

PUBLISHABLE SUMMARY (FINAL):

Project Summary

The ESTABLISH (European Science and Technology in Action: Building Links with Industry, Schools and Home) project (2010-2014) has been funded by the European Commission's Framework 7 Programme for Science in Society. The overall objective of this project is 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 specific key stakeholders in science 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. 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 through specific and targeted dissemination events.

To achieve these goals, ESTABLISH has adopted the definition of inquiry as the *"intentional process of diagnosing problems, critiquing experiments, and distinguishing alternative, planning investigations, research conjectures, searching for information, constructing models, debating with peers, and forming coherent arguments"*. An agreed framework to guide the development of ESTABLISH teaching and learning units encompassing this definition of inquiry as well as key aspects such as pedagogical content knowledge (PCK) and industrial content knowledge (ICK) has been utilised. Specific project actions have involved the identification, development, trialling and evaluation of these units and, where applicable, the localisation of these activities and materials to ensure their relevance to current industry and research in science, as well as gender and cultural considerations. ESTABLISH consortium members have collaborated with local actors during the development and piloting of these IBSE teaching and learning materials and to date 18 substantial IBSE teaching and learning units have been developed that encompass an extensive range of science activities that are suitable for using in inquiry teaching and learning across the participating 11 countries (Ireland, Germany, Sweden, Cyprus, Czech Republic, Poland, Slovakia, Malta, Netherlands, Estonia and Italy). ESTABLISH consortium members continue to support and inspire the further development of IBSE activities and units and facilitate the sharing and dissemination of these materials.

An agreed framework for ESTABLISH Teacher Education Programmes (TEPs), informed by existing good practice in in-service and pre-service teacher education, has been adopted by the project. This framework outlines the purpose and scope of such programmes and outlines core and additional teaching elements identified as supportive for the implementation of IBSE (Fig.1), together with inquiry activity suggestions from the units to enable these elements to be realised. This framework provides a flexible and comparable

description of ESTABLISH Teacher Education Programmes which cater for in-service and pre-service teacher education delivered by face-to-face and online strategies across a variety of cultural, educational and disciplinary contexts. The resulting experiences and examples which have emerged from the implementation of ESTABLISH TEPs have been empowering for those participating directly in the project and continue to inform the dissemination activities of the project.

This innovative approach adopted by ESTABLISH is targeted at achieving increased use of IBSE methodologies by teachers and thereby impacting positively on student's intrinsic motivation in science and technology, improving scientific literacy and promoting student involvement in experiential learning and informing science career choices by students. Through initial and ongoing engagement with teachers and students, the skills and confidence gained through IBSE have improved with a range of specific instruments indicating positive outcomes as a result of interacting with ESTABLISH. At all times, ESTABLISH looks to foster a mutually beneficial relationship between industries/research, teaching communities and local educational systems, for the on-going advancement of science and technology.

Description

The ESTABLISH project aims to enhance science learning by bringing together and involving all the key communities in second level science 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.

An initial focus has been on the identification, development, trialling and local adaptation of teaching and learning materials (**ESTABLISH Units**), informed by scientific, academic and industrial communities. These actions engaged teaching communities (through the piloting with teachers in each participating country) and industrial communities (through the inclusion and incorporation of scientific contexts, applications and examples in each unit). ESTABLISH has produced 18 substantial IBSE units with topics from across the science disciplines, selected so as to be appropriate for the second level science curricula in the participating countries. Within these units, 282 activities are offered at various levels to suit second level students (age range 12-18 years) and promote different elements of inquiry so as to offer flexible resources for use in teacher education and in the classroom. Each unit describes essential elements of pedagogical content knowledge (PCK) to support the unit's scientific concepts together with elements of industrial content knowledge (ICK), whereby examples, contexts and, or applications from industrial communities are integrated into teaching of the topic. Following piloting, the units have been revised and prepared, with a specific focus of enriching the ICK and ICT links, for use in teacher education programmes, both at in-service and pre-service level and to support the implementation of IBSE in classrooms across Europe.

ESTABLISH Teacher Education Programmes (TEPs) have been designed and implemented to facilitate teacher's engagement with IBSE and to inform and support the use of IBSE into their own teaching practices. An agreed framework for ESTABLISH Teacher Education Programmes (TEPs), informed by existing good practice in in-service and pre-service teacher education, has been adopted by the project. This framework outlines the purpose and scope of such programmes and outlines core and additional teaching elements identified as supportive for the implementation of IBSE together with inquiry activity suggestions from the units to enable these elements to be realised. This framework provides for flexible models for ESTABLISH TEPs which cater for in-service and pre-service teacher education delivered by face-to-face and online strategies across a variety of cultural, educational and disciplinary contexts. This framework points to four core elements that have been identified as essential in teacher education, as well as four additional elements to support participating teachers to use IBSE in their teaching as depicted in Fig. 1. It provides teacher educators with a roadmap to share examples of inquiry activities, whether adapted from the ESTABLISH units or other sources, used to achieve particular learning objectives, in the various learning contexts presented, as depicted in Fig 2. The resulting experiences and examples which have emerged from the implementation of ESTABLISH TEPs have been empowering for those

participating directly in the project and continue to inform the dissemination activities of the project.

Ongoing monitoring, revision and enhancement of project progress and outputs to ensure scientific and education quality, as well as consideration for ethical and gender issues has been carried out by the internal Quality Assurance Committee. The project has also benefited from input from four international experts appointed to the External Advisory Panel that has informed the evaluation of the ESTABLISH Units and TEPs, the online presence of ESTABLISH as well as the overall approach adopted by ESTABLISH to reach its objectives. These inputs have been presented at ESTABLISH General Assembly and Project Steering Committee meetings and have informed key aspects of this project. Through participation at a variety of national and international, ESTABLISH's consortium members have actively promoted and disseminated the project's outputs and achievements to a wide audience. As this project has progressed it has contributed to other European projects to inform their project objectives and also to initiate further projects and build relationships and networks to support the widespread implementation of IBSE in classrooms.

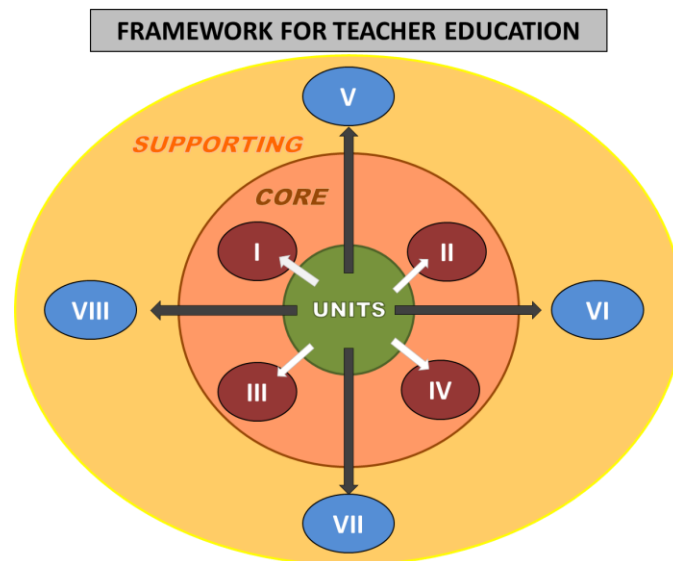


Fig. 1. Framework for ESTABLISH Teacher Education

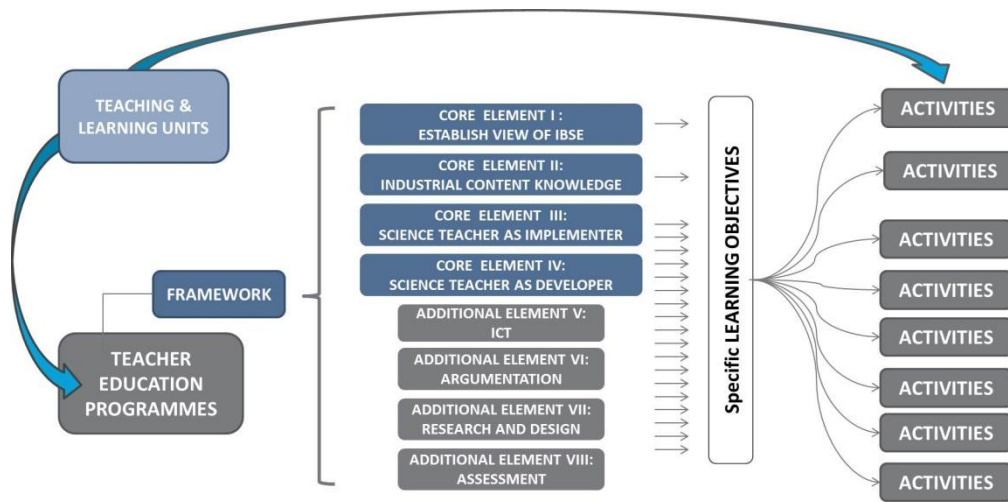


Fig. 2. Graphical overview presenting the interrelationship between the ESTABLISH units and Teacher Education Programmes; in particular the activities of the units to achieve the learning objectives of the ESTABLISH TEP elements.

Expected Results

ESTABLISH has achieved its objectives in contributing towards the increased use of inquiry based science education in classrooms across Europe 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.

18 ESTABLISH IBSE units have been developed, piloted and implemented in teacher education programmes which provide an extensive range of (282) science activities appropriate for use in IBSE across the science disciplines and levels. The model(s) for effective teacher education in each country is based on an agreed framework for ESTABLISH teacher education programmes (TEPs) that describes the use of IBSE activities and units and the minimum criteria required for such programmes. In particular the agreed framework presents four core and four additional elements that may be included in IBSE teacher programmes as appropriate for each country and context. ESTABLISH units have been designed to provide examples of IBSE teaching and learning materials and each unit provides examples of student activities designed to encourage and facilitate student learning. Uniquely, the units also link scientific concepts and content to real world scientific and industrial experiences.

The provision of ESTABLISH TEPs across the 11 participating countries was successfully implemented through a variety of face-to-face sessions. A key action to inform this implementation of ESTABLISH TEPs has been the review of the main obstacles to implementing inquiry and the development of intervention programmes to tackle these. The agreed ESTABLISH framework and model(s) for ESTABLISH teacher education, both in-service and pre-service, builds on these reported findings and has resulted in the successful provision of appropriate and effective IBSE teacher education. Key results show that following the TEPs, all cohorts of the in-service teachers have increased their understanding of inquiry and their understanding of the roles of teacher and student in an inquiry classroom, with the biggest increase by those who classify themselves as beginners in IBSE. Also many have shifted their attitudes to inquiry towards overcoming the barriers often associated with IBSE, with again the biggest shift by the beginner cohort.

The provision of ESTABLISH TEPs will continue to inform science teacher education in each of the participating countries and is offered online, so that more teachers can participate in IBSE teacher education, through use and sharing of IBSE resources and experiences. For this purpose, the website has been revised to serve as a self-guided on-line support for the ESTABLISH TEPs. It is expected that other audiences may also like to engage with the website, and the consortium welcome this sharing of project approaches and materials with other teacher educators in IBSE.

ESTABLISH consortium members are actively engaged in promoting the project and disseminating its outputs and achievements. The work of this project has informed policy makers and other stakeholders in science and science education on the factors that affect innovative and sustainable change in classroom practice across Europe, in particular through consideration of the role of IBSE in curricula and assessment policies and the need for appropriate and continual teacher professional development.

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.