WP4| D4.6

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D4.6 Effective Models for in-service & pre-service science teacher training in IBSE

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A. Background to this report

This report is a deliverable of Work Package 4 (WP4) and Work Package 5 (WP5) of the European FP7-funded project "European Science and Technology in Action: Building Links with Industry, Schools and Home" (ESTABLISH; 244749, 2010-2013). The deliverable is about **Effective models for in-service and pre-service science teacher training in IBSE** and describes the lessons, we as consortium, have learnt about what is important when implementing TEP. The implementation of IBSE materials in in- and pre-service teacher education in participating countries is described in Milestone report M15/M20. Detailed information about the programmes and activities can be found on the project website (www.establish-fp7.eu).

(See Table 1 for beneficiary list).

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B. The ESTABLISH consortium

Beneficiary short name	Beneficiary name	Country	Abbreviation
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

Introduction 6
Background to ESTABLISH Teacher Education 6
ESTABLISH Teaching and Learning Units 6
ESTABLISH web-based materials 7
ESTABLISH Teacher Education Programmes 7
Framework for ESTABLISH Teacher Education 8
Position of IBSE in each country 9
Implementing ESTABLISH Teacher Education 10
Impact of ESTABLISH TEP 10
Procedure for implementation 10
Organisation of Teacher Education Programme (TEP) 11
Programme objectives 11
Recruitment of participants 12
Duration of programme 12
Structure of programme 12
Location of programme 13
Timing of programme 13
Content in TEP 14
Introduction 14
Core Element 1: Introduction to IBSE 14
Models 15
Core Element 2: Industrial content knowledge 16
Models 16
Core Element 3: Implementer 17
Teacher training on IBSE activities, ESTABLISH Units 17
Connection to curriculum 18
Helpful hints for further development of science teachers as implementer 20
Core Element 4: Developer 20
Recommended skills for a developer 20

Time ... 21
Reflective discussions ... 21
Network of learners to support sustainable professional development ... 21
Motivator to encourage teachers to become developers ... 21
Supportive Elements ... 22
Supportive element V: ICT ... 22
Use of ICT in teacher education ... 22
How should ICT be used in teacher education? ... 23
Reflections on using ICT in teacher education ... 23
Supportive Element VI: Argumentation ... 23
Argument is an essential component of science ... 24
Classroom management to scaffold argumentation ... 24
Supportive Element VII: Research and Design Projects ... 24
Supportive Element VIII: Assessment ... 25
Discussion ... 25
References ... 28
Appendix 1 ... 29
Appendix 2 ... 31
Appendix 3 ... 39

Introduction

This report outlines the process of development of ESTABLISH Teacher Education Programme (TEP) and the implementation of teacher education programmes in each of the ESTABLISH beneficiary countries. The report focuses on predictive effective models of ESTABLISH TEP based on evidence in the partners' narratives about how they have implemented the in- and pre-service TEP.

In order to promote the use of Inquiry Based Science Education (IBSE) in second level schools (those teaching young people normally 12-18 years), the ESTABLISH partners have developed, piloted and trialled a suite of teaching and learning materials for teaching inquiry based science (IBS) and Industrial Content Knowledge (ICK) appropriate for use with students of this age group as well as materials for developing in-service and pre-service teachers' skills in teaching IBS and ICK. The first section (A) of the report describes the context within which the Teacher Education Programmes were developed and implemented. The second part (B) of the report describes effective models concerning organisation and content of TEP. In this section we will discuss in- and pre-service together or separately depending on the situation.

Background to ESTABLISH Teacher Education

ESTABLISH Teaching and Learning Units

During the first year, it was decided to first develop three pilot lessons to explore and optimise the relationship between the teaching and learning materials (also referred to as Units) and teacher education so as to develop concrete examples for the whole consortium to discuss and agree as standards for subsequent Unit developments. Four partners were tasked with the responsibility of developing these Units, Disability (MaH and UmU), Holes (DCU) and Sound (AMSTEL/CMA), from biology, chemistry and physics respectively. During this work, reference working groups were established with four or five partners actively working together on the development of the materials. The process of this development is detailed in the project Milestone report "Report on pilot phase of ESTABLISH"[1]. The three Units were made available for all partners and were translated to several languages. After the development of these pilot Units, partners took responsibility for developing and producing at additional Units with the result that eighteen ESTABLISH IBSE teaching and learning Units have been made available for teachers in Europe. Each Unit consists of teacher's guide and student activities sections, and they are used both in pre- and in-service teacher education programmes.

[1] MS10 – Report on pilot phase of ESTABLISH to project partners, available on request from info@establish-fp7.eu

ESTABLISH web-based materials

Parallel to this work, MaH and UmU started to adapt these materials to produce web based content for in-service and pre-service teaching in order to promote and extend the implementation of IBSE methodology across Europe. These web-based materials have been reported previously as "D4.2: Interim web-based materials of teacher education" and are available on the project's website.[2] The objectives of the web-based teacher education programme are described in Deliverable D4.4 and D5.4.[3]

ESTABLISH Teacher Education Programmes

As a guide to further action, the consortium agreed on some minimum criteria for in-service teacher training. These are:

- Minimum total time for in-service: 10 hours
- Training is delivered over a minimum of three stages;
- Strongly encouraged that the materials are trialled in real classrooms.
- Recommended that a minimum of two teachers per school attend the workshops.
- Recommended that the workshops are hosted in the schools where possible.
- Suggested that a workshop take place in a relevant industrial setting (e.g., industry learning centre)

While minimum criteria could be agreed for in-service teacher education, the consortium felt that the criteria for pre-service teacher training were difficult to identify because of existing timetables for pre-service. It was recommended that partners include ESTABLISH material and work with links to industry, but it was recognised that it will be necessary to adapt to existing national pre-service teacher training programmes. The teacher training at pre-service level may only be introduced as ESTABLISH related. It was suggested that the "Guide for developing ESTABLISH teaching and learning Units" (D3.0) be used as teaching materials at pre-service level. Each beneficiary has to identify local constraints, and examine the possibility of discussing with departments of education within their institutions to see where overlaps occur with teaching modules for methodology so as to bring the focus towards the objectives of ESTABLISH teacher education at pre-service level. It is envisaged that a particular module of a pre-service programme will be devoted to IBSE teaching, with support for teachers to implement this approach, if possible, in their own teaching practice in the classrooms.

[2] http://www.establish-fp7.eu

[3] D4.4: Web-based IBSE materials for Teacher Education and D5.4: Web-based Teacher Education Programme

The teacher education programme focuses on the IBSE Units that have been developed by ESTABLISH. These Units can be used as exemplary materials for teachers during the science teacher education programmes and can be used to inform all the other elements within the programme. As shown in Fig 1, the ESTABLISH teacher education programme (in-service and pre-service) consists of Core Elements that were intended to be included in all training programmes, and additional Supporting Elements that could be used as required, depending on the experiences of teachers or on local situations.

Framework for ESTABLISH Teacher Education

Informed by the ESTABLISH report “Main obstacles to implementation IBSE” (D4.1), which identified the main obstacles that teachers usually face in implementing IBSE in their classrooms, and informed by the group discussions by the science teacher educators within the ESTABLISH project, the following Core Elements (I – IV) for teacher education were identified.

I. ESTABLISH view of IBSE – outline of ESTABLISH view of inquiry, benefits to learning, role of inquiry in curriculum, provision of direct experience of inquiry, ethical issues.
II. Industrial Content Knowledge (ICK) – industrial linking – provision of authentic experiences informed by industry or real applications. In many cases study visits may be an appropriate way of meeting this objective.
III. Science Teacher as Implementer - followed by implementation in classroom – key area here is for the science teachers to be prepared for implementing inquiry teaching/learning in their own classroom, identifying and meeting any challenges.
IV. IV. Science Teacher as Developer – evaluation of classroom experience; identification of further needs – teachers should have experience and be equipped to implement IBSE and start on the process of modifying their own materials to include inquiry.

In order to support teachers in overcoming the challenges and barriers that have been identified and discussed, a number of supporting workshops were developed by different partners to address the following Support Elements (V-VIII).

V. ICT – develop confidence and competence in the effective use of ICT in teaching and learning of science and in its appropriate use in inquiry-based teaching/learning.
VI. Argumentation in the classroom – address skills to develop and manage effective argumentation in the classroom.
VII. Research and design projects for students – providing authentic experiences – address the development of these ideas, what aspects provide authenticity, student ownership and endorsement.

VIII. Assessment of IBSE – address assessment of many aspects of inquiry; how assessments can be changed to recognise the skills (cognitive, affective etc.) linked to IBSE.

It was envisaged that each country would implement elements I – IV in their in-service and pre-service science teacher education programmes but would incorporate elements V-VIII as required. The list of Support Elements is not exhaustive and may be added to, particularly for pre-service teachers, following experience of running these programmes.

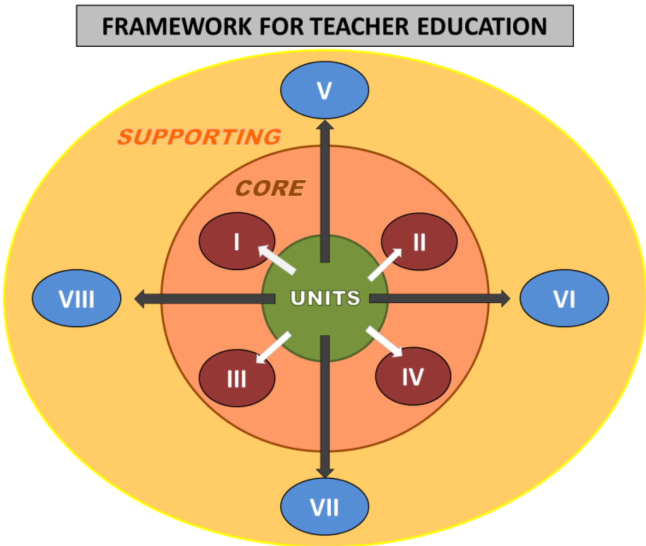

Figure 1. Organization of elements in in-service and pre-service teacher programmes.

Position of IBSE in each country

From our previous work it was shown that there are variations across the partners in how inquiry is included in the curriculum (D2.1) and national tests (D2.1). All countries have some inquiry included in the curriculum, with six countries having all nine elements of inquiry present (Czech Republic, Germany, Estonia, Netherlands Slovakia and Sweden) and the other countries having less. Most commonly included in the national curricula are "Planning investigations" (11 of the countries), "Critiquing experiments" and "Searching for information" (10 of the countries) with "Constructing models" having the lowest occurrence and is not listed by four of the countries. In some countries IBSE has been included in the curriculum for many years and in, for example, Estonia it is quite new and included in year 2010.

It also became evident that there were variations in how inquiry is perceived, as can be seen in the Units prepared by different partners, and in how partners reported on their use of activities. The teachers in different countries are likely to have different 'starting points' in the teaching of inquiry and thus require a programme that takes this into account. This variation suggested that cultural issues are important to consider when running in-service and pre-service teacher education and to think of when preparing the web-based Teacher Education Programme.

Implementing ESTABLISH Teacher Education

Impact of ESTABLISH TEP

In ESTABLISH most partners have worked with teacher education in pre- and in- service programmes. The number of teachers and students who have participated in programmes is shown in table 1 and 2 in appendix 1. Most partners have educated more students and teachers than was proposed in the application. More information about each partner's organisation, type of workshop and how respective partner dealt with the content during TEP are presented in table 3 (in-service TEP) and table 4 (pre-service TEP) in Appendix 2.

Procedure for implementation

In this report effective models are described. These models are based upon experiences from all workshops, performed with students and teachers in 11 countries in Europe. Our concept of "effectiveness" is now described.

The way in which 'effective' is defined in the project arises from the aims of teacher education programmes with respect to teacher development. Thus effective is seen as achieving teacher participation in the programme, teacher implementation of the Units, Core and Support elements of the framework with students, and reporting successful practice. The term 'models' refers to the ways in which partners have designed and implemented teacher education programmes to be effective, so there is a range of models that have been developed across the partnership that can be used to inform teacher education planning.

Partners wrote narratives about the worker experience with pre- and in-service teachers. At a General Assembly meeting in Krakow the partners discussed the Milestone report and whether enough information was available to fully describe effective models. The consortium agreed upon what additional information were important and formulated questions for all partners to address concerning their organisation and content of the TEP. These questions are listed in Appendix 3.

After that, four groups consisting of members from different partners took this information and analysed one Core Element each. Each group wrote a report describing key aspects of how the different partners have worked with the specific Element.

This report is based upon the narratives and the questionnaires from each partner, the reports from the group work with the element, the web based material and what teachers have reported from classroom work.

Organisation of Teacher Education Programme (TEP)

In this section we will discuss effective models for organising TEP in IBSE. These models are derived from the experience of ESTABLISH partners in planning and running a number of teacher education programmes across the partner countries. There is no doubt that each individual programme, even in the same country, can present different problems. However, these models will inform those who want to plan inquiry based teacher education programmes. The models set out in the following are inter-related and, consequently, the treatment below overlaps to some extent.

In pre-service there is usually a need for more adaptation of both the content and the organisation as the students usually follow a pre-specified course or a programme. An effective approach is to integrate elements of IBSE into regular *science education* courses. Another example is by integrating IBSE in *science* courses the students learn science by inquiry. In new courses, IBSE can be kept in mind when planning the course. Another model which has been practised by some partners is to organise a full course, e.g. in science education, in IBSE. In the description of different models we assume that the teachers can work in flexible ways e.g. there are opportunities for hands-on activities and group discussions.

Programme objectives

The programme objectives are similar for both in-service and pre-service teacher education. While setting sound objectives for any teacher training programme are important, there are particular reasons for paying attention to the objectives for an IBSE oriented programme.

Firstly, such a programme is concerned with learning rather than teaching. It is important that participants develop the skills to enhance their students' learning via inquiry rather than simply be informed about the nature and characteristics of inquiry. When the objectives are defined they should inform the learning outcomes which, in turn, can then inform any assessment process.

The following sub-headings concern models for organisation of in-service TEP, since no particular effort was necessary to recruit pre-service teachers and the duration, structure, location and timing of the pre-service courses were mainly decided outside the organisation of the ESTABLISH-project

Recruitment of participants

The ESTABLISH experience isolated three particular variables under this heading.

- **Experience level**
  The IBSE experience level of participants can have a critical impact on the effectiveness of a programme. Accordingly, IBSE experience should be considered an important variable when considering the optimum design. See Structure below.
- **Subject discipline focus**
  There is some evidence that less experienced teachers tend to work better in a mixed discipline environment and that more experienced teachers tend to work better with those who share the same disciplines. Of course, this may not always be so, but it is a consideration that must be borne in mind. See Structure below.

  Upper secondary teachers were more difficult to reach for some partners (UNIPA, Sweden). The local cultural, contextual and systemic circumstances play a role in how teachers perceive the necessity/possibility/values/attitudes of using IBSE.

- **School/teacher ratio**
  It is often difficult for participants to transfer their newly acquired skills 'from the workshop to the workplace' if the workplace culture does not actively support such skills.[4] This often applies to schools because much teaching is traditionally based transmission style with focus on syllabus content and short term recall measures. IBSE is 'process' based and challenges teachers in terms of time allocation and content coverage. Therefore, if possible, it is advantageous that more than one teacher from a given school attend the programme. This requirement may result in a mixed discipline attendance because it is often difficult for a school to release more than one teacher from the same discipline at the same time.

Duration of programme

The ESTABLISH framework calls for a programme of at least ten hours**.** However, overall duration may be dictated by the availability of participants and will also be decided influenced by the overall structure of the planned programme.

Structure of programme

The prior experience of participants also influences decisions on programme structure. For example, those with little experience of IBSE techniques may need early engagement by, for

[4] Heaven et al, 2006; Singh et al, 2003).

example, a short hands-on experience that can demonstrate essential differences between traditional teaching and IBSE. This session should be designed to increase engagement and raise enthusiasm.

In order to be optimally effective, the overall programme should comprise at least two modules. The reason is that this allows participants to apply their new skills for a period of time and then report back and share their experiences. This will be beneficial for those who may have had serious difficulties with classroom application. The second module will also facilitate participants in deepening and internalising their skill sets. The time between sessions should be long enough (several weeks) for participants to practice IBSE in the classroom and gain valid experience.

It may be possible that a programme can be officially certified by a national authority in terms of Continuous Professional Development (CPD). This will enhance recruitment and offer some reward for participants. If this is not possible, a certificate of attendance or completion can be offered.

Finally, an on-line complement to the programme can offer several advantages. It can provide a forum to on-going discussion and sharing of experience. It can also link to additional support resources (http://ibse.establish-fp7.eu/), thus enhancing the sustainability of the educational process.

Location of programme

ESTABLISH programmes were delivered in four distinct settings - in training institutions, an official training centre, in schools and in industrial settings. Each has particular advantages. An institutional or official setting provides a professional training environment which may influence participant responses. A school setting offers the obvious advantage that numbers of teachers form the same school can attend, although programmes mat have to be delivered in the evening or at weekends. An industrial setting facilitates inputs from industry personnel and exposure of participants to industrial processes, thereby enhancing their industry content knowledge (ICK).

The possibility of generating clusters of schools and industries in a locality should be explored. Such clusters offer the possibility of developing a sustainable learning community.

Timing of programme

The optimum time to offer a programme will depend on various factors such as the structure of the school year and the CPD culture of the country. Summer schools have the advantage of not interfering with class timetables while in-year programmes allow teachers to bring their new skill to the classroom immediately. No clearly definitive timing guidelines emerged from the ESTABLISH experience.

Content in TEP

Introduction

In this section we will discuss these effective models in terms of the Core Elements of teacher education identified as part of the ESTABLISH framework for Teacher Education.

For more detailed information about how each partner has organised the work and what content that has been used please see tables 3 and 4 in Appendix 2. They show how activities from the Units, from the interim web-based workshop materials, and how the elements in the Framework have been addressed through activities for teachers. Some elements have been more developed than others outside of the four Core Elements. For information about which Elements each partner worked with please see Milestone 15 and 20.

The models that are described in the following sections can be used in both in-service and pre-service teacher education. In pre-service there is usually a need for more adaptations as the students usually follow a course or a programme. An effective approach is to integrate elements of IBSE into regular courses. For example, by integrating IBSE in science courses the students learn science by inquiry. In new courses IBSE can be kept in mind when planning the course. Another approach which has been implemented by some partners is to organise a full science education course using IBSE methods. In the description of different models we assume that the teachers can work in flexible ways e.g. there are opportunities for hands-on activities and group discussions. This means that teachers in the programmes are not only informed about IBSE, but are given opportunities to try some of activities themselves, to share experiences with each other and to discuss benefits and obstacles.

Core Element 1: Introduction to IBSE

Teachers have different experience of IBSE. In some countries IBSE has been included in the curriculum for many years while in other countries IBSE has only recently been introduced. Irrespective of the curriculum there is also a variation in how individual teachers understand and interpret IBSE. In a country like Sweden, where IBSE has been included in the national curriculum for a long time, the teachers still interpret IBSE differently. Some teachers are satisfied with working with cook-book recipes in the laboratory while others have developed actives in which students are encouraged to solve problems and to discuss different solutions. In countries where IBSE was recently introduced, e.g. Slovakia, there are teachers who for a long time have used inquiry methods with their students. Different approaches to the introduction of the ESTABLISH view of IBSE in TEPs which will be discussed in the following section.

In summary, teachers need to be introduced to IBSE, to interpret the meaning of the different elements of IBSE and to discuss it with colleagues in order to understand how IBSE can be interpreted and be developed in their own teaching.

Models

In order to teach students to ask questions and plan investigations, the teachers must possess these skills themselves. It is important that teachers acknowledge their own curiosity and desire to learn more. Therefore, it is effective to let teachers work at their own level by asking their own questions on issues they observe in media or phenomena they wonder about. It is important to follow up by discussion on the kind of questions that are asked, how and if they can be answered, and which of them might be answered by an investigation. It is also important to discuss what is characteristic for a scientific investigation. There are examples of such activities on the e-learning platform on website http://ibse.establish-fp7.eu/. Another way is to introduce questions that can be answered by a scientific experiment. Good examples of activities can be found in the units, which are developed the project and published on the website. A list of these can be found in the report about ESTABLISH's web-based Teacher Education Programme (Deliverable 5.4).

Even relatively simple tasks that require the use of elementary science and mathematical skill, when presented in an unfamiliar context, can be quite challenging for many teachers. However, working through a number of short exercises that require personal effort can lead to deeper learning and a sense of achievement.

Field work is an opportunity to apply inquiry learning about scientific processes over a longer term. For example, if teachers are in an ecosystem with different plants and animals and certain abiotic factors, they can ask a number of questions about species, populations etc.

Introduction of the definition and rational for inquiry, how it could be used, what skills might be developed in the teaching process etc., can be delivered by lectures and other presentations. There is a useful power point presentation on the website that can be used for this purpose. For inexperienced teachers, it is important to explain what IBSE is, but experienced teachers also need to express their own interpretations of IBSE. If we believe that IBSE is effective way to learn, it is reasonable that the teachers themselves learn by IBSE. Therefore, a lecture cannot stand alone. Instead, the lecture can be completed with a review of teachers' understanding of IBSE and how they might use this method in school. In that way the teachers also have the opportunity to bring up constraints. For example, it is widely felt that there is a tension between *teaching for understanding* and endeavouring to *complete the specified content* of the curriculum. In some countries the curriculum recommends inquiry, especially at junior secondary level, but time constraints limit its application in practice.

To watch videos clips from classroom work with IBSE is also an effective way to help teachers reflecting on IBSE and their own practice. Another approach is to create teams of teachers with different experience in, and knowledge of, IBSE and provide the opportunity to cooperate and exchange ideas in each school. One way to develop teaching at a school is for teachers to observe each other's' lessons and discuss what they see. In general, it is necessary to analyse and interpret the IBSE possibilities in the curriculum of a particular country in order to adjust material to the actual school situation.

Finally, we want to emphasise that it is important to combine hand-on activates with reading of theoretical texts about IBSE and research in IBSE. Teachers are often less interested in particular theories of learning and more interested in the resources and the activities, especially those activities that are suitable for use in the classroom. Therefore these texts must be carefully chosen.

Core Element 2: Industrial content knowledge

The main reason for working with ICK is to give young people the opportunity to meet professionals who work with science and technology in industry, research and communities. By working with ICK, the students can widen their knowledge about fields in which people educated in science and technology work, how they work and how they contribute to society. The students can learn that scientists and engineers are people who have interesting and important jobs, work in social contexts and that they are like most other people. Another reason for working with ICK is to connect school science to reality so that students learn about situations when science is applied in different ways. Science can, in this way, become more interesting to the students.

The situation in each country is different and, therefore, it is important to adapt to these different conditions. For example, in some countries it is impossible to take the students out of school for study visits.

Models

The partners have worked in different ways with ICK and some of the models are now described.

One approach is to start with products or processes that are results of scientists' and engineers' work. This can be achieved by a study visit. It is valuable if students can observe the production process but it is also important that they can also meet people who are scientists and engineers in labs and development departments.

It is also possible to start with common familiar products or everyday activities, for example, at the pharmacy, hairdresser, super market, traffic scenes, etc. and trace a product or process back to its origin. How were these products developed? By whom? What science and technology is behind the product? What research related to the product, process or activity is done? An advantage here is that local places are easy to find and the students can visit in small groups.

Another approach is to start with the scientist or engineer. He or she tells about education, work, results of work and implications for society. Students can meet the person at an industry or at a research department and directly observe the processes.

If it is impossible to leave school, the teacher can invite people to school. In some countries there are organisations that support this kind of work. By inviting someone you can learn both about the profession, education and the scientific content as well as the nature of science.

In all these cases it is important that the students prepare for the study visit or meeting. They can formulate questions and find information about the topic or company in advance. After the activity it is important to follow up.

If the main purpose is to connect school science with real applications and to learn about the scientific process, one model is to start with a number of applications and discuss the related scientific principles. The students can also work with processes in miniature in the classroom. For example, they can construct cars driven by solar cells and carry out all steps from design to construction and evaluation and then compare with "real" sun driven cars. The students can make a cosmetic product in lab scale and there are many other activities that can be approached in this way.

On the website (http://ibse.establish-fp7.eu/) these activities are described in more detail including suggestions on preparing a study visit and carrying out the subsequent follow-up work.

Pre-service ICK: Even though the models for this element can be used for both in- and pre-service TEP, the core element ICK has not been implemented very often (by many partners) in the pre-service teacher education even though the model is working for both types of TEP. In pre-service TEE you have to adapt to the on-going course and it is more difficult to include new time-consuming activities in contrary to in-service TE where you invite teachers to programmes with specific content.

Core Element 3: Implementer

The key aspects to help teachers prepare for successful implementation of IBSE activities, and to identify and meet the associated challenges are:

- Teacher training in order to practice the application of IBSE and to reflect on how to encourage communication within the classroom,
- Identification of IBSE links with the curriculum,
- Support and scaffolding for students and teachers.

Teacher training on IBSE activities, ESTABLISH Units

Implementation is a key point of IBSE teacher in-service training. In general, the ESTABLISH Units are effective materials for developing an understanding of the IBSE process. For successful implementation it is invaluable that:

1. Teachers carry out these activities during the training in the role of students, in order to properly understand the inquiry process. They should analyse the variety of activities at different levels of inquiry. When teachers carry out these activities during training, they explore how IBSE works and get to know the process. They are doing the same thing for two reasons:
2. When implementing the activities in the classroom, it is recommended to start with the lower level IBSE activities, instead of starting with more open inquiry activities, especially in cases when students have no prior experience of IBSE. However, the suitable level of openness is also dependent on how difficult the content is. Very complex content knowledge can sometimes work better with a more guided or structured inquiry. At other times students can benefit from doing more open inquiry with a less complicated subject content.

Connection to curriculum

Since there are elements of IBSE included in the curriculum of each country, this can provide motivation for teachers to implement IBSE activities. However, not all the available materials are suitable for direct use in teaching since they offer cover topics that are not included in the curriculum. Therefore, the crucial point is to find a connection between the curriculum content and materials that are available for IBSE. For the novice implementers it is essential to have tailor-made activities that fit to the curriculum well. Later on, teachers can implement activities that they adapt, or create their own material; based on personal experience and needs.

Teacher education programmes for novice teachers, or in countries where IBSE are quite new, benefits by activities with a closer connection to the curriculum. This was explicitly requested by some teachers.

Scaffolding for students and teachers

Teachers are sometimes slow to implement new teaching methods. By introducing them to different levels of IBSE to the teachers, they may learn how to implement IBSE in the classroom using a structured approach. Table 2 (in D3.0 *Guide for developing ESTABLISH teaching and Learning units*) presents a hierarchy of how pedagogical practice.

Many teachers see inquiry-based teaching as a purely linear process — from a hypothesis to a result, without argumentation or discussion (Davis et al, 2006). Therefore scaffolding is required and the teacher needs to support the process so that pupils learn to formulate questions and articulate their ideas. One way of doing this is to ask “productive and guiding questions” (Harlen, 2001) such as “What can be the reason for…”, “What happens if…”, “If you compare…”, “Can you think of a way to …” etc. If one uses more person-centred and subject-centred questions, it is usually easier to stimulate the pupils. In this way, the pupils are also encouraged to listen to each other’s suggestions, get new ideas and build upon each other’s suggestions. The question phase helps to broaden pupils’ perspectives and transfer the ownership of the learning (Oliveira, 2010; Chin et al, 2002; Chin & Chia, 2004). In the next step, the teacher needs to guide the pupils as they begin the planning of their investigation. Introducing a “what we need to know” scheme can make it easier to progress. It also gives a structure to “what we know”, “what we need to know”, “how we can find out” and may suggest how the investigation can be carried out.

It is very important to make teachers aware that their first attempt of IBSE-teaching might not meet their expectations or be highly motivating for students, especially if the method is new for the students or if the teachers are not confident enough in using of IBSE methods. Therefore they should be prepared to try this teaching approach a few times, especially if students are not used to this method, or are passive. Disappointment can be averted by discussion with other teachers who experienced similar situations or who were more successful and saw positive effect.

It is crucial to discuss a variety of concrete situations that might occur in classroom (too many questions, too few, or too diverse) and how they can be solved. For this purpose, examples of IBSE activities successfully carried out in the classroom might be video recorded and analysed subsequently with teachers, to illustrate important parts/ moments of the lesson.

If IBSE is a new teaching method for teachers, then problems that are typical of innovations may occur: e.g. neglecting colleagues, school management or school facility issues. It is advisable to consider such factors (time, materials, fit to curriculum and so on) in advance. Support from university level and an exchange with other (experienced) colleagues can help here. It also helps if several teachers from the same school have been educated in the field of IBSE and think the same way. However, experience shows that a single pioneer in a school can be very effective.

Support structure depends very much in the national system. Generally there is support from the institute providing in-service teacher training, from the school management and from colleagues who also use IBSE methods.

In general it seems easier to start in lower secondary school, or even earlier, since lower level students are more likely to interact and carry out inquiry and are thus prepared when they encounter IBSE at higher levels of education.

Helpful hints for further development of science teachers as implementer

Other actions that the teacher as implementer can take include the following.

- Cooperate with examinations boards to include questions referring to IBSE
- Cooperate with curriculum developer in order to implement IBSE in case it is not a part of the curriculum
- Cooperate with the school management and persuade them about the importance and usefulness of IBSE, also for other subjects
- Involve other teachers, colleagues of already educated teachers to create groups of teachers across several disciplines from the same school

Core Element 4: Developer

The learning objectives of the Core Element **Teacher as developer** are to develop teachers' ability to develop IBSE practice to the appropriate level of student experience and to modify their own materials to include inquiry. A developer is an implementer who has gained the ability and confidence to modify inquiry based material. A developer might go through stages from adapting material to develop original material. As a developer one should know what a group of students need and should have learned the necessary skills for creating anything from structured to guided to open inquiry material. Furthermore, a developer is also able to switch between types of inquiry (structured – guided – open) based on an evaluation of the classroom work at hand. The stages of engaging in inquiry as a teacher are: implementer (use material) – adapter (makes necessary adjustment based on classes needs of structure or openness) – developer (coming up with own ideas, considering both for classroom management, students' needs, inquiry type).

Most partners have reported experience of teachers becoming developers. In many TEPs the final workshops were devoted to teachers reporting back on their achievements in the classroom, with many presenting classroom activities developed by themselves. This is evidence of good training and the courses´ effectiveness.

Recommended skills for a developer

The knowledge and skills recommended for a developer are:

- Know the difference between guided, structured and open inquiry.

- Know which skills are needed for a teacher to scaffold inquiry: probing questions, etc.
- Ability to design activities to match the level of the students' knowledge and the content in the curriculum.
- Understand the importance of giving time for reflection on the methodology.

Time

The time needed to reach "teacher as developer" differs for novice or experienced teachers. Overall, it is more difficult to follow and scaffold the progress of teachers; development and how the time is used is important. Teacher education programmes, distributed over a longer time period, have the potential to allocate time and space for reflection of "homework" applications of IBSE activities. Also, it may be possible to spend time on group work, where teachers (or teacher students) produce material together, i.e. set time for them to develop ideas/outlines for how they would teach a topic by inquiry.

Discussion of changes made in selected examples were used to show teachers that making small changes to a particular lesson could dramatically change the focus of the learner from 'following the recipe' to actively involved in inquiry learning without being more time-consuming.

Reflective discussions

In all cases it is essential to provide opportunity to try things out in school and reflect on usage (guided by researchers/peers/students feedback). The reflection and feedback provides ownership and empowerment of teachers and explicitly shows effects on "own" classes and develops the desire to revise materials for future use.

Network of learners to support sustainable professional development

Continuous support is strongly needed to achieve a sustainable professional development. One approach is to promote networks of learning communities where have teachers can come back and discuss their implementation and success/problems. If this is not possible, an e-environment can be provided for teachers to share ideas. Creating a website to store a bank of teacher produced material that can be used by other teachers in TEP is an effective way to motivate and engage teachers as developers. Environments for more elaborated collaboration are important, since the character of the collaboration is not to present ready-made Units, but to generate ideas (including pupils' ideas to create IBSE materials and activities.

Motivator to encourage teachers to become developers

To be able to reach the level of developer it is important that teachers are motivated and challenged. The SMEC-conference arranged by Dublin and the consortium was a good opportunity to motivate teachers to work towards producing something that could be shared and discussed. The materials teachers produced were presented at the teacher conference in Dublin (Link to posters?). It is also effective to encourage teachers from one school to work together as developers (short distances for collaboration). By developing their own Units, teachers have ownership and feel empowered. The experience has been that once teachers were involved in developing materials, they were happy to continue as a group of collaborators.

Supportive Elements

The Core Elements 1 to IV, described above, are the base in the teacher education programmes and all partners have worked with these and this experience has made it possible to define these effective models. During the work with TEP some questions about more supportive material were raised. Therefore, four 'Support Elements' have been developed. As not everyone has implemented with these, there is much less experience from classroom work. Therefore, it is more difficult to define what is effective or not.

Supportive element V: ICT

ICT is an important actor in teaching and learning and its use in science education contexts has increased all over the world. The purpose of including ICT as a supporting element in the Teacher Education Programme has been to develop confidence and competence in the effective use of ICT in teaching and learning of science and appropriate use in inquiry-based teaching/learning in inquiry.

In the Establish project we focused on the following tools of ICT:

- measurement with sensors;
- measurements from videos and photographs;
- numerical modelling, and
- animations.

These tools are integrated in the Open Learning Environment for Mathematics and Science Education Coach, developed by the partner CMA. Coach is available in most languages of the participating countries, and in the Units of Work package 3 many ICT activities are included.

On incidental base of course also other uses of ICT has been applied in the developed Units and during teacher workshops, like the use of special simulations and websites.

Use of ICT in teacher education

To support preparing teachers and students for the use of ICT in IBSE in an effective way, new support materials have been designed by University of Kosice and CMA. These materials, consisting of Power point presentations, background articles, short instructional movies, etc. are also very suitable for self-study. The full course is offered in Moodle environment.

To prepare the partners for using the course on ICT in their own Institute a '*training for trainers'* meeting of 3 days has been organized September 2012 in Amsterdam. All partners were represented.

This training stimulated some partners indeed to offer the ICT possibilities to their teachers. For others it still is too unfamiliar or their teachers are already well prepared.

How should ICT be used in teacher education?

Several partners made use of the special prepared course on measurements with sensors, video-measurements and modelling. CMA for instance used the course materials for pre-service students from three Universities. This trail is published in the Proceedings of the ICPE Conference (Trinh, T, et al, ICPE Conference 2013 Proceedings, Prague 2014). University of Kosice integrated the course in an extended in-service course.

Other partners have chosen different approaches to introduce ICT in the context of inquiry based science education, for example use of teaching models of TPACK and AMR.

Details of these case-studies of implementation are also available in the project report "Science Teacher Training in IBSE – selected models" (D5.6).

The lack of equipment and/or suitable software and other facilities in schools is a major problem to stimulate the learning about ICT by teachers. And this still leads to a situation in many European countries of an under-use of the powerful possibilities of ICT for IBSE.

Reflections on using ICT in teacher education

From the reports of Amsterdam and Kosice we can see that a relatively short intervention (in order of 20 hours of which 9 hours workshops, rest self-study) can establish much more confident in students and teachers. The integrated use in several of the ESTABLISH Units stimulates the real implementation in the classroom.

Other experiences show that content, inquiry and technology/ICT is a complex challenge. A balanced training program, pre- or in-service, is needed to have the required success.

Supportive Element VI: Argumentation

Argumentation was not specifically included in many partners TEP. The reason for this was mainly that argumentation is not specifically included in the national curriculum. In addition, lack of time was also cited as a reason. Below is a model of how to integrate argumentation in inquiry based science education. This model is also presented in the e-learning website http://ibse.establish-fp7.eu/ which contains resources for developing the use of argumentation in the science classroom.

First of all, it is important to explore what an argument in science is, and why argumentation is important in the science classroom. Moreover, a structured classroom management and a supportive classroom climate are important to support argumentation in the classroom.

Argument is an essential component of science

Fundamental skills for a scientist are: asking questions, making predictions, designing investigations, making focused observations, analysing data, supporting claims with evidence and debating the conclusions with other scientists. Engaging in argumentation provides students with a better insight into the nature of scientific inquiry and the ways in which scientists work. Much of the content in the science curriculum includes dealing with argumentation in different ways, for example: evaluation of evidence; classification; experiments; and socio-scientific issues. In all investigations and experiments the scientist must justify decision, for example when designing the investigation, making predictions, interpreting data, and supporting claims with evidence when debating the conclusions of the investigation. Very often the process of developing claims is ignored in the instructions.

Classroom management to scaffold argumentation

Argumentation needs to be explicitly taught to develop students' ability to understand and practice scientifically valid ways of arguing, enabling them to recognise not only the strengths of scientific argument, but also its limitations. When teaching argumentation it is important to break the tradition of authoritative exposition through a pedagogy that promotes discussion and reasoning, and a supportive classroom climate. It needs to be practised with structured tasks where the teacher can scaffold the students' development.

Group discussions are valuable for practising argumentation. Students need to develop sound skills of listening carefully to each other and taking it in turns to respond to each other before they can fully engage in argumentation. For successful group discussions the tasks needs to be well planned in order to engage all students. It is important to have clear concrete focus and explicit outcomes. Specific time limits are helpful to focus the group work.

Once students have developed the basic skills of listening and responding, they can begin to engage more fruitfully in argumentation. Strategies that can help students to take stances and justify their position through constructing arguments with evidence are for example the use of arguing prompts to scaffold argumentation and writing frames to enhance the quality of the argumentation (examples presented on the e-learning website http://ibse.establish-fp7.eu/).

Supportive Element VII: Research and Design Projects

When students are familiar with IBSE, it can be both motivating and challenging to work with authentic problems. Then the students can formulate questions, plan investigations to which neither the student nor the teacher know the answer. Other ways of applying the method is to work with projects. Research and design projects are rather time consuming and only a few partners have worked in this area with students or have had teachers whose students worked with it.

Supportive Element VIII: Assessment

All partners have emphasised the importance of formative assessment related to IBSE. It is also important to find methods to assess, not only the content, but also the process. They also emphasise the need for supportive material. Most partners have discussed assessment with teachers. The responsible partner for each unit has added some examples of how some activities can be assessed. Also DCU coordinates another EUfp7 project, SAILS, which is about IBSE and assessment. It started in 2012 and within this project supportive materiel in assessment will be developed.

Discussion

An objective of ESTABLISH is to develop the student's sustained interest in science. Such an interest would mean means that students are willing to read about and engage in scientific issues in school, as well as in daily life, now and in the future. It also means that more students will become interested in studying science at higher levels of education. In the project there have been two approaches aimed at increasing interest in science and technology – Inquiry Based Science Education and working with Industrial Content Knowledge. In many cases, but not always, it is possible and fruitful to integrate these two approaches. In all Units there are suggestions of how ICK can be connected to the specific topic and the suggested activities are inquiry based.

Narratives produced and evaluations performed by the partners show that both in-service and pre-service teachers were very positive about the ESTABLISH TEP. In this report we have described some effective models for teaching IBSE and ICK. Research has found that there are barriers for teachers who start working with IBSE. The report D4.1 "Main obstacles to implementing inquiry and intervention programmes in IBSE" was produced half way of the project and summarises the discussions from the ESTABLISH consortium and the key reports from literature on the challenges and obstacles that teachers have identified as potential barriers to the implementation of IBSE. The TEP-workshops have been planned and implemented to address the issues and concerns found, i.e., about *Teachers beliefs, Management* and *Pedagogical and scientific knowledge*. We will now discuss these barriers in relation to the models.

Teachers' beliefs refer to the fact that teachers have ideas of how students learn best and what the best teaching method is. If a teacher has the idea that a student learns best if he or she is told what to learn, such a teacher will not be likely to use IBSE methods. In Core Element 1 the teachers' ideas of IBSE are reviewed and they get the opportunity to discuss and to try activities where the different elements of IBSE are demonstrated. They get time to discuss with colleagues and to reflect over their own teaching, what they do and why they do what they do. Their ideas are challenged and debated by colleagues and the course leader.

Pedagogical and scientific knowledge refer to teachers' experience that students often have rather simple argumentation and that is difficult to develop their skills in argumentation and in asking questions. Therefore, a supportive element Argumentation has been developed as a resource. It can be found on the website. In order to support teachers, all Units explain the scientific content when necessary, and in the Teacher's Guide there is information about students' difficulties and what to think about as a teacher.

Anderson (2007) reports key factors important for the successful introduction of inquiry: good teaching material, input to how teachers can develop own material, discussion with colleagues on materials and support over time. All partners have fulfilled most of these key factors in their TEP. All partners have worked with the Core Element one: "The Establish view of IBSE", and with the teaching material (Units) produced by the consortium. Almost all partners have also worked with Core Element four: "Teacher as developer".

All partners have offered time for sharing and reflection with colleagues, and probably given support over time, even though this is not specifically mentioned in the narratives**.** For example, UmU, MaH and UCY present results from interviews and course evaluations showing that the teachers highlight the importance of collaborative work in teacher development. The reflective discussions with other teachers were highly valued. These findings are consistent with theories about the professional development of teachers, pointing to the need of reflective practice, as well as the development of the teacher's agency in pedagogic design of teaching (e.g., Clarke & Hollingsworth, 2002; Hoban, 2002; Simon, Campbell, Johnson & Stylianidou, 2011). According to Hoban (2002), conditions that are needed to bring about teacher learning for professional development to take place are:

1. A conception of teaching as a dynamic relationship with students and with other teachers where there is uncertainty and ambiguity in changing teaching practice
2. Room for reflection in order to understand the emerging patterns of change
3. A sense of purpose that foster desire to change
4. A community to share experiences
5. Opportunities for action to test what works or does not work in the classrooms
6. Conceptual inputs to extend knowledge and experience
7. Feedback from students in response
8. Sufficient time to adjust the changes made

An appropriate combination of these conditions is important; meeting a single condition by itself will not suffice. Many of these conditions have been fulfilled according to the narratives of the partners TEP.

Classroom management refer to difficulties in managing, for example, small group discussions and more student oriented work forms. In the section about Organisation we suggest that, if possible, the TEP should run over a longer period of time. In that way the teachers get the opportunity to try classroom material with their students and they can report about the work and discuss how it worked in the course. In that way the difficulties are brought up and dealt with.

Another constraint teachers experience is time. IBSE takes longer time and teachers feel that they cannot manage to cover the curriculum. These assumptions must be challenged. It is known that students are engaged by and enjoy IBSE. Therefore, there is a possibility that the teaching becomes more effective and that teachers can spend less time in maintaining order in the classroom. Research also says that IBSE is an effective way of learning − which also indicates that time might be gained. In Core Element 1, IBSE and curriculum is discussed. There is also the opportunity to challenge ideas of what has to be taught − if it is in the curriculum or if it is tradition. Of course, there are time consuming activities such as research and design projects. In these situations local solutions can be developed

In this report we have described a number of models. From the descriptions it is possible to highlight some important aspects for successful teacher educations programmes.

To conclude, in a successful TEP teachers have opportunities to discuss and share experience with colleagues. They also have the opportunity to collaborate with colleagues. They must get time to reflect upon their own practice and upon changes they introduce in their classrooms. Their ideas have to challenged but also respected. The teachers should be provided with good material and resources but also encouraged to develop their own material so that it fits with their actual situation**.**

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Appendix 1

Table 1: Numbers of teachers attending in-service teacher education workshops during year 2011-2013.

Beneficiary	Teachers during 2011-2013 Minimum criteria fulfilled	Additional teachers during 2011-2013 TEP shorter or lack of some Core Element
DCU	60	36
AGES		17 (+50 planned)
UCY	67	
UmU	25 + 6 teacher educators	117
JU	52	150 on lectures
CUNI	80	
AL	23	
UPJS	50	40
UTARTU	59	6
UNIPA	57	200
MaH	59	19
IPN	20-30	146
CMA	29	
MLU	24	65

Table 2: Number of students in pre-service teacher education workshops during year 2011-2013.

Beneficiary	Teachers during 2011-2013
DCU	38 +11+10
Ages	0 (as in application)
UCY	33+29
UmU	10 + 34
JU	64
CUNI	50
AL	5
UPJS	17+8+5
UTARTU	8+15+5
UNIPA	17+26
MaH	20
IPN	25+15
CMA	27
MLU	200+6

Appendix 2

Table 3. Organisation and content for in-service TEP.

University	Structure	Elements	Units/visits/activities
JU	5 day summer school, 30 teaching hours in 2-hour blocks. 1 day 6 months later (lots of detail in the story to show how elements were addressed) Units: Exploring Holes, Polymers, Photochemistry, Chemical care and plastic waste.	1 2 3 4 5 6 7 8	Lecture/ inquiry activities, Questioning skills, Constructivism Brewery, Waste water treatment, Chemical company/industry, Petroleum refinery, Ceramics Group work and practical work from the Units Posters/reflection Data logging Thinking Hats Lecture and planning projects Evaluating evidence- Exploring Holes Short lecture about examinations
AL	23 teachers participated in a three days long course	1 2 3	Introduction to IBSE – activities from workshop one. Activities from several Units. ICT Data logging ICK including visit to brewery
UPJS	50 teachers, 4 sessions, each one 3 hours. Teachers trained from this first run then trained and supported colleagues the following year.	1 2 3 4 5	Introductory session with talk and group discussion about inquiry. Video recordings of lessons used. Working with activities from the Units to focus on skills developed and problems in teaching. Analysing Units for industrial links; discussion of visits. Working with unit activities to identify teaching approaches. Teachers' design of own activities. Use of sensors; data collection. Additional course from Safarik to meet training demand.
CUNI	Weekend courses Summer school	1	Aim of courses to deepen understanding about IBSE

	Development and testing of Units in schools: Water in the life of man, Blood donation, Disability, Polymers, Exploring Holes, Chemical care, Photochemistry	2	Companies provided materials for teachers; visits undertaken to Meopta, Silon, police museum (forensic science), transfusion centre
UNIPA	22 teachers 2011-12 at UNIPA. 35 teachers 2013 at schools with trained teacher. Workshops of varying length (half day/day): 2010 – 9 hours (1) 2011 – 36 hours (4) 2012– 42,5 hours (9) 2013 – 8 hours (2) Units: Sound, Design Low Energy Home, Light, Electricity, Blood Donation	1 2 3 4 5 8	Approach and methodology presented using Units included cycle of workshop activities and teacher feedback to address this and other elements. As above Discussion of pedagogy based on Units As above Experimentation from Units Workshop discussion
MAH	Year one: Two parallel groups 30 and 29 teachers. Each group 16 hours (4:8:4) Units: Disability, Sound, Holes, Blood Donation, Energy House, Direct current Year 2. One group with 19 teachers year 2, 16 hours (4:8:4)	1 2 3 4 1	Introduction – basically workshop 1 Introduction to IBSE. Exemplifying IBSE with activities from three Units. (Disability, Sound, Holes). The teachers were then split into three small groups. ICK Group one worked with Disability using activates in workshop 2, followed by a visit to CERTEC. Group 2 worked with the Sound unit and with a visit to TV studios followed. Follow up discussion of ICK in both groups. Teachers worked with the Units and developed their own material. The teachers reported their project and shared experiences. Classroom management. IKC Invited researcher in molecular biology. Content: The scientific process in a research community – basic research and applied research. Comparison to IBSE. Modern biotechnology.

		2	ICT. Data logging for measuring pulse and experiments from Sound and Renewable energy. Teachers worked with the Units and ICT and developed their own material. The teachers reported their project and shared experiences. Classroom management.
IPN	Pilot workshop on Chitosan; afterwards series of workshops all limited to afternoon sessions (4 hours), due to local regulations; integration into the state-wide program "Transfer of scientific findings into education"; ESTABLISH and similar IPN-workshops were offered to 7 out of 10 school networks in the state of Schleswig-Holstein; 8-20 teachers participated at each workshop, some of them came more than once; with a total number of 13 workshops reported here (the program still continues) <u>Establish Units</u>: Holes, Chitosan, Care <u>Related IPN IBSE-Units</u>: Energy, Survival in the cold, Cotton on my skin (connected to Holes and Care), Flying through the air, Functional materials (connected to Holes)	1 2 3 4 Extra elements only in some workshops (e.g. argumentation in Holes / Cotton on my Skin and Chitosan or Research and Design projects in Holes, Chitosan and Flying through the air)	Introductory presentations, group work, reflection and outlook. Meaning of IBSE integrated, steps of inquiry guiding the material and workshops, comparison of inquiry in research and production (ICK), discussion during experiments and reflection of Units connection to curricula (e.g. based on experiences with analogous projects like science in context)
AGES	One group 12 teachers 12 hours over 2 days Units: Photosynthesis,	1 3 5	Discussion on IBSE; short problem solving exercises; basic computation, proportionality, estimation, forces, electricity and magnetism; hands-on construction of teaching resources.

	Renewable Energy, Electricity		
CYPRUS	Design of Ecobiology, tested in 13 secondary schools, previously trained IBSE teachers	1 2 3 4 5 7	Steps followed from unit of IBSE methodology, each group designed projects; students presented projects. Visits followed by questions and activities using internet, experts, places for focused scientific research – pharmaceutical, honey, fish farming, greenhouse, mushroom, wineries. Implementing projects Planning investigations/projects, range of variables Data logging. Graph plotting. Ecology project
UMU	Grade 7-9 teachers 2-4 workshops Grade 4-6 teachers Grade 10-12 teachers 6 Teacher educators – 3 meetings of 2 hours Units: Disability, Low Energy House, Plastic waste, Blood Donation	1 2 3 4 5 6 8	Introduction to IBSE, group work with Units Invited people to workshops – community and school working together Group work activities, questioning skills Developing inquiry in teaching Simulations, data logging SSI, concept cartoons, card sort activities Examples from national science test
CMA	2012 9 teachers started, 6 finished, three meetings of 5 hours Units: Sound, Low Energy House (LEH) 2013 13 teachers, four meetings of 5 hours Units: Sound, LEH,	1 3 4 5 8 same as 2012	Introduction to IBSE using PowerPoint and mind-maps, submerge into IBSE activities, e.g., musical instruments Planning IBSE in own lessons, focus on skills, questioning Planning investigation ICT Assessment – evaluating the IBSE material Two sessions for element 1 Between meetings teachers used the developed materials in their lessons. Some Units completely translated, other

	Disability, Electricity		partially translated, some teachers used the English version in their classroom.
TARTU	2011 – 34 biology, chemistry, science teachers, 22 continued 2 days summer school 2 one day seminars 2012 – 7 teachers, 2 days school-based, 2 days summer school 2013 –18 chemistry and physics teachers Holes, Disability, Cosmetics, Photosynthesis, plus Sound, Chitosan, Blood donation, Polymers, Forensic Science	1 2 3 5	Lectures to introduce ESTABLISH, nature of inquiry, use of group work and feedback. Discussion of the value of ICK, including pollution, expectation to use ICK in school. Implementation and feedback expected in schools, workshop experiments. Use of data loggers in experiments
DCU	2 day summer school School based workshops 4 × 2.5 hours - evenings Holes, Sound, Chemical Care, Light, Disability	1 2 3 4	Introduction to ESTABLISH view of inquiry; cycle of inquiry Discussion of using links Doing inquiry based activities, devising questions for inquiry, sharing experiences Planning inquiry lessons, adapting activities for inquiry
MLU	Focused and continues collaboration with three schools since 2012, involving 12 science and math teachers and the principals Holiday workshop in autumn 2013 Regional conference on building a network between schools, companies and teacher trainers Disability, Renewable Energy, Invisible holes	1 2 3 4 8	Introduction to IBSE orientated planning, conducting and evaluating Science teaching. Support to implementing a new subject “STEM” into the regular curriculum Collaboration between University and School, including companies

Table 4. Organisation and content for pre-service TEP.

University	Structure	Elements	Units/visits/activities
JU	One 2 hour lecture, one 3 hour seminar, one 3 hour lab class Chemistry Units: exploring holes, polymers	1 2 3 8	View of IBSE ICK: How to organise a visit Teacher as implementer Lab work from the Units, variety of other approaches Analysis of questions from exam for IBSE skills
IPN	Implemented within existing chemistry education modules 25 and15 student teachers (two cohorts), 2-4 hour workshops in different courses; Units: Holes, Chitosan, Care, Polymers	1 2 3 4 And others integrated in other courses, like argumentation or assessment (due to the teacher training curriculum=	IBSE approaches in Germany, ESTABLISH as one example, frames of inquiry in research and industrial production, goals and demands of experiments from the Units, own development of exemplary Units, (later on in different courses: methods of assessment, areas of competence like argumentation and judgement)
MAH	Three groups of primary, (20-30) Two half-day workshops, 4 hours each. Included in Human body course Unit: Disability and Blood donation.	1 3	Introduction to IBSE Activities from the unit, and an assignment Teacher as Implementer
UMU	2012-13 Groups for grade 1-6, 4 hours/10 hours Units: Holes, photosynthesis, Low Energy House, Plastic Waste	1 2 3	Worked with inquiry based activities Visit to farm and waste power station Activities from Units
CUNI	2 hours per week for 6 months. Together		

	with in-service? Now incorporated into regular courses in pre-service TE-		
UNIPA	Pilot with 17 students doing physics education for primary Six 4-hour workshops Units: Sound, design a low energy home Part of a Physics course	1 3 5	View of IBSE Introduction and discussion Teacher as Implementer : Activities from Sound, DLEH Activities from Sound, DLEH ICT
DCU	C1 - 38 pre-service teachers in undergrad. prog. For lower sec. science, upper sec. phy/chem. 4 × 3 hr lab sessions. Unit: Sound C2 – 21 third year chemistry, 4 × 3 hr lab sessions Unit: Exploring Holes.	1 2 3 4 1 2 3	Introduction to ESTABLISH view of inquiry Developing ICK concept – sound applications Activities from the Sound Unit. Light activities, students generate inquiry questions and activities. Inquiry as a methodology in teaching Relevance of industry to school – Holes cyclodextrins Exploring holes activities, development of inquiry skills
CUNI	Two hours per week during half a year.		Content and methods same as for in-service
UPJS	17 pre-service biology, 8 chemistry, 5 physics, Running alongside course 16, 10, 12 lessons. Second run in science courses also.	2	Programme mostly as in-service Visit to transfusion centre and waterworks in Bukovec.
Cyprus	None reported		
TARTU	8 biology pre-service teachers for approx. 24 contact hours f2f, plus homework Units: Invisible holes, disability Part of a course Inquiry, learning and constructivism.	1 2 3 4	Introduction to ESTABLISH, inquiry approaches Introduction to AGES as industrial partner Working with Units – modifying to Estonia curriculum, inquiry experiments. Design on interdisciplinary experiment

	15 science 16 contact hours f2f, plus homework Units: disability, cosmetics, photosynthesis, chitosan, sound Open university group		on pollution. Create a module for IBSE.
CMA	2013 Two series of three sessions. 13 and 14 students, respectively. Students from: UU (Utrecht), UvA (Amsterdam) and VU (Amsterdam).	1 4 5	Between sessions students used the materials in lessons. Students developed their own IBSE_ICT_activity. These activities where visited and analysed by a Ph D student (and captured on video). The whole series was supported by our own version of the Establish Moodle.
MLU	Continuing introduction into pre-service courses since 2010 Disability, Renewable Energy	1 2 3 4 5 8	Introduction to IBSE orientated planned conducted and evaluated Science teaching Units. Contexts from Biology, but also bound to the other subjects and to engineering. Development of new Units Organising summer courses for pupils involving pre-service teachers
AGES	Not applicable		Should not report

Appendix 3

Deliverable - Models of Teacher Education In-service

Section 1: ESTABLISH Model - Build around 18 Units – 4 core + 4 additional elements

Section 2: Operationalizing Model

1. Organisation
    i. Why have you organised it in this way?
    ii. Recruitment of teachers (voluntary, mandatory, accredited, more approved)
    iii. Mixed science groups, or each subject separated
    iv. Teachers are novices, experienced or very experienced with IBSE, mixed groups
    v. Have meet inquiry workshops earlier
    vi. 10 hours or more
    vii. Block/ Distributed
    viii. Trialled in class
    ix. Number of schools, Number of teachers per school
    x. WS based in schools
    xi. WS based in industry

2. Implementation
    a. Into to IBSE
        i. How you have used this element and why/why not?
        ii. content vs Inquiry in curriculum
        iii. What Cases of interest should be included? Lessons learnt
        iv. Informed by profiles- pre data
        v. Effects- matched data- teachers enjoyment, will it be sustained, changes in teachers
    b. ICK
        i. How you have used this element and why/why not?
        ii. content vs Inquiry in curriculum
        iii. What Cases of interest should be included? Lessons learnt
        iv. Informed by profiles- pre data
        v. Effects- matched data- teachers enjoyment, will it be sustained, changes in teachers
    c. Implementer
        i. How you have used this element and why/why not?
        ii. content vs Inquiry in curriculum
        iii. What Cases of interest should be included? Lessons learnt

iv. Informed by profiles- pre data
v. Effects- matched data- teachers enjoyment, will it be sustained, changes in teachers

d. Developer
i. How you have used this element and why/why not?
ii. content vs Inquiry in curriculum
iii. What Cases of interest should be included? Lessons learnt
iv. Informed by profiles- pre data
v. Effects- matched data- teachers enjoyment, will it be sustained, changes in teachers

e. ICT
i. How you have used this element and why/why not?
ii. content vs Inquiry in curriculum
iii. What Cases of interest should be included? Lessons learnt
iv. Informed by profiles- pre data
v. Effects- matched data- teachers enjoyment, will it be sustained, changes in teachers

f. Argumentation
i. How you have used this element and why/why not?
ii. content vs Inquiry in curriculum
iii. What Cases of interest should be included? Lessons learnt
iv. Informed by profiles- pre data
v. Effects- matched data- teachers enjoyment, will it be sustained, changes in teachers

g. Research & Design
i. How you have used this element and why/why not?
ii. content vs. Inquiry in curriculum
iii. What Cases of interest should be included? Lessons learnt
iv. Informed by profiles- pre data
v. Effects- matched data- teachers enjoyment, will it be sustained, changes in teachers

h. Assessment
i. How you have used this element and why/why not?
ii. content vs. Inquiry in curriculum
iii. What Cases of interest should be included? Lessons learnt
iv. Informed by profiles- pre data
v. Effects- matched data- teachers enjoyment, will it be sustained, changes in teachers

Section 3: national case studies/reflection/Future suggestions

Agreed Actions:

1. Each partner to update partner information on organisation and implementation for each of the 8 elements. Using table in this document.
2. Email updated document to partners@establish-fp7.eu , to be uploaded to platform by 9am on September 17th.
3. Sit in international working groups to identify <u>key points</u> in each section on elements 1-8- how you present this aspect of the model(s).
    1. Organisation
    2. Intro to IBSE
    3. ICK
    4. Implementer
    5. Developer
4. Prepare a document with your agreed key points and present on Sept 17th.

Partner:____

Organisation – recruitment (If you have run different types of TEP – prepare several tables. One for each TEP). Describe in detail.

TEP Model	
Description Recruitment of teachers (e.g. voluntary, mandatory, through other projects)	
Accreditation (points, etc.)	
How teachers experience TEP Novice, experienced, very experienced, Mixed,	
Mixed group or single subject	
Have experienced IBSE workshops in other CPD?	

Organisation – workshop design (If you have run different types of TEP – prepare several tables. One for each TEP). Describe in detail.

TEP Model	
Total time (10 h or more)	
Time frame – possibility to trial in classroom (block/distributed)	
Opportunity for reflection of trials	
#Teachers/school	
WS done in schools	
WS done in industry setting	