



**Project No.:** 244749  
**Project Acronym:** ESTABLISH  
**Project Title:** European Science and Technology in Action:  
 Building Links with Industry, Schools and Home

## Work Package 9 | Deliverable 1 D9.1 Final Report on the conduct, implementation and outcomes of ESTABLISH

**Dissemination Level:** Public  
**Thematic Priority:** Science in Society  
**Funding Scheme:** Coordination and Support Actions

**Deliverable No.:** D9.1  
**Due date of deliverable:** 31/03/2014  
**Actual submission date:** 31/03/2014

**Start date of project:** 01/01/2010 **Duration:** 51 months  
**Name of Coordinator:** Dr. Eilish McLoughlin

**Name of lead partner for this deliverable:** DCU

**A. Background to this report**

This report is a deliverable of Work Package 9 (WP2) of the European FP7-funded project “European Science and Technology in Action: Building Links with Industry, Schools and Home” (ESTABLISH; 244749, 2010-2013). It meets the requirements of this deliverable by presenting a synopsis of how the project has performed; detailing what we (as the ESTABLISH beneficiaries listed in Table 1) wanted to achieve through the project, how we organised ourselves to do this, what we actually did, the progress and process of development, the impact of our efforts, whether we our expectations and lessons learned from the process.

(See Table 1 for beneficiary list).

This document, published in March 2014, has been produced within the scope of the ESTABLISH Project, which has received funding from the European Union’s Seventh Framework Programme for research, technological development and demonstration under grant agreement no 244749.

The utilisation and release of this document is subject to the conditions of the contract within the Seven<sup>th</sup> Framework Programme, project reference FP7-SIS-2009-1-244749 and reflects the authors’ views; the European Union is not liable for any use that may be made of the information contained therein.

For further information regarding ESTABLISH please contact:

Dr. Sarah Brady (ESTABLISH project manager)

Email: sarah.brady@dcu.ie

ESTABLISH website: <http://www.establish-fp7.eu>

**Table 1: The ESTABLISH consortium**

<b>Beneficiary short name</b>	<b>Beneficiary name</b>	<b>Country</b>	<b>Abbreviation</b>
DCU	DUBLIN CITY UNIVERSITY	Ireland	IE
AGES	AG EDUCATION SERVICES	Ireland	IE
UCY	UNIVERSITY OF CYPRUS	Cyprus	CY
UmU	UMEA UNIVERSITET	Sweden	SE
JU	UNIwersytet Jagiellonski	Poland	PL
CUNI	UNIVERZITA KARLOVA V PRAZE	Czech Republic	CZ
AL	ACROSSLIMITS LIMITED	Malta	MT
UPJS	UNIVERZITA PAVLA JOZEFA ŠAFÁRIKA V KOŠICIACH	Slovakia	SK
UTARTU	TARTU ULIKOOL	Estonia	EE
UNIPA	UNIVERSITA DEGLI STUDI DI PALERMO	Italy	IT
MaH	MALMÖ UNIVERSITY	Sweden	SE
IPN	LEIBNIZ-INSTITUT FUER DIE PAEDAGOGIK DER NATURWISSENSCHAFTEN UND MATHEMATIK AN DER UNIVERSITAT KIEL	Germany	DE
CMA	CENTRE FOR MICROCOMPUTER APPLICATIONS	Netherlands	NL
MLU	MARTIN LUTHER UNIVERSITAET HALLE-WITTENBERG	Germany	DE
FU	FREDERICK UNIVERSITY	Cyprus	CY

# Table of Contents

Executive Summary.....	2
1. Introduction.....	3
2. Roles & responsibilities .....	5
3. Scientific Quality, Gender and Ethical Considerations .....	7
4. Implementation.....	9
5. Managing Unexpected Events.....	11
6. Managing Changes during the project .....	13
7. Monitoring Progress .....	15
8. Information Flow .....	21
9. Dissemination and Knowledge Utilisation.....	23
10. Conclusions and future implications .....	29

## Executive Summary

The overall objective of ESTABLISH was to facilitate and implement an inquiry-based approach to science education for second level students (age 12-18 years) on a widespread scale across Europe by bringing together, within a collaborative environment, the key stakeholders in science education across twelve European countries.

ESTABLISH has achieved this objective by addressing three key issues associated with the practical implementation of IBSE in the classroom, and provided:

- relevant teaching materials to engage the learner in inquiry based learning
- appropriate training support for teachers to implement an inquiry methodology
- sustainable connections with policy makers and scientific and industrial community.

The ESTABLISH project has effectively carried out all tasks and activities towards achieving the originally proposed goals and the resulting impact of these actions is evident at multiple levels - all collectively contributing towards the increased usage and research into the area of inquiry based science education in classrooms across Europe. The findings, analysis and conclusion of specific ESTABLISH actions and impacts are discussed within the various project deliverable reports. This report will describe the overarching approach adopted by the ESTABLISH beneficiaries (Table 1) to manage and coordinate the project and will report on the conduct, implementation and outcomes of this core project activity.

The outcomes of the project have been shown to result in:

- greater implementation of IBSE methodologies by teachers;
- greater understanding, attitude and ability to use IBSE in their teaching;
- increased student's motivation and communication during science lessons;
- greater student attitude towards science and taking up careers in science or technology;
- increased interaction between those teaching and learning about science and those using science.

These are significantly positive outcomes when considered in the context of the need for increased engagement and participation of young people in science and technology, both for industrial and widespread societal benefit in Europe. This overall impact of the ESTABLISH project has been achieved through the adoption of an effective strategy for the management and coordination of resources (personnel and budget), information flow, tasks and activities to deliver internationally significant outputs, outcomes and recommendations.

# 1. Introduction

The overall objective of ESTABLISH has been the facilitation and implementation of an inquiry-based approach to science education for second level students (age 12-18 years) on a widespread scale across Europe bringing together, within a collaborative environment, the stakeholders in science education.

The reasons or specific project objectives (PO) for undertaking this project were:

- PO1.** To facilitate and implement an inquiry-based approach in teaching and learning of science and technology across Europe, through the following actions:
- (i) To identify, further develop, trial and evaluate teaching and learning inquiry-based materials and localise where applicable, based on relevance to current industry and research in science, gender considerations, cultural and local pre-conditions.
  - (ii) To provide support for teachers to successfully implement this approach.
  - (iii) To further develop and implement the teaching and learning materials across Europe.
  - (iv) To share and disseminate inquiry-based approaches and teaching and learning materials for science education.
- PO2.** To stimulate learning and promote intrinsic motivation in students and identify career opportunities in science and technology for both men and women, by providing with authentic experiences from across research and industry.
- PO3.** To foster a mutually beneficial relationship between industries/research, teaching communities and the local education system, for the on-going advancement of science and technology.
- PO4.** Encourage sharing of experiences from across all the partners over Europe to deliver model(s) of best practice for incorporation of inquiry based teaching in classrooms and in teacher education.
- PO5.** Evaluation of model(s) of best-practice in driving curricula and pedagogical change and this includes the involvement of all stakeholders from parents to policy makers.
- PO6.** Widespread dissemination of resources and models of best practice to the wider EU community.

ESTABLISH has sought to reach these objective by addressing three key issues associated with the practical implementation of IBSE, these being the:

- lack of relevant teaching materials to engage the learner and provide authentic learning experiences;
- lack of training support of teachers to implement this methodology and
- lack of support or connection with policy makers and those who use science.

ESTABLISH has been the opportunity for key stakeholders in second level science education to work together to achieve the specific aim of creating authentic learning environments for science education. This collaboration has informed the development of the project's **teaching and learning materials (ESTABLISH Units)** as well as **educational supports** for both in-service and pre-service teachers (**ESTABLISH Teacher Education Programmes**) designed to promote the use of Inquiry-Based Science Education (IBSE) in classrooms across Europe.

The outcomes of the project has been shown to have resulted in:

- greater implementation of IBSE methodologies by teachers

- greater understanding, attitude and ability to use IBSE in their teaching;
- increased student's motivation and communication during science lessons
- greater student attitude towards science and taking up careers in science or technology
- increased interaction between those teaching and learning about science and those using science.

Each of these outcomes have been addressed and measured within specific work-packages of the project. Specifically, WP4 & WP5 looked at the benefits of suitable and appropriate IBSE teaching and learning Units (D3.1-D3.3) and TEPs (D4.6) on teachers' implementation of IBSE in the classroom and on their attitudes towards IBSE (D4.5 and D5.5). WP6 looked at the benefit of ESTABLISH's materials on students' interest and motivations in science and their attitudes towards careers in science (D6.1). Additionally WP8 has reported on ESTABLISH dissemination activities in promoting the ESTABLISH approach and outputs to drive change in the way that science is taught in schools throughout Europe and to lead to other IBSE research- and practice- led initiatives (D8.1).

In order to achieve these desirable outcomes, WP9 focused on the organization, quality, planning, risk-analysis, impact of change and monitoring of progress, as carried out by the ESTABLISH beneficiaries to conduct the project activities. This report provides an overview of these processes and procedures, in terms of the roles and responsibilities of project beneficiaries and other collaborators cognisant of achieving excellence in scientific quality and with regard to gender and ethical considerations. The overall planning strategy adopted to deliver on core project objectives is outlined as well as plans for managing unexpected events or changes that occurred during the lifetime of the project. As all ESTABLISH beneficiaries were involved in all the work packages of the project, it was essential that regular meetings were held to review overall project progress and provide opportunities for face-to-face discussions for developing, critiquing and sharing experiences gained in developing of the project's teaching and learning materials (units) and implementing Teacher Education Programmes. The discussions on the engagement of ESTABLISH, at local, national and European level provides a perspective of the global impact of ESTABLISH. The conclusions drawn from managing such a pan-European Coordination and Support Action are presented along with the implications for future such projects in implementing innovation in STEM education.

## 2. Roles & responsibilities

As mentioned, the specific aim of ESTABLISH has been to create authentic learning environments for science education by bringing together and involving all the key communities in second level science education. To ensure effective direction, management, delivery and communication a series of project roles and responsibilities were established to achieve the goals of the project. As the following list outlines the project engaged a roles including those who would deliver, use and supply the projects expected outputs. These roles and responsibilities were:

Role Title	Membership	Responsibilities
Project Coordination Team (PCT)	Individuals from coordinating beneficiary (DCU)	Project Management Communication liaison with European Commission and External Advisory Panel
Project Steering Committee (PSC)	Representation from each of the ESTABLISH Beneficiaries	Approval of project reports, project activities; consider input from internal Quality Assurance Committee and external Advisory Panel
External Advisory Panel (EAP)	Invited international experts	Review of project reports and activities with suggestions for subsequent implementation
Quality Assurance Committee (QAC)	Subgroup of PSC	Review of project reports, activities to recommend decisions at PSC.
Work Package Leader (WPL)	Subgroup of PSC	Manage and deliver the project reports and actions as defined within each work package
Lead National Partner (LNP)	Subgroup of PSC	Manage and deliver the project reports and actions relevant to each country
General Assembly (GA)	All ESTABLISH Beneficiaries	Execute and contribute to the different project activities and reports Project liaison with industry partners, science teachers and students
Key Stakeholders in STEM Education	Including science teachers and educators, the scientific and industrial communities, the young people and their parents, the policy makers responsible for science curriculum and assessment and the science education research community	Users and suppliers of the project; Piloted and trialled IBSE materials in classrooms; contributed to development of IBSE materials; supported IBSE teaching and learning by facilitating study visits.



A strategy to manage communication flows to and from key stakeholders was developed to provide guidelines for the ESTABLISH beneficiaries on how to send and request information to and from individuals within the consortium. A project website with e-learning platform was also developed @ <http://www.establish-fp7.eu> to facilitate communications and promote the project both internally within the consortium and externally to the key stakeholders, as well as the general public. Further information about the nature and success of the ESTABLISH dissemination strategy is located in the project report “D8.1 – Final Report presenting the nature and success of the dissemination strategy”.

To assist with project reporting, in particular financial reporting, guidelines for ESTABLISH beneficiaries were developed and circulated internally. These were reviewed and updated during the lifetime of the project.

### 3. Scientific Quality, Gender and Ethical Considerations

To ensure the Scientific Quality, Gender and Ethical Considerations of project outputs (ESTABLISH units) and activities (ESTABLISH Teacher Education Programmes), a system of development involving piloting of the materials and their revision before their widespread implementation –this involved representatives from the key stakeholders.

#### Internal Monitoring

In general the scientific quality, ethical and gender considerations of the materials and activities were reviewed internally by the quality assurance committee /project steering committee before being approved by PSC for general implementation. The plan for this review is outlined in the project report, Milestone MS23. Additional quality assurance mechanisms were employed during the project specific to each work package. The following table shows these schemes.

Workpackage	Project output / activity	Quality Assurance Mechanism	Outcome
WP3	ESTABLISH IBSE Teaching and Learning material / “UNITS”	<ul style="list-style-type: none"> <li>• Drafting</li> <li>• Piloting with small group of teachers</li> <li>• Revision</li> <li>• Trialling with teachers in each county</li> <li>• Publication of core unit</li> <li>• Translation &amp; cultural adaption of unit to local contexts</li> </ul>	Materials are reviewed for scientific quality, gender and ethical considerations and are deemed fit for purpose by the primary users (second level teachers)
WP4/5	ESTABLISH Teacher Education Programme (TEP)	<ul style="list-style-type: none"> <li>• Review of challenges and issues towards implementing IBSE in local contexts</li> <li>• Proposal of criteria for ESTABLISH TEP</li> <li>• Implementation of TEP</li> <li>• Develop questionnaire tool to determine impact of TEP on teachers, both in-service and pre-service</li> </ul>	<p>Teacher Education Programmes which are assured for scientific quality, gender and ethical considerations and which can be implemented successfully in each country</p> <p>Teacher questionnaire that is appropriate for capturing the required information and can be implemented with in-service and pre-service teachers.</p>
WP6	ESTABLISH Student evaluation questionnaire	<ul style="list-style-type: none"> <li>• Drafting</li> <li>• Piloting of questionnaire with student sample</li> <li>• Revision to questionnaire to address issues</li> <li>• Implementation</li> </ul>	Student questionnaire that is appropriate for capturing the required information and that can be implemented without difficulty

### External Advisory Panel

At specific points in the project, international experts were invited to engage in the project as External Advisory Panel members to review particular aspects of the project and to provide independent advice on how to improve the quality and effectiveness of the project process and products.

The following table outlines the EAP members who were engaged in the ESTABLISH project:

EAP Member	Area of Review	Review Report	Outcome
Prof. Marcia Linn, details, USA	Review of the structure and methodology of the development of the ESTABLISH units	Milestone report MS 29	Prof. Linn outlined and advised on models for the structure and methodology for the development of the IBSE teaching and learning materials (Units). The agreed framework for the development of IBSE units and activities was informed by her review to consider the diversity of language and prior knowledge of IBSE.
Prof. Shirley Simon, Institute of Education, UK	Review of structure and methodology for the development and implementation of ESTABLISH Teacher Education Programmes (TEPs)	Milestone report MS 30	Prof. Simon outlined and advised on models and materials for teacher education (both face-face and online) that would incorporate ESTABLISH units and framework for TEPs, and in particular use the “stories” as described by each beneficiary to engage teachers and educators. This approach was considered and adopted into an action plan for models for ESTABLISH TPDs.
Prof. Shirley Simon, Institute of Education, UK	Review of structure and methodology for the evaluation of ESTABLISH Teacher Education Programmes (TEPs)	Milestone report MS 31	Prof. Simon outlined and advised on models for evaluating models of teacher education. This approach was considered and adopted into an action plan to extend the descriptive models to include evaluations to inform the models for implementing and evaluating ESTABLISH Teacher Education in IBSE.
Mr. Mathy Vanbuel	Review of structure and methodology for the development of ESTABLISH on-line content and presence	Milestone report MS 34	Mr. Vanbuel outlined and advised on models for the structure and methodology for the online presentation of the ESTABLISH project and resources. This approach to revise and consolidate the online presence of ESTABLISH into one site has been adopted.
Prof. Dean Zollman	Review of structure and methodology for the whole project implementation, outcomes and outputs for increasing the use of IBSE.	Milestone report MS 33	Prof. Zollman outlined and provided summative advice on the structure and methodology for highlighting the impact of the ESTABLISH project in achieving its core objective – increasing use of IBSE in classroom practice – through collecting evidence of the impact on teachers, students and key stakeholders in STEM Education. This advice has been adopted in all final project deliverables, period reports and on project website.

## 4. Implementation

ESTABLISH aimed to facilitate and implement an inquiry-based approach to science education for second level students (age 12-18 years) on a widespread scale across Europe by focusing on the development and delivery of two key products:

1. the project's **teaching and learning materials** (***ESTABLISH Units***)
2. the project's **educational supports** for both in-service and pre-service teachers (***ESTABLISH Teacher Education Programmes***).

Achieved through interaction between those teaching and learning about science and those using science as outlined in

3. the project's **strategy for engagement with key stakeholders** in STEM education.

These were designed to promote the use of Inquiry-Based Science Education (IBSE) in classrooms across Europe by directly addressing the challenges caused by the lack of relevant teaching materials to engage the learner and provide authentic learning experiences; and lack of training support of teachers to implement this methodology.

By identifying first what is it that was needed, the activities, dependencies and resources required to deliver these products could then be identified, as reported in the following project reports.

ESTABLISH product	Description	Activities and Dependencies
ESTABLISH Teaching and Learning Materials ( <i>units</i> )	Framework for IBSE teaching and learning units (D1.1)	Piloted, culturally adapted, teaching and learning IBSE units – Part I (D3.1) Piloted, culturally adapted, teaching and learning IBSE units – Part II (D3.2) Piloted, culturally adapted, teaching and learning IBSE units – Part III (D3.3) Guide for developing ESTABLISH Teaching and Learning Units (D3.4)
ESTABLISH Teacher Education Programme ( <i>face-to-face</i> )	Framework for Teacher Education Programme (D5.2)	Report on the main obstacles to implementing inquiry and intervention programmes in IBSE (D4.1) Report on effective instruments and tools for evaluation of IBSE with in-service and pre-service teachers (D5.1) Interim & Final Profile of in-service science teachers' attitudes and understanding of IBSE (D4.3/D4.5) Interim & Final Profile of pre-service science teachers' attitudes and understanding of IBSE (D5.3/D5.5) Effective models for science teacher training in IBSE (D4.6)

ESTABLISH Teacher Education Programme (online)	Web-based IBSE materials for Teacher Education (D4.4)  Web-based Teacher Education Programme (D5.4)	Guide for developing ESTABLISH Teaching and Learning Units (D3.4)  Effective models for science teacher training in IBSE (D4.6)
ESTABLISH Engagement with key Stakeholders	Effective models for engagement with key stakeholders (D2-3)	Report on how IBSE is implemented and assessed in participating countries (D2.1) Key forces for driving change in classroom practice (D2.2)

The strategy adopted by the project has been for all consortium beneficiaries to be involved in all work packages and therefore required the need for regular forums for exchange of ideas and experiences through bi-annual general assembly meetings.

The nature of the work plan of ESTABLISH required close interaction between the Project coordinator and WP5 leader (DCU), WP4 leaders (UMU/MaH) and WP3 leader (CMA) for the development of IBSE teaching and learning units to be used as a core element in in-service and pre-service teacher education programmes. A series of tri-lateral meetings were held between these beneficiaries to define and review the tasks and activities of these core aspects of the project. This activity benefited the project well and resulted in the development of high quality scientific outputs and processes.

The process adopted for the development of IBSE Units involved the management of all beneficiaries working in small discipline groups to develop the initial three IBSE units in Physics, Chemistry and Biology. This process resulted in all beneficiaries pilot engaged in trialling and revising these units and established the approach for the development of the other 15 IBSE units. This developmental process was informed by input from independent evaluator Prof. Marcia Linn and facilitated the consortium defining the purpose and criteria for developing units and the preparation of a Guide for developing IBSE units – that is an invaluable resource for all curriculum developers. The entire collection of 18 ESTABLISH IBSE units, with 3-13 IBSE activities in each unit, now provides an extensive bank of fit-for-purpose resources for teachers and educators in adopting IBSE.

## 5. Managing Unexpected Events

As with any project there is a certain amount of uncertain events which can occur and which can impact on the workplan and performance of the project. During the lifetime of ESTABLISH a number of these unexpected events did occur which were addressed and managed as described in the following table.

Relevant Workpackage	Risk Identity	Outcome	Plan & implementation
WP 4/5	Not all beneficiaries could carry out the teacher profile pre- and post-questionnaires	This would have a negative impact on the breath of analysis about the profile and change in teachers' attitudes and understanding of IBSE	For those beneficiaries who could not carry out the profile questionnaires to supplement the profile data sets with descriptive case-studies and/or interview about teachers' attitude and understanding of IBSE.
WP 4/5	Request for additional Teacher Education Programmes by national teacher education services	This is a positive outcome which will deepen the promote the project in relevant beneficiary countries	To use the ESTABLISH Teacher Education Programme and units as models for developing national Teacher Education programmes in IBSE
WP 6	Not all beneficiaries could carry out the student impact questionnaires	This would have a negative impact on the breath of analysis about the impact of ESTABLISH units on second level students	For the range of analysis to be reduced to those who could carry out the questionnaires. For other beneficiaries to supplement the questionnaire data with descriptive case-studies or other evaluations on the impact of ESTABLISH units on second level students.
WP 8	Project products translated and shared beyond the beneficiary countries	This is a positive outcome which will widen the spread of the project's promotion	To share the teaching and learning materials ( <i>ESTABLISH Units</i> ) and Teacher Education Programme materials for promotion of IBSE methodology (e.g. Catalonia and Romania).
WP 9	EAP members unable to engage with project	This would lessen the impact of the project	To continue to seek out candidates who would be have the relevant expertise and availability to provide independent advice about specific aspects of the project.

WP 9	Delays in payment schedules due to amendment status applying to project	This would have a negative impact on the ability of beneficiaries to conduct core work of the project such as attend Teacher Education events	To facilitate and maintain responsive communications between EC and consortium to minimise the impact of delays to payment schedules
WP9	Changes in project beneficiaries	This would have a negative impact on the ability and scalability of the project to conduct its core work.	To facilitate and maintain responsive communications between EC and consortium beneficiaries to minimise the impact of delays to consortium.
WP9	Changes in project plan to implement an adapted approach or extension to due date of specific deliverables	This is a positive outcome to provide added value to the overall work of the project.	To facilitate and maintain responsive communications between EC and consortium beneficiaries to explain deviations from Annex I.

## 6. Managing Changes during the project

During the lifetime of the project there were a number of changes which occurred regarding the management of the project. These have included a change to the membership of the consortium, with the withdrawal of three beneficiaries, and accession of three additional beneficiaries leading to three amendments of the project's grant agreement. These particular issues have been beyond the control of the beneficiaries and have had both positive and negative impacts on the performance of the project. While the additional new beneficiaries have ensured the standard of expertise was maintained and the geographical reach of the project expanded, the delays in project reporting and financial payment schedules incurred by the amendment processes have caused a significant amount of stress to the beneficiaries and required certain core project activities to be delayed.

Other changes which have occurred include the development process of the ESTABLISH units. Initially it was proposed that the units would be piloted at the beginning of the project (within WP3) and then subsequently developed within the teacher education work-packages (within WP4/5). This process changed which saw the duration of the unit workpackage (WP3) extended over the lifetime of the project to allow for the piloting and development of the units to occur within this section of the project. This change has led to the development of 18 substantial industry-informed IBSE units, an increase on the initially estimated 12-16 units proposed for the project.

Review of the project deliverable reports identified a degree of overlap, for example D4.1 and D5.1 were both to report on the effective instruments and tools for evaluation of IBSE with in-service and pre-service teachers. Where such items of repetition were identified, they were reviewed and combined to reduce duplication. Additional deliverable reports which supported and informed the core work of the project were proposed, agreed and delivered.

The following table outlines the changes with regard to the ESTABLISH deliverable reports

Deliverable No.	Original Title	Revised Title
D2.3	<i>Additional Deliverable</i>	Engagement of stakeholders in IBSE
D3.4	<i>Additional Deliverable</i>	Guide for developing ESTABLISH Teaching and Learning Unit
D4.1	Effective instruments and tools for evaluation of IBSE with in-service teachers	Report on the main obstacles to implementing inquiry and intervention programmes in IBSE
D4.2	Interim web-based IBSE materials for in-service teacher education	Interim web-based IBSE materials for teacher education
D4.4	Web-based IBSE materials for in-service teacher education finalised	Web-based IBSE materials for Teacher Education
D4.6	Effective models for in-service science teacher training	Effective models for science teacher training in IBSE



	in IBSE	
D5.1	Effective instruments and tools for evaluation of IBSE with pre-service teachers	Report on effective instruments and tools for evaluation of IBSE with in-service and pre-service teachers
D5.2	Interim web-based IBSE materials for pre-service teacher education	Framework for Teacher Education Programme
D5.4	Web-based IBSE materials for pre-service teacher education finalised	Web-based Teacher Education Program
D5.6	Effective models for pre-service science teacher training in IBSE	Science teacher training in IBSE – selected models
D6.1	<i>Additional Deliverable</i>	The impact of Inquiry Based Science Education on second level students

## 7. Monitoring Progress

Progress is a measure of the achievements of the project objectives. The following table outlines this progress, in terms of the major outcomes, using the projects' meeting as punctuation for this monitoring process. It is noted that in addition to these major outcomes, these meetings have provided the beneficiaries with the possibility to discuss, draft, critique and learn from one another to engage in the development of the project's teaching and learning materials (units) and Teacher Education Programme.

Meeting ID	Meeting Location	Level	Key Focus and Outcomes	Prominent Workpackage
PSC 1	Dublin, Ireland	Project Steering Committee	<ul style="list-style-type: none"> <li>PSC membership,</li> <li>General management and financial procedures</li> </ul>	WP9
GA 1	Dublin, Ireland	General Assembly	<ul style="list-style-type: none"> <li>Launch with Irish Minister of Education;</li> <li>Discussion of IBSE materials to inform ESTABLISH IBSE materials;</li> <li>Discussion and definition of "inquiry" in ESTABLISH</li> <li>Discussion of challenges facing implementation of IBSE in teaching and learning of science;</li> <li>Discussion of the project website.</li> </ul>	WP1 +WP3  WP8
PSC 2	Dublin, Ireland	Project Steering Committee	<ul style="list-style-type: none"> <li>Framework and content of first three ESTABLISH units;</li> <li>ESTABLISH introduction flyer and poster for translation and dissemination;</li> <li>QAC membership;</li> <li>EAP invitations.</li> </ul>	WP1 WP8
GA 2	Dublin, Ireland	General Assembly	<ul style="list-style-type: none"> <li>Discussion of framework and guide for development of ESTABLISH units;</li> <li>Discussion and development of first three ESTABLISH units;</li> <li>Proposal of 15 ESTABLISH units;</li> <li>Discussion of objectives and expectations for the ESTABLISH Teacher Education Programme.</li> <li>Presentation from other FP7 projects (Fibonacci and S-Team) and representative from industry;</li> <li>Discussion of strategic partners to identify and engage stakeholders;</li> </ul>	WP1 +WP3  WP4/5  WP8

			<ul style="list-style-type: none"> <li>• Discussion about the key forces for driving change in the classroom practice.</li> </ul>	+WP2
PSC 3	Dublin, Ireland	Project Steering Committee	<ul style="list-style-type: none"> <li>• Development plan for subsequent ESTABLISH units;</li> <li>• Reporting on how IBSE is implemented and assessed across participating countries;</li> <li>• Reporting of the key forces for driving change in the classroom practice;</li> <li>• Reporting of teacher training practices;</li> <li>• Procedures for translation and dissemination of ESTABLISH flyer and poster</li> </ul>	WP3  WP2  WP4/5
PSC 4	St. Julian's, Malta	Project Steering Committee	<ul style="list-style-type: none"> <li>• Reporting on how IBSE is implemented and assessed across participating countries;</li> <li>• Continued progress of dissemination activities and quality review</li> </ul>	WP2  WP8
GA 3	St. Julian's, Malta	General Assembly	<ul style="list-style-type: none"> <li>• Development of first three pilot ESTABLISH units;</li> <li>• Discussion of ESTABLISH IBSE Teaching and Learning units;</li> <li>• Discussion about evaluation tools for determining the impact of ESTABLISH on teachers and on students;</li> <li>• Discussion of report on how IBSE is implemented and assessed across participating countries</li> </ul>	WP3  WP4/5 WP6  WP2
PSC 5	St. Julian's, Malta	Project Steering Committee	<ul style="list-style-type: none"> <li>• Trialling and evaluation of ESTABLISH units;</li> <li>• Selection and profiling of teachers;</li> <li>• Drafting of e-learning platform</li> </ul>	WP3 WP8
PSC 6	Umea, Sweden	Project Steering Committee	<ul style="list-style-type: none"> <li>• Progress towards period reporting</li> <li>• Report on e-learning training</li> </ul>	WP9
GA 4	Umea, Sweden	General Assembly	<ul style="list-style-type: none"> <li>• Finalisation of first three pilot ESTABLISH units;</li> <li>• Development of e-learning activities to support the units;</li> <li>• Integration of ICT with Science Education;</li> <li>• Discussion on the main obstacles to implementing inquiry and intervention programmes in IBSE;</li> </ul>	WP3  WP4/5

			<ul style="list-style-type: none"> <li>• Discussion on the report of effect instruments and tools for evaluation of IBSE with in-service and pre-service teachers;</li> <li>• Discussion of workshop and web-based materials for teacher education programmes;</li> <li>• Discussion on the report of impact on students;</li> <li>• Discussion and development of ESTABLISH units;</li> <li>• Reporting on the key forces for driving change in classroom practice across participating countries;</li> <li>• Discussion of project promotion to teachers and research community;</li> <li>• Discussion of project promotion tools and website.</li> </ul>	WP8 WP2
PSC 7	Umea, Sweden	Project Steering Committee	<ul style="list-style-type: none"> <li>• Progress of development plan for subsequent ESTABLISH units;</li> <li>• Reporting on the key forces for driving change in classroom practice across participating countries;</li> <li>• Development plan for Teacher Education Programme at in-service and pre-service level;</li> <li>• Development of evaluation instruments of teachers and students;</li> <li>• Action plan for project conference and to promote ESTABLISH at specific international conferences;</li> <li>• Engagement of EAP to review structure and methodology for developing the ESTABLISH IBSE teaching and learning units.</li> </ul>	WP3  WP4/5 WP6 WP2  WP8
PSC 8	Limassol, Cyprus	Project Steering Committee	<ul style="list-style-type: none"> <li>• Amendment to adjust consortium;</li> <li>• Preparation for EAP representation;</li> <li>• Action plan for dissemination, including project conference;</li> <li>• Action plan for impact evaluation on teachers and students;</li> <li>• Action plan for implementation of Teacher Education Programme at in-service and pre-service level;</li> <li>• Action plan for completion of seven ESTABLISH units.</li> </ul>	WP9  WP8  WP4/5
GA 5	Limassol, Cyprus	General Assembly	<ul style="list-style-type: none"> <li>• Discussion and development of ESTABLISH units with input from EAP member;</li> <li>• Discussion of Framework for Teacher Education with focus on “supportive elements”;</li> </ul>	WP3  WP4/5

			<ul style="list-style-type: none"> <li>• Discussion of student impact pilot;</li> <li>• Discussion towards completion of seven ESTABLISH units;</li> <li>• Discussion of piloting and trialling units with teachers;</li> <li>• Action plan for industry engagement.</li> </ul>	WP6
PSC 9	Dublin, Ireland	Project Steering Committee	<ul style="list-style-type: none"> <li>• Update meeting with regard to: <ul style="list-style-type: none"> <li>• Amendment;</li> <li>• Collection of evidence of dissemination; impact on students; in-service &amp; pre-service teachers;</li> </ul> </li> <li>• Planning of ICT with IBSE workshop;</li> <li>• Engagement of EAP to review structure and methodology for developing the ESTABLISH IBSE Teacher Education Programme.</li> </ul>	WP9 WP4/5
PSC 10	Prague, Czech Republic	Project Steering Committee	<ul style="list-style-type: none"> <li>• Discussion and development of ESTABLISH units;</li> <li>• Revision of units with respect to ICK and ICT;</li> <li>• Reporting of Teacher Education Programmes;</li> <li>• Action plan for development of web based Teacher Education Programmes;</li> <li>• Amendment to adjust consortium.</li> </ul>	WP3 WP4/5
GA 6	Prague, Czech Republic	General Assembly	<ul style="list-style-type: none"> <li>• Discussion and development of Teacher Education Programme and associated activities with input from EAP;</li> <li>• Discussion of the connections and links between each of the outputs (units, e-platform, associated frameworks and measurement of impact on teachers and students) and how they inform and influence the ESTABLISH Teacher Education Programme;</li> <li>• Discussion of interim impact evaluation on teachers;</li> <li>• Discussion of impact evaluation on students;</li> <li>• Discussion and small-group revision of units with respect to ICK and ICT.</li> </ul>	WP4/5 +WP3 +WP8  WP6
PSC 11	Palermo, Italy	Project Steering Committee	<ul style="list-style-type: none"> <li>• Action plan for completing nine ESTABLISH units;</li> <li>• Action plan for impact evaluation on teachers and students;</li> <li>• Action plan for revision/enrichment of units;</li> <li>• Action plan for reporting of ESTABLISH Teacher Education Programmes</li> </ul>	WP4/5  WP3 +WP7

			<ul style="list-style-type: none"> <li>which can be shared online;</li> <li>EAP invitations.</li> </ul>	
GA 7	Palermo, Italy	General Assembly	<ul style="list-style-type: none"> <li>Discussion and development of Teacher Education Programme and associated activities with input from EAP;</li> <li>Clarification and development of connections and links between each of the outputs (units, e-platform, associated frameworks and measurement of impact on teachers and students) and how they inform and influence the ESTABLISH Teacher Education Programme;</li> <li>Sharing of evidence of IBSE in practice from ESTABLISH Teacher Education Programmes;</li> <li>Sharing of evaluations of ESTABLISH Teacher Education Programme;</li> <li>Discussion and small-group revision of ESTABLISH Teacher Education Programmes elements, evaluations and online-presentation.</li> </ul>	WP3 +WP4/5 +WP8
PSC 12	Krakow, Poland	Project Steering Committee	<ul style="list-style-type: none"> <li>Engagement of EAP to review of structure and methodology for the development of ESTABLISH on-line content and presence;</li> <li>Engagement of EAP to review of ESTABLISH in terms of implementation;</li> <li>Action plan for generating online content to link the ESTABLISH units with Teacher Education Programmes;</li> <li>Action plan to report on the web-based ESTABLISH materials and Teacher Education Programmes.</li> </ul>	WP4/5 +WP8
GA 8	Krakow, Poland	General Assembly	<ul style="list-style-type: none"> <li>Discussion and small group revision of narratives describing models and evaluation of ESTABLISH Teacher Education Programmes;</li> <li>Discussion of ESTABLISH's Teacher Education Programmes online;</li> <li>Discussion of impact evaluation on students.</li> </ul>	WP4/5 +WP8 WP6
PSC 13	Dublin, Ireland	Project Steering Committee	<ul style="list-style-type: none"> <li>Presentation by Project Officer;</li> <li>Action plan for additional deliverables;</li> <li>Action plan for completing remaining deliverables;</li> <li>Engagement of EAP to review of structure and methodology for the development of ESTABLISH on-line content and presence.</li> </ul>	WP9
PSC 14	Amsterdam	Project	<ul style="list-style-type: none"> <li>Review of structure and methodology for the development of ESTABLISH</li> </ul>	WP8

		Steering Committee	<p>on-line content and presence with input from EAP;</p> <ul style="list-style-type: none"><li>• Review of structure and methodology for the whole project development to promote and increase implementation of IBSE with input from EAP;</li><li>• Action plan for completing remaining deliverables;</li><li>• Discussion and small-group revision of remaining deliverables.</li></ul>	WP9
--	--	--------------------	--	-----

## 8. Information Flow

### Communications with beneficiaries and stakeholders

A communication infrastructure was established to co-ordinate the project activities and to disseminate information. Communication between participants was mostly conducted via email and through the project website and e-learning platform. Remote meetings were also frequently used, through phone calls or Skype. General Assembly meetings are held approximately every six months with project steering meetings held at the same time. Periodic activity reports were requested by the project manager in advance of project meetings and for updating the status of the project work plan. Input from beneficiaries to all work package tasks and activities were requested by the Work Package Leader in collaboration with the Project Manager. The members' area of the ESTABLISH website was designated to act as an archive facility for all ESTABLISH project products, such as, working documents and completed deliverables and milestone reports. The ESTABLISH e-learning platform was designated to act as an interactive online platform for beneficiaries and teachers to view and contribute to the development of ESTABLISH teaching and learning materials. Modes of communication developed during the lifetime of the project as more techniques became available and reliable. For example during the lifetime of the project it was decided (PSC 7) to use the forum facility on the e-learning platform to allow members to provide feedback on draft reports, and later (PSC 14) to create a Facebook page to engage with stakeholders. Also, it was decided that along with the General Assembly meetings, that smaller consortium meetings (e.g. bi-lateral/tri-lateral meetings to discuss an IBSE unit) would be held as required to improve communication and progress on ESTABLISH tasks. A separate report outlining the Communication Management Strategy for ESTABLISH beneficiaries has been prepared and this is available on ESTABLISH member's area of the website.



## Monitoring progress of Beneficiaries

Each beneficiary's progress was monitored through the use of short overview presentations at each of the project steering committee meeting. These updates enabled the partners to share with one another their own achievements as well as highlighting the challenges they faced at each of the meeting points during the project. Also by sharing these updates as presentations to the members of the project steering committee, which had representation from each beneficiary, similar issues could be identified and managed by the consortium. In particular the key activities and tasks from different Work Packages are the actions required by each beneficiary are outlined in the following table.

Activity (Work package)		Actions
Development of ESTABLISH IBSE Teaching and learning Units (WP 3)	⇒	Drafting of materials; Piloting with teachers
Engagement with industry (WP2)	⇒	Introductions and building of collaborations; study-visits; lobbying meetings
Development of ESTABLISH Teacher Education Programmes (WP4/5)	⇒	Drafting of materials to address IBSE elements; Facilitation of teacher training sessions
Impact on Teachers (WP4/5) & Students (WP6)	⇒	Administration of teacher profile questionnaires; Administration of student questionnaires; Interviews; observations
Promotion & Dissemination (WP8)	⇒	Recruitment of teachers; Awareness generation of project; Publication of impact

## 9. Dissemination and Knowledge Utilisation

Dissemination activities have played a central role in the ESTABLISH project, with reporting on outcomes from tasks and outputs from all work packages included in these activities. The objective was to implement dissemination firstly on a local (national) scale and secondly on a larger (European and international) scale enabling the knowledge to be shared in a constructive and engaging manner beyond the beneficiary partner organizations.

Beneficiaries have engaged in a variety of dissemination tasks and actions, aimed at

- Generating links with strategic stakeholder groups within their own country, and internationally where applicable.
- Agreeing to adhere to a strategy for promoting best teaching practice of IBSE through the use of local dissemination links.
- Piloting and trialling exemplar materials and processes with teachers (both in-service and pre-service) and students.
- Evaluating and reporting on the outcomes of implementing ESTABLISH teaching and learning materials, methods and processes, and highlighting the effectiveness of the cultural adaptation of these resources and the role of industry in STEM education
- Contributing to the overall project's operation and dissemination strategy by providing feedback on the national experience of ESTABLISH in their own country as well as the international experience.

Through the development of an effective management strategy for dissemination and knowledge utilisation the consortium has delivered the following achievements:

- a) Teacher participation in ESTABLISH:
- b) Student Participation in ESTABLISH:
- c) Dissemination and Project Promotion:
- d) Stakeholder participation in ESTABLISH:

**a) Teacher participation in ESTABLISH:**

The development of a framework for the ESTABLISH Teacher Education Programme (TEP) has resulted in the implementation of a variety of different models in each country, as reported in D4.6. However, the strategy for the management of this task has led to the participation of 2,090 teachers in TEPs across the twelve beneficiary countries, as outlined in the following table. Of these participants, 591 in-service teachers completed at least 10 hours of workshops while an additional 796 teachers completed shorter programmes.

**Table 2: Number of Teachers participating in ESTABLISH Teacher Education Programme (2011-2013)**

Beneficiary	IN-SERVICE			PRE-SERVICE	TOTAL
	Minimum criteria fulfilled (≥10 hours)	Shorter TEP (<10 hours)	TOTAL	duration varied between 2-10 hours	
DCU	60	36	96	59	155
AGES	-	17	17	-	17
UCY/FU	67		67	62	129
UmU	31	117	148	44	192
JU	52	150	202	64	266
CUNI	80	-	80	50	130
AL	23	-	23	5	28
UPJS	50	40	90	30	120
UTARTU	59	6	65	28	93
UNIPA	57	200	257	43	300
MaH	59	19	78	20	98
IPN	25	146	146	40	211
CMA	29	-	29	27	56
MLU	24	65	89	206	295
<b>TOTAL</b>	<b>591</b>	<b>796</b>	<b>1387</b>	<b>678</b>	<b>2090</b>

These participating teachers engaged in completing the ESTABLISH profile instruments, both prior and after completion of the TEP. The impact on the engagement of in-service teachers is reported in D4.5 and is based on 458 teachers (across 13 beneficiaries) completing the initial profile and 233 of these completing the final profiles (~51% matched). The impact on the engagement of pre-service teachers is reported in D5.5 and is based on 367 teachers (across 8 beneficiaries) completing the initial profile and 217 of these completing the final profiles (~59% matched). Thus the results reported in these deliverables provide a European perspective on the process for the development, implementation and impact of ESTABLISH TEPs.

**b) Student Participation in ESTABLISH:**

In order to assess the impact of the ESTABLISH approach to IBSE on second level students in the classroom, participating in-service teachers were asked to implement student questionnaires in their classrooms (D6.1). The development of these instruments was led by CUNI and was informed by similar instruments reported in literature. In this development of these instruments, the WP6 leaders coordinated the piloting of these instruments in five countries and engaged 709 students in this phase, as shown in the following table which is extracted from D6.1

**Table 3. Extracted from D6.1 Table 1. Sample of student participants in piloting student questionnaires.**

<b>Country</b>	<b>Czech Republic</b>	<b>Italy</b>	<b>Poland</b>	<b>Slovakia</b>	<b>Total</b>
Type of questionnaire	No. students	No. students	No. students	No. students	<b>No. students</b>
1 A	136	54	15	-	<b>205</b>
1 B	-	64	31	-	<b>95</b>
2 A	22	54	13	199	<b>288</b>
2 B	-	64	57	-	<b>121</b>
Total	158	236	116	199	709

During the lifetime of the project, student Questionnaires 1 (A and B) were addressed to more than 3,100 students aged in range from 11 to 18 years. Questionnaire A for upper secondary schools was answered by 2502 students from Slovakia, Poland, Italy and Czech Republic. In the sample, there were almost 60 % of girls there. Questionnaire B for lower secondary schools was answered by 646 students from Slovakia, Poland, Italy, Czech and Germany (48 % of girls). Almost 900 students participated in pre- and post- testing, i.e. Questionnaire 2 (A and B) was addressed to them and these were aged in range from 11 to 18 years.

### ***c) Dissemination and Project Promotion:***

All project promotion and dissemination activities are managed and recorded through the tasks in WP8. All beneficiaries are obliged to provide regular reports on such activities to the WP8 leader and the project manager using a specially prepared dissemination template and these are then updated on SESAM. A separate group called the Dissemination Policy Subgroup (DSP), which is a subset of PSC members, was set up to prepare guidelines on the Dissemination Policy to be adopted by all consortium participants in disseminating and reporting on ESTABLISH activities. These guidelines have been agreed at the PSC5 meeting (month 14) and this report on ESTABLISH Dissemination Policy is available on ESTABLISH member's area of the website. An overview of engagement in dissemination activities is presented in the following table which has been extracted from SESAM and showcases that 536 dissemination activities have been carried out with an estimated audience of 161,684 individuals.

**Table 4: Overview of ESTABLISH Dissemination Activities**

<b>Activities (validated on SESAM, 31 March 2014)</b>	<b>Number events</b>	<b>Number individuals</b>
Publication	35	74,199
Exhibitions	10	28,020
Web sites/Applications	8	19,029
Posters	43	10,662
Presentations	129	7,799
Flyers	45	5,922
Oral presentation to a scientific event	50	5,274
Organisation of Workshops	114	4,431
Oral presentation to a wider public	74	4,029
Organisation of Conference	26	1,715
Press releases	1	600
Interviews	1	4
<b>TOTAL</b>	<b>536</b>	<b>161,684</b>

Information on training opportunities and events organized within the projects were available on the project website and in due time to the platform. All partners contributed to the applicable sections of the website (news, fora, activities, teaching materials, events, reports, etc.). The project website and platform was developed and maintained by beneficiary Across Limits Malta. Website statistics have indicated (available in D8.1) the total number of visits increased from 934/year in 2010 to 7028/year in 2012.

**d) Stakeholder participation in ESTABLISH:**

Generally speaking all partners directed their activities to all stakeholders, and a full report on all ESTABLISH engagement with stakeholders is provided in D2.3 and details dissemination activities are provided on SESAM and presented in D8.1. These included 346 dissemination activities for scientific community (the most active partners - CUNI, CMA, IPN and UNIPA), 229 towards civil society, especially JU and UMEA, 102 for industry, 70 for policy makers. Beneficiaries often used those channels that were most familiar to them. For example the SME's have been prominent in conducting more of the industry-type activities with AGES hosting 51 meetings with various industrial partners such as Bord Gais Networks, Boston Scientific, Cordis, CRH, Novartis, Leo Pharma, Pfizer, TEVA. As many of the ESTABLISH were sourced from the science research community, it was expected that many of the activities were also appropriate for the scientific community. Project partners gave 253 oral presentations at national level and international level. All partners were engaged in workshops and conferences at national, European and international level to share project process, outcomes and examples of best practice. Among them the most active were: IPN, MAH & UMEA, CMA, DCU and UNIPA. Workshop targeted smaller audience such as 15-30 people, while conferences organised by partners up to 240 participants. All together 114 workshops and 26 conferences have been organized by ESTABLISH beneficiaries.

Communications between partners have always been encouraged and have resulted in partners working together on many activities to achieve tasks such as developing and refining the teaching and learning units (WP3 activities), or through the provision of teacher education (WP4 & WP5). Also where multiple national partners exist, partners have communicated with one another to coordinate and reinforce their activities.

ESTABLISH is committed to supporting the implementation of inquiry-based science teaching across Europe and has contributed to this vision, by facilitating networking opportunities for projects to communicate as well as contributing to multi-project collaborations. Communications have also occurred with other FP7-SIS consortia to support and reinforce the activity of supporting teacher education in inquiry-based science education across Europe. For example, representatives from S-TEAM and Fibonacci led short presentations during the second general assembly meeting (GA2) to share their experiences and approaches to deliver inquiry based teacher education. Also representatives from ESTABLISH were present at the S-TEAM conference project (Glasgow, October 2010), to meet with and discuss such issues with representatives from projects such as Primas, Scientix, Fibonacci and S-TEAM, as well as other LLP-funded projects in the areas of supporting the teaching and learning of science and mathematics.

In June 2012, ESTABLISH hosted a teacher education conference in conjunction with the 5<sup>th</sup> biennial Science and Mathematics Education Conference (SMEC 2012) which took place on 7-9<sup>th</sup> June 2012 in Dublin City University, Dublin, Ireland. This conference invited representatives from all the current FP7 projects involved in supporting and coordinating actions on innovation in the classroom: dissemination and use of inquiry-based teaching methods on a large scale in Europe, with the result that there were workshops and oral presentations from the INQUIRE, Fibonacci, and Scientix project. This conference was also focused on facilitating teachers to network and to share their experiences of implementing inquiry in their classrooms, through a series of round-table discussions and poster presentations. The conference attracted an attendance of 235 delegates from across 20+ international countries.

ESTABLISH are contributors to the Comenius network project, INSTEM, (<http://instem.tibs.at/>, 527333-LLP-1-2012-1-DE-Comenius-CNW) which brings together the experience and learning of a wide range of projects in European STEM education to link research, practice and policy in a unique way are very powerful in providing platforms for collaboration and communication at European level. Indeed the INSTEM project has developed as a consequence of the formation of a pan-European network for project Coordinators in STEM Education (ProCoNet) which was initiated by ESTABLISH Coordinator (DCU) inviting the S-TEAM project manager to present on the S-TEAM project at the ESTABLISH kick-off meeting. The INSTEM project includes two of ESTABLISH partners (DCU and MLU) as consortium partners to contribute insight and outcomes from ESTABLISH for the development of accessible synthesis reports and briefings to promote and facilitate the implementation of inquiry as a teaching methodology at pan-European level.

## 10. Conclusions and future implications

ESTABLISH has provided the opportunity for key stakeholders in second level science education to work together to:

- develop industry-informed IBSE teaching and learning materials (IBSE units),
- provide a framework for Teacher Education Programmes (TEP) in IBSE to facilitate the implementation of flexible models and pathways for science teachers to engage and develop their understanding of IBSE

for the overall result of enhancing teaching and practice in science classrooms across Europe.

The formation of ESTABLISH pan-European consortium has provided culturally and educationally rich contexts in which to form meaningful collaborations (involving the development of strategies and frameworks) to promote the use of IBSE in the second level classroom. The consortium makeup of twelve third-level universities and three Small Medium Enterprises (SMEs) has offered both challenges and opportunities for innovation and development. The mix of disciplines – physics, chemistry, biology – and experiences in IBSE and teacher education, across pre-service and in-service, in IBSE has provided an exciting platform for exchange of ideas and experiences amongst science teacher educators and researchers. The strategy adopted by the project has been for all consortium beneficiaries to be involved in all work packages and therefore required the need for regular forums for exchange of ideas and experiences through bi-annual general assembly meetings. The milestone achievements outlined in the project work plan have provided a road map for the execution of this project and have achieved their objectives in guiding the work of the project at key stages of implementation.

The nature of the work plan of ESTABLISH required close interaction between the Project coordinator and WP5 leader (DCU), WP4 leaders (UmU/MaH) and WP3 leader (CMA) for the development of IBSE teaching and learning units to be used as a core element in in-service and pre-service teacher education programmes. A series of tri-lateral meetings were held between these beneficiaries to define and review the tasks and activities of these core aspects of the project. This activity benefited the project well and resulted in the development of high quality scientific outputs and processes.

The process adopted for the development of IBSE Units involved the management of all beneficiaries working in small discipline groups to develop the initial three IBSE units in Physics, Chemistry and Biology. This process resulted in all beneficiaries pilot engaged in trialling and revising these units and established the approach for the development of the other 15 IBSE units. This developmental process was informed by input from independent evaluator Prof. Marcia Linn and facilitated the consortium defining the purpose and criteria for developing units and the preparation of a guide for developing IBSE units – that is an invaluable resource for all curriculum developers. The entire collection of 18 ESTABLISH IBSE units, with 3-13 IBSE activities in each unit, now provides an extensive bank of fit-for-purpose resources for teachers and educators in adopting IBSE. This has been further validated by virtue of the fact that educators in other countries (e.g. Spain and Romania) have requested access and have translated these teaching and learning resources into their own native language for use in their own TEP programmes.

The process adopted for the development of the ESTABLISH Teacher Education Programmes (TEPs) has been an inclusive model, involving all beneficiaries to work within existing pre-service



and in-service teacher education programmes where available or to establish new programmes where none previously existed. This resulted in a variety of starting points for the TEPs and models for implementation, but all which aim to address specific element of teacher education that are required or desirable to facilitate IBSE. This process has been informed with input from Prof. Shirley Simon on both the successful implementation models for teacher education as well as input regarding the evaluation of these models. This diversity has enriched the development process, enabling the consortium to define criteria to structure a framework for teacher education to be delivered both face-to-face and online, with the resulting collective efforts greater than the sum of the individual parts. The impact of these teacher education programmes have been primarily on teachers to enable them to increase their awareness and understanding of IBSE and also their attitude towards IBSE so that they are more confident to implement it in their classrooms. Secondly there has been an impact on students', with their attitudes becoming more positive towards scientific activities.

The evaluations of the impact of IBSE units and teacher education programmes which have been conducted during the course of this project have provided interesting comparative and collective results on change in teacher's understanding of inquiry, attitude towards inquiry and personal skills in relation to inquiry and practice in the inquiry classroom. The adoption of these methods of evaluation has been informed by relevant research studies. The process of evaluation used during ESTABLISH was to ensure that the materials and supports developed were practical and fit for purpose so as to engage current and future teachers to adopt them into their own teaching. This process has enabled multiple collaborative relationships to flourish not only across the international research community but also across the educational continuum.

The resulting ESTABLISH outputs of frameworks, models and evaluation of teacher education which have been developed, piloted and culturally adapted for local contexts, have enhanced beneficiaries' own teaching and learning activities in numerous national projects and teacher education programmes. This engagement and extended engagement, over the 51 months of ESTABLISH, is expected to have significant impact on the future practices of the science educators and researchers involved.

Small deviations have been made to the work plan of the project, e.g. initially a smaller number of units were envisaged to be developed towards the beginning of the project. This process changed to a more inclusive model with the result that 18 substantial units were developed, supported by 8 elements for Teacher Education Programme offering greater flexibility for use. The extension of these deliverables has provided significant added-value to the outputs of the project, and in some cases resulting in delayed submissions of some deliverable reports.

A certain number of challenges however remained beyond the control of consortium, such as the delay in payment schedule experienced following the amendment to remove UvA and add CMA, most notably resulting in project partners from Malta being unable to attend a facilitated Teacher Education Programme event in Dublin, due to lack of financial resources.

The opportunities that ESTABLISH has provided to the project participants and collaborators have been vast and the wealth of knowledge gained and outcomes achieved have only been made possible by using a robust and appropriate management strategy for this type of project, i.e. Coordination and Support Action. Through continuous dissemination activities, key stakeholders

have gained an appreciation of the value of the materials and supports that ESTABLISH offer teachers to support the use of IBSE across Europe. The scale and scope of the impact of projects such as ESTABLISH, however, are limited by the level of resources/funding provided.

This project has led onto and contributed to a number of other European collaborative projects including SAILS (FP7-2012) coordinated by DCU; INSTEM (Comenius-2012) with DCU and MLU partners; FaSMEd (FP7-2013) with UmU partners, ASSIST-ME(FP7-2013) with IPN partners. In addition, multiple national initiatives in which education and industry are working together to support science teaching have arisen (AMGEN Science Teacher Training Initiative). Significantly, Ministries of Education across Europe have supported the adoption of the ESTABLISH TEP model into national programmes and implemented changes in national curricula to sustain the use of IBSE. Indeed the ESTABLISH model for engaging the key stakeholders in STEM education as a core focus of enhancing science education resonates in other FP7 funded projects (InGenious-2011).

In particular one of the first calls of the new EU Framework Programme, Horizon2020, is focussed on *“Innovative ways to make science education and scientific careers attractive to young people”* (SEAC.1.2014.2015) to address the specific challenge:

*“The Union needs all its talents to boost creativity and competitiveness. It needs an innovative science education which shall enable today's and tomorrow's citizens to play a more active role in the Research and Innovation process, to make informed choices and to engage in a democratic, knowledge-based society. It needs young boys and girls to pursue careers in science, technology, engineering and mathematics (STEM), while at the same time adhering to the values embedded in Responsible Research and Innovation. In such a manner, the Union will reach the objective of a R&D intensity of 3% of GDP which is essential. Yet it has been increasingly difficult to attract adequate numbers of young people, to these domains and to avoid a brain-drain of talent from Europe. Therefore, a shift to innovative and effective methods is necessary, so as to raise the attractiveness of science education and scientific careers and boost the interest of young people in STEM”.*

The scope for proposals is described as:

*“The proposals shall focus on innovative, forward-looking science education methods and/or on incentives and measures to make scientific and technological careers attractive to young students, including actions addressing the challenges in offering long term career perspectives. They may inter alia make young people work with open-access educational resources; become familiar with the use of science media; make the link between creativity and science; appreciate the relevance of gender balance and dimension in research; understand the practical value of research ethics and integrity; actions. The proposals shall also foster sustainable and cross-cutting interaction between the different levels of the education system, research institutions and other establishments, industry, Civil Society Organisations (CSOs). Such proposals shall improve the attractiveness of science education and scientific careers to young people; address challenges in offering long term career perspectives, as well as raise awareness of the importance of trans-disciplinary research and Responsible Research and Innovation in the education system”.*

The inclusion of this call in H2020 further supports the need for the continuation of projects such as ESTABLISH and calls for the creation of multi-stakeholder partnerships to work together to address one of the grand challenges currently facing society. Such projects are ambitious but essential. However, given appropriate opportunities and resources these goals are achievable and the benefits can be sustained well beyond the lifetime of the project.