often varied from one context to another and that some of the existing approaches to inquiry lacked rigorous conceptualization.

Providing partners with a careful conceptualization of inquiry-based science and mathematics education was thus one of the main tasks of the project's scientific committee. It involved coming to terms on an operational definition of inquiry pedagogy for science and mathematics inspired on the general pedagogical principles shared by the project partners[13]. It also involved building bridges between two distinct, yet interdependent epistemologies: the natural sciences and mathematics.

The **Resources for Implementing Inquiry in Science and Mathematics at School** convey a coherent and consistent view of inquiry pedagogy in science and mathematics and provide some of the necessary tools and recommendations for its successful implementation in the classroom. They are addressed to teachers, teacher educators and, more generally, local actors concerned with the practical implications of implementing inquiry-based science and/or mathematics education. They speak of the pedagogical and didactical implications of such an approach, both from the theoretical point of view and from the practical point of view at the classroom level, and help local actors to set up support networks for this pedagogy to become a reality in the classroom. These are documents designed to help bring about the desired reform in science and mathematics education on the field.

The **Background Resources** define the general principles of inquiry-based science education and inquiry-based mathematics education and their implementation. They include the following booklets:
• Learning Through Inquiry
• Inquiry in Science Education
• Inquiry in Mathematics Education.

The **Companion Resources** provide practical information, instructional ideas and activities, and assessment tools for the effective implementation of an inquiry-based approach in science and mathematics at school. They include the following booklets:
• Tools for Enhancing Inquiry in Science Education
• Implementing Inquiry in Mathematics Education
• Setting up, Developing and Expanding a Centre for Science and/or Mathematics Education
• Integrating Science Inquiry across the Curriculum
• Implementing Inquiry beyond the School.

Editorial process
An editorial process was led by the European Coordination to coordinate the work among the members of the Scientific Committee and the coordinators of the common topic groups, and thus ensure coherence and fruitful dialogue among all the different booklets. All the booklets were reviewed, commented, edited, and validated by at least one member of the Scientific Committee. The booklets are all cross-referenced where pertinent.

Diffusion
• Internet download: all booklets can be downloaded, free of charge, at the Fibonacci Project website, in the Resources section (both in the web version and the print version). http://www.fibonacci-project.eu/

[13] These pedagogical principles shared by the project partners refer to the nine "Basic Patterns" of the SINUS project.

• Printed copies: The Background Resources were printed in 100 copies each by the European Coordination which were distributed among partners. Each partner is free to print as many copies as required (printer versions are available on the Fibonacci website).

• Reprints, translations and adaptations: The Resources for Implementing Inquiry in Science and Mathematics at School are protected by a Creative Commons Licence. The Copyright holder is the Fibonacci Project, but all documents can be reproduced, distributed, and even modified (i.e. translated or complemented), as long as it is non-profit, as long as credit is given concerning the original document, and as long as the new document is licensed under the same conditions. Many reprints, translations and adaptations of the different booklets are already under way under the initiative of individual partners. Translations and adaptations will be uploaded on the Fibonacci website as soon as they are finished.

- **The most innovative elements of the Fibonacci project**

- The **twinning process**: development and implementation of the RC-TC clusters to transfer innovation in IBSE/IBME from experienced RC to the TC. The exchange of knowledge and expertise and the cross-fertilisation between the RC and TC has definitely been useful to all the members of the cluster and to the whole network.
- The organization of **Field visits** for all RC and TC which have proven to be real peer learning activities stimulating cross-fertilization between all the members of the networks. In this way, the networking across the project was also strengthened.
- The creation of a **Community Board** to promote the local involvement in innovation in science and mathematics education and support the sustainability of what was started up during the project. Even if not all partners have set up a real Community Board, yet the foundations have been laid to further develop this in the near future.
- The development and the implementation of the activities in the **five cross-cutting working groups** which have enabled all partners to share specific expertise. The European training workshops and the companion resources developed by these 5 groups will prove to be very useful for all those who want to promote IBSE/IBME and set up and implement reference centres.
- The activities of the **scientific committee** which has clearly defined the framework of key principles which were the basis for the Fibonacci project. The three background resources developed by the scientific committee have been useful while implementing the project and will offer valuable theoretical background to others starting to work on IBSE/IBME.
- The development of **various forms and models of continuing professional development (CPD)** ranging from short CPD of one day to CPD of 40, 70 and even 120 hours resulting in some cases in credits being given to the teachers involved. Furthermore also the fact that in CPD not only teachers were involved but in some cases future teachers and even engineering students who support primary school teachers.
- The fact that most of the RCs and TCs have not only focused on CPD but have also made efforts to set up courses or modules for **pre-service teacher education** to enhance continuity in innovation in science education through IBSE/IBME.

- **Publication: *The Fibonacci Legacy to Science and Mathematics Education. A systemic approach for the sustainable implementation of inquiry pedagogy tested in primary and middle schools throughout Europe (2010-2013)***

Target readers: Policy makers and decision-takers concerned with education at a national and European level

The “Fibonacci Book” will show how the Fibonacci Project responded to the needs identified in the ‘Rocard Report’: namely, massive dissemination of inquiry-based education in science and mathematics throughout the European Union.

It will show how the Fibonacci Project has built on and gone beyond the SinusTransfer and Pollen projects, promoting not just a renewed inquiry pedagogy for science and mathematics, the key feature of which is understanding, but also an efficient and successful dissemination strategy based on twinning, involving a transformational approach to change in education and, most importantly, forms of collaboration where learning from others was the key.

It will also show the challenges raised by the Fibonacci Project for science and mathematics education and emphasize the need for further research and funding of inquiry-based education research and implementation initiatives in the framework of Europe 2020.

Since its target readers will be political actors, the book will seek to convince the reader of the interest of inquiry pedagogy and of Fibonacci's dissemination strategies. It will be concrete, factual, and illustrative, but also solidly grounded on relevant research. The book will be short (45-60 pages) and include an executive summary.

The book will be available for on-line download.

- **Beyond Fibonacci: Feasibility study of a European Network of Reference Centres (ENRC)**

One of the objectives of the project was to develop a feasibility study concerning the creation of a European network of reference centres. This study was made and it emphasizes the different roles and activities these centres could have. It also emphasizes the management and the organisation of such a structure and its conditions of sustainability. Steps are suggested to create and implement such a centre. The feasibility study points out that the creation of such a European network of national reference centres should be a long-term objective and it advises to launch a limited structure to respond to the immediate needs of the Fibonacci partners: viz. to continue the Fibonacci activities as soon as possible. This resulted in an application for a Comenius multilateral network submitted by the coordination in February 2013.

The overall objective of the European Network of Reference Centres is to enhance the quality of IBSE/IBME by stimulating the development and the implementation of a network of IBSE/ IBME Reference centres (RC) all across Europe. Such RCs are centres of excellence specialised on the one hand in IBSE/IBME and on the other hand in organising Continuing Professional Developments for school teachers or Pre-service teacher education courses for future teachers focusing on IBSE/ IBME.

These RCs are also specialised in making available to teachers and schools creative resources to promote IBSE/IBME and in giving teachers support while implementing IBSE/IBME in the classroom. It is hoped that the activities of the RCs will result in more pupils and students interested and motivated to study mathematics and science, and hopefully more of them choosing scientific, technological or mathematical studies in upper secondary school and in higher education, and eventually scientific, technological or mathematical careers.

The ENRC would liaise with policy and decision makers at national and European levels to ensure integration of IBSE/IBME innovation in regional, national STEM policies as well as European strategies developed by the European Commission. It would enhance knowledge brokerage between researchers and research users focusing on IBSE/IBME. It would encourage networking between existing RCs to disseminate and valorise what has been achieved or to stimulate and support the creation of new RCs by transferring the expertise of existing RCs to new ones. The ENRC would organize specialised training for those who want to create a Reference Centre and those who want to act as expert trainers within those RCs.

Finally, the ENRC would promote European and international cooperation and innovation through partnerships in IBSE/IBME to the benefit of teacher education (CPD + Pre-service) and school education by supporting the creation of various types of projects. It would also stimulate research, applied research and comparative studies focusing on IBSE/IBME.

- **How to sustain the exploitation of the project results**

The strong cooperation within the RC-TC twinning is the first key element to guarantee the sustainable use and exploitation of the project results. In several cases national coordination teams will try to broaden their support basis to other higher education institutions and partners and more focus will be given to IBSE/IBME pre-service teacher education. New European projects are being developed and partners have been invited to create European Comenius training courses making use of the expertise, tools and guidelines developed within Fibonacci.

Finally, the different dissemination initiatives set up at European and national level by all the RCs and TCs should also enhance the sustainability.

A sustainable change in teaching patterns of the majority of the teachers involved in the project has been reached thanks to appropriate quality CPD. However, even if the Fibonacci project activities prove that the project has promoted innovation in science and mathematics education in the schools involved, the evaluators and the Fibonacci partners point out that there is one key element that needs particular attention and focus in order to enhance the sustainability of what has been achieved so far: the integration and mainstreaming of the achievements of the Fibonacci project in the education systems across Europe. This also includes the mainstreaming of the positive teaching and learning approaches of the Fibonacci project into the education systems as a whole.

To reach this kind of sustainability and to enhance mainstreaming, the external evaluators suggest to focus on two key elements: the creation and development of more references centres across Europe which can support more schools (and teachers), and more and stronger support of the regional or national educational authorities which have to promote the dissemination of IBSE or IBME at regional or national level. In a few cases the support of the regional or national educational authorities has resulted in extra support to the Fibonacci partner. Support from the regional or national authorities can only materialise if they are well informed about the impact of the project.

The support of the national or regional education authorities must be actively sought to see to it that the benefits of Fibonacci are made available to more (or all) schools that more CPD is organised and that IBSE or IBME is part of PRE-service teacher education. This also means that national or regional authorities have to make resources available to enhance the sustainability of what has been achieved and have to promote mainstreaming of IBSE or IBME innovation building on the achievements of Fibonacci and possibly of other major FP7 projects.

The strong cooperation within the RC – TC twinning is the first key element to guarantee sustainability. In several cases national coordination teams will try to broaden their support basis to other HE institutions and partners and more focus will be given to IBSME Pre-service teacher education. New European projects are being developed and partners have been invited to create European Comenius training courses making use of the expertise, tools and guidelines developed within Fibonacci. The European coordination team is on the one hand taking steps to create a Comenius network focusing on IBSME and is on the other hand looking into the possibility to set up a European network of reference centres (ENRC) to enhance the sustainability of what has been achieved by Fibonacci. Finally the different dissemination initiatives set up at European and national level by all the RC and TC should also enhance the sustainability.

In particular, the evaluation recommended repeating the European training sessions on the cross-cutting topics with support of the mobility grants within Comenius of the LLP programme.

- **Commercial exploitation of R&D results**

No commercial exploitation of results. No patents.

- **Exploitation of R&D results via standard**

Not applicable.

- **Exploitation of results through EU policies**

Not applicable.

- **Exploitation of results through (social) innovation**

Fibonacci was an innovative model of dissemination of inquiry-based science education in Europe, focusing on support for teachers, and based on several levers inspired by previous pilot projects, deemed necessary to bring about change in teaching practices, i.e. twinning & tutoring, access to pedagogical resources.

Further recommendations made by partners

- There is a need to consider support for dissemination of project findings in order to ensure that the outcomes of projects like this are used effectively in supporting further research and development, by informing future lines of research proposed by the Commission and future research projects within the European Union
- There is a need to develop means of ensuring that the findings of projects such as this are effectively used to inform practice in schools across the European Union.
- Within this, there is a need to consider support for maintenance of partnerships between education systems and universities in different European countries after and outside such projects as this.
- The research literature highlights the limitations of "one-off" type in-service courses, especially where promoting enduring changes in pedagogical practices are concerned. The experience from Fibonacci confirms that for professional development for teachers in primary science to be really fruitful, it should include the following key features: (1) be on-going and long-term; (2) have an emphasis on content and pedagogy; (3) be teacher driven and actively engage participants; (4) be collaborative in nature; and (5) provide feedback and reflection.
- **Accreditation/certification:** there is a need to develop a framework that accommodates more than one form of accreditation in CPD. Traditionally, accreditation in CPD for teachers in most European countries occurs through a university route; i.e. participants study for a postgraduate qualification. This type of accreditation will only appeal to certain teachers. There is a need for a non-university form of accreditation as a means of rewarding those teachers who want to pursue accreditation without having to leave the classroom. Future CPD programmes should provide teachers with such opportunities. Furthermore, future EU CPD collaborations should provide cross-European accreditation for participants from the various countries.
- **Teacher mobility:** in future projects ideally it would be good if teachers could be provided with more opportunities to visit teachers and teachers' classes from other European countries. This would help teachers have a better experience of the 'European Nature' of the project and would provide them with opportunities to develop contacts with primary teachers in other European countries.

A General Information

Grant Agreement Number: **244684**

Title of the Project: The FIBONACCI Project - Large-scale dissemination of inquiry-based science and mathematics education

Name and Title of Coordinator: David Jasmin, Director of Fondation *La main à la pâte*, Ecole Normale Supérieure, Paris

B Ethics

1. Did your project undergo an Ethics Review (and/or Screening)? • *If Yes: have you described the progress of compliance with the relevant Ethics Review/Screening Requirements in the frame of the periodic/final project reports?* *Special Reminder: the progress of compliance with the Ethics Review/Screening Requirements should be described in the Period/Final Project Reports under the Section 3.2.2 'Work Progress and Achievements'*	***1Yes 7No***
2. Please indicate whether your project involved any of the following issues (tick box) :	***YES***
RESEARCH ON HUMANS	
• *Did the project involve children?*	4
• *Did the project involve patients?*	
• *Did the project involve persons not able to give consent?*	
• *Did the project involve adult healthy volunteers?*	1
• *Did the project involve Human genetic material?*	
• *Did the project involve Human biological samples?*	
• *Did the project involve Human data collection?*	2 Contact infos of teachers and schools
RESEARCH ON HUMAN EMBRYO/FOETUS	
• *Did the project involve Human Embryos?*	
• *Did the project involve Human Foetal Tissue / Cells?*	

• *Did the project involve Human Embryonic Stem Cells (hESCs)?*	
• *Did the project on human Embryonic Stem Cells involve cells in culture?*	
• *Did the project on human Embryonic Stem Cells involve the derivation of cells from Embryos?*	
PRIVACY	
• *Did the project involve processing of genetic information or personal data (eg. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)?*	
• *Did the project involve tracking the location or observation of people?*	
RESEARCH ON ANIMALS	
• *Did the project involve research on animals?*	
• *Were those animals transgenic small laboratory animals?*	
• *Were those animals transgenic farm animals?*	
• *Were those animals cloned farm animals?*	
• *Were those animals non-human primates?*	
RESEARCH INVOLVING DEVELOPING COUNTRIES	
• *Did the project involve the use of local resources (genetic, animal, plant etc)?*	
• *Was the project of benefit to local community (capacity building, access to healthcare, education etc)?*	***3***
DUAL USE	
• *Research having direct military use*	*0 Yes 9 No*
• *Research having the potential for terrorist abuse*	

C Workforce statistics

3. Workforce statistics for the project: Please indicate in the table below the number of people who worked on the project (on a headcount basis).

Type of Position	Number of Women	Number of Men
Scientific Coordinator	11	10
Work package leaders	17	10
Experienced researchers (i.e. PhD holders)	45	27
PhD Students	17	6
Other	77	42

4. How many additional researchers (in companies and universities) were recruited specifically for this project?	**11**
Of which, indicate the number of men:	11

D Gender aspects

5.	**Did you carry out specific Gender Equality Actions under the project**?	2 20	Yes No

6. Which of the following actions did you carry out and how effective were they?

		Not at all effective				Very effective
❑	Design and implement an equal opportunity policy	○	○	○	2	○
❑	Set targets to achieve a gender balance in the workforce	○	○	○	2	○
❑	Organise conferences and workshops on gender	1	○	○	1	○
❑	Actions to improve work-life balance	○	○	1	1	○

2 Other: **No actions carried out. The majority of participants (trainers and teachers) are females /** Arranging options to attend to primary school teacher activities / prepare science education activities equally attractive for both genders

7. Was there a gender dimension associated with the research content – i.e. wherever people were the focus of the research as, for example, consumers, users, patients or in trials, was the issue of gender considered and addressed?

1 Yes- please specify - The aim of our project is to get pupils interested in science and technology. It´s especially important to encourage girls to choose a STEM – carrier.

22 No

E Synergies with science education

8. Did your project involve working with students and/or school pupils (e.g. open days, participation in science festivals and events, prizes/competitions or joint projects)?

20 Yes- please specify The aim of the project was to engage students in their regular school classrooms sessions in inquiry based learning activities (under the supervision of their regular science and math teacher). / Schools activities, Science Festivals, science centre and field visits / The program is based on teacher training and providing teaching material, which is in accordance with the Berlin school curriculum. Teachers were visited in school and supported by using newly adapted material, Open days; Awards ceremony / Activities for parents at the end of the school year; presenting project activities / Scientific competition/science fair

2 No

9. Did the project generate any science education material (e.g. kits, websites, explanatory booklets, DVDs)?

22 Yes- please specify - Teachers were asked to write a short project report. The reports were collected and are now distributed to other teachers to inspire inquiry based education. / kits, explanatory booklets available on internet. **Manipulatives (a specific flexible kits for tessellating the plane, for propedeutics of geometric transformations, for enhancing spatial imagination). Website in two languages-English and Bulgarian (http://www.math.bas.bg/omi/Fibonacci/archive.htm), 4 explanatory booklets ,** Teacher guides for IBSE units **, Booklet** Implementing Inquiry beyond the School, **kits, websites, explanatory booklets, DVDs,** articles in teacher journals

1 No - No, we already had these type of material

F	Interdisciplinarity

10. Which disciplines (see list below, p.6) are involved in your project?

○ Main discipline [14]: 1.2** / 5.3**********. (educational sciences)/ **1.1 Mathematics****– 1.5** / NATURAL SCIENCES**** / physical, chemical, environmental related and biological sciences / Social Sciences: Educational Sciences/1.4 / 1.1

○ Associated discipline [1]: 1.1****/: **6.3 Arts -** 6.1/ 1.2, 1.5**/ language/2.2/5.3

○ Associated discipline [1]: : **1.3** Chemical Sciences** - 6.2

G	Engaging with civil society and policy makers		
11a.	**Did your project engage with societal actors beyond the research community?** *(if 'No', go to Question 14)*	18 5	Yes No
11b.	**If yes, did you engage with citizens (citizens' panels / juries) or organised civil society (NGOs, patients' groups etc.)?** 1 No ○ Yes- in determining what research should be performed 6 Yes - in implementing the research 15 Yes, in communicating /disseminating / using the results of the project		
11c.	**In doing so, did your project involve actors whose role is mainly to organise the dialogue with citizens and organised civil society (e.g. professional mediator; communication company, science museums)?**	13 8	Yes No
12.	**Did you engage with government / public bodies or policy makers (including international organisations)** 3 No 2 Yes- in framing the research agenda 3 Yes - in implementing the research agenda 17 Yes, in communicating /disseminating / using the results of the project		

[14] Insert number from list below (Frascati Manual), p.6.

13a. Will the project generate outputs (expertise or scientific advice) which could be used by policy makers?

8 Yes – as a **primary** objective (please indicate areas below- multiple answers possible)
9 Yes – as a **secondary** objective (please indicate areas below - multiple answer possible)
3 No

13b. If Yes, in which fields ?

Agriculture		Energy 1		Human rights	
Audiovisual and Media		Enlargement		1 Information Society	
Budget		Enterprise		Institutional affairs	
Competition		Environment 1		Internal Market	
Consumers		External Relations		Justice, freedom and security	
Culture		External Trade		Public Health	
Customs		Fisheries and Maritime Affairs		Regional Policy	
Development Economic and Monetary Affairs		Food Safety		1 Research and Innovation	
17 Education, Training, Youth		Foreign and Security Policy		Space	
Employment and Social Affairs		Fraud		Taxation	
		Humanitarian aid		Transport	

13c If Yes, at which level?

10 local / regional levels
10 national level
5 European level
4 International level

H Use and dissemination

14. How many articles were published/accepted for publication in peer-reviewed journals?	**27**
To how many of these is open access[15] provided?	**25**
How many of these are published in open access journals?	**18**
How many of these are published in open repositories?	**8**
To how many of these is open access not provided?	**1**
Please check all applicable reasons for not providing open access: 1 publisher's licensing agreement would not permit publishing in a repository ❑ no suitable repository available ❑ no suitable open access journal available ❑ no funds available to publish in an open access journal ❑ lack of time and resources ❑ lack of information on open access ❑ other[16]: ……	

[15] Open Access is defined as free of charge access for anyone via Internet.
[16] For instance: classification for security project.

15. How many new patent applications ('priority filings') have been made? *("Technologically unique": multiple applications for the same invention in different jurisdictions should be counted as just one application of grant).*		
16. Indicate how many of the following Intellectual Property Rights were applied for (give number in each box).	Trademark	
	Registered design	
	Other	
17. How many spin-off companies were created / are planned as a direct result of the project?		
Indicate the approximate number of additional jobs in these companies:		

18. Please indicate whether your project has a potential impact on employment, in comparison with the situation before your project:

❑	Increase in employment, or	❑	In small & medium-sized enterprises
❑	Safeguard employment, or	❑	In large companies
❑	Decrease in employment,	17	None of the above / not relevant to the project
3	Difficult to estimate / not possible to quantify		

19. For your project partnership please estimate the employment effect resulting directly from your participation in Full Time Equivalent (*FTE = one person working fulltime for a year*) jobs:	*Indicate figure:*
Difficult to estimate / not possible to quantify	*0.3FTE+ 2.3FTE+0.5FTE 2 part time+ ½ FTE+1* 11

I	Media and Communication to the general public

20. As part of the project, were any of the beneficiaries professionals in communication or media relations?

3 Yes 20 No

21. As part of the project, have any beneficiaries received professional media / communication training / advice to improve communication with the general public?

3 Yes 20 No

22 Which of the following have been used to communicate information about your project to the general public, or have resulted from your project?

14	Press Release	11	Coverage in specialist press
3	Media briefing	8	Coverage in general (non-specialist) press
4	TV coverage / report	3	Coverage in national press
7	Radio coverage / report	❑	Coverage in international press
18	Brochures /posters / flyers	21	Website for the general public / internet
6	DVD /Film /Multimedia	17	Event targeting general public (festival, conference, exhibition, science café)

23 In which languages are the information products for the general public produced?

19	Language of the coordinator	9	English
2	Other language(s)		

For question F-10 above: Classification of Scientific Disciplines according to the Frascati Manual 2002 (Proposed Standard Practice for Surveys on Research and Experimental Development, OECD 2002):

FIELDS OF SCIENCE AND TECHNOLOGY

1. NATURAL SCIENCES

1.1 Mathematics and computer sciences [mathematics and other allied fields: computer sciences and other allied subjects (software development only; hardware development should be classified in the engineering fields)]

1.2 Physical sciences (astronomy and space sciences, physics and other allied subjects)

1.3 Chemical sciences (chemistry, other allied subjects)

1.4 Earth and related environmental sciences (geology, geophysics, mineralogy, physical geography and other geosciences, meteorology and other atmospheric sciences including climatic research, oceanography, vulcanology, palaeoecology, other allied sciences)

1.5 Biological sciences (biology, botany, bacteriology, microbiology, zoology, entomology, genetics, biochemistry, biophysics, other allied sciences, excluding clinical and veterinary sciences)

2 ENGINEERING AND TECHNOLOGY

2.1 Civil engineering (architecture engineering, building science and engineering, construction engineering, municipal and structural engineering and other allied subjects)

2.2 Electrical engineering, electronics [electrical engineering, electronics, communication engineering and systems, computer engineering (hardware only) and other allied subjects]

2.3. Other engineering sciences (such as chemical, aeronautical and space, mechanical, metallurgical and materials engineering, and their specialised subdivisions; forest products; applied sciences such as geodesy, industrial chemistry, etc.; the science and technology of food production; specialised technologies of interdisciplinary fields, e.g. systems analysis, metallurgy, mining, textile technology and other applied subjects)

3. MEDICAL SCIENCES

3.1 Basic medicine (anatomy, cytology, physiology, genetics, pharmacy, pharmacology, toxicology, immunology and immunohaematology, clinical chemistry, clinical microbiology, pathology)
3.2 Clinical medicine (anaesthesiology, paediatrics, obstetrics and gynaecology, internal medicine, surgery, dentistry, neurology, psychiatry, radiology, therapeutics, otorhinolaryngology, ophthalmology)
3.3 Health sciences (public health services, social medicine, hygiene, nursing, epidemiology)

4. AGRICULTURAL SCIENCES
4.1 Agriculture, forestry, fisheries and allied sciences (agronomy, animal husbandry, fisheries, forestry, horticulture, other allied subjects)
4.2 Veterinary medicine

5. SOCIAL SCIENCES
5.1 Psychology
5.2 Economics
5.3 Educational sciences (education and training and other allied subjects)
5.4 Other social sciences [anthropology (social and cultural) and ethnology, demography, geography (human, economic and social), town and country planning, management, law, linguistics, political sciences, sociology, organisation and methods, miscellaneous social sciences and interdisciplinary , methodological and historical S1T activities relating to subjects in this group. Physical anthropology, physical geography and psychophysiology should normally be classified with the natural sciences].

6. HUMANITIES
6.1 History (history, prehistory and history, together with auxiliary historical disciplines such as archaeology, numismatics, palaeography, genealogy, etc.)
6.2 Languages and literature (ancient and modern)
6.3 Other humanities [philosophy (including the history of science and technology) arts, history of art, art criticism, painting, sculpture, musicology, dramatic art excluding artistic "research" of any kind, religion, theology, other fields and subjects pertaining to the humanities, methodological, historical and other S1T activities relating to the subjects in this group]

Conclusion

The Fibonacci project has achieved much more than it set out to achieve. More teachers and schools than scheduled were involved as the numbers initially targeted. PRE-service teacher education was involved, which originally was not the objective of the project. New networks have been created across Europe. New expertise as to IBSE and IBME has been gathered and shared. New cooperation forms have been set up between various TC1 and TC2. New European projects have been developed between various Fibonacci partners etc. What has been achieved should not be lost but should be the solid foundation for mainstreaming IBSE or IBME in the near future in close cooperation with the national authorities.

No doubt quality IBSE or IBME has been promoted, enhanced and largely disseminated through the Fibonacci project. All of the partners have been involved in organising CPD and/or Pre-service teacher education activities for IBSE or IBME. Furthermore, all of them have been involved in various national, European and international pilot projects focusing on innovation in mathematics and science in general and on IBSE or IBME in particular. The expertise of the RC is also strengthened by the fact that most of them have, for many years, carried out and are carrying out research into the effects of IBSE or IBME, which they have put at the disposal of all the TC to which they are twinned or are collaborating with on some of the common topics. It should be clearly stressed that many of the TC also had solid experience and expertise in IBSE or IBME which has definitely been strengthened by being linked to a more experienced RC.

Of course, this could not have been done without a constant and careful steering from all the partners involved, starting with the scientific committee (Michèle Artigue, Peter Baptist, Justin Dillon, Wynne Harlen, Pierre Léna), whose devoted and demanding attention to the project, and acute expertise in the area, enabled to maintain a high standard in the activities developed, while producing some truly reference documents on inquiry-based learning in science and mathematics.

As a learning process, the project also owes a lot to the sharp scrutiny of Educonsult, the external evaluator, to Yves Beernaert and Magda Kirsch, whose experience and recommendations always came as precious and inspiring formative assessment for the project as a whole.

As based as it may be on a mathematical model, Fibonacci was above all a very concrete project, grounded in the realities of multiple local contexts and situations. Critical for a successful implementation on the field was the role of all the coordinators of the Fibonacci centres. It is not possible to name them all here, but they certainly deserve the bulk of the credit for making an attractive idea come true, and, overcoming all the difficulties, stimulatingly engaging with teacher educators, teachers and pupils, who, as the end-targets and essential players of the project, should be warmly thanked for enthusiastically taking part in all the Fibonacci activities.

Last but not least, our gratitude goes to the European Commission, whose trust and meaningful support deserve rightful recognition, as they simply made the project possible, as much as its continued investment in inquiry-based science and mathematics education must be saluted and encouraged. This way, one can hope that the Fibonacci sequence of centres for science and mathematics education can be deployed further on the educational map of Europe, and that more research and development can be done in effective teacher professional development, teaching and learning models, thus contributing to reaching the long-term objective of successfully renewing science and mathematics education.

Indeed, by definition, there is no ending to the Fibonacci sequence, where a generation always breeds a new and larger one.