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

Work Package 2 | Deliverable 3

D2.3 Engagement of Stakeholders in IBSE

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

Deliverable No.: D2.3
Due date of deliverable: New Deliverable
Actual submission date: 31/03/2014

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

Name of lead partner for this deliverable: DCU

Total Number of Pages: **93**

A. Background to this report

This report is a deliverable of Work Package 2 (WP2) of the European FP7-funded project "European Science and Technology in Action: Building Links with Industry, Schools and Home" (ESTABLISH; 244749, 2010-2013). This additional deliverable, Deliverable 2.3, identifies and describes the implementation of a series of models adopted by ESTABLISH beneficiaries (Table 1) to engage and involve stakeholders to support the dissemination of IBSE through the implementation of ESTABLISH Inquiry-based science education materials and resources in the participating countries.

(See Table 1 for beneficiary list).

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

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Table 1: 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

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Executive Summary

The overall objective of ESTABLISH 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.

While other ESTABLISH project reports have addressed the aspects of effective models for teacher education (D4.6), impact on teachers attitudes to IBSE (D4.5 and D5.5) and impact on students' learning, this report will describe the ESTABLISH rationale for the engaging stakeholders traditionally outside the classroom, for adopting and supporting the dissemination of Inquiry Based Science Education and outline strategies adopted by ESTABLISH beneficiaries (Table 1) to engage those stakeholders.

The classic learning environment for the teaching and learning of science takes place in the classroom. Outside of the classroom, though, there are multiple examples of individuals and organisations (stakeholders) using science and technology for a variety of reasons and if these stakeholders are engaged, they can support the teaching and learning of science in the classroom. These are the identified stakeholders that ESTABLISH aims to engage with at a variety of levels to support and promote the use of IBSE approach and materials.

As the projects' name suggests (European Science and Technology in Action: Building Links with Industry, Schools and Home), ESTABLISH's aim aims to bring together stakeholders in science education to create authentic learning environments to promote the use of inquiry based science education (IBSE) in classrooms. This requires collaborative actions to foster a mutually beneficial relationship between industries/research, teaching communities and the local education system for the on-going advancement of science and technology.

This is a very ambitious task, taking into consideration that there are many and varied stakeholders in each country and across Europe. The methods to engage these stakeholders are also variable. The ESTABLISH consortium has addressed this challenge and through the case-studies presented within this report, we believe that this report will exemplify that there is much benefit and learning gains in pursuing this challenge.

Introduction Background

The aim of ESTABLISH is to create unique learning environments for science education by bringing together and involving all the key communities (strategic stakeholders) in second level science education. The key stakeholders are identified as 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, as illustrated in Figure 1.

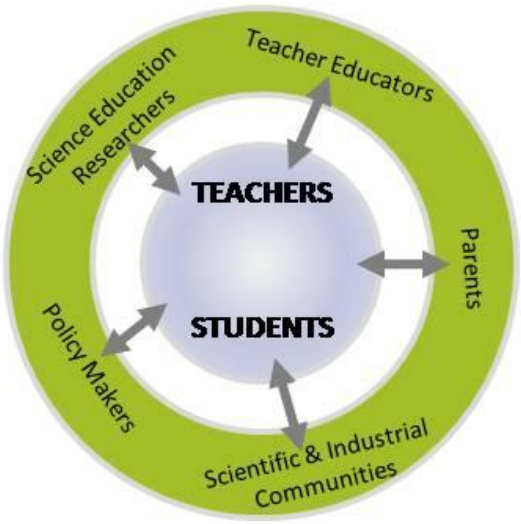


Figure 1: ESTABLISH Model of Interaction between Stakeholders in Science Education

ESTABLISH is by its nature a "coordination and support action" project, thus it is focused on developing and sustaining networks of people to implement innovation. In this case, the innovation is inquiry-based science education (IBSE). This project has facilitated an opportunity to, not only share but, embed this methodology into the teaching and learning of science in classrooms across Europe. This facilitation of IBSE has been an overall objective of the project. ESTABLISH has sought to do this by bringing together, within a collaborative environment, and engaging the specific key stakeholders in science education.

These collaborations have occurred in each of the participating countries and have informed the development of the project's **teaching and learning materials** (***ESTABLISH Units***) as well as **educational support** for both in-service and pre-service teachers (***ESTABLISH Teacher Education Programmes***) designed to promote the use of Inquiry-Based Science Education (IBSE) in classrooms across Europe. The implementation and impact of these resources and supports, both on teachers and on students are available in other project reports and will not be specifically addressed within this report. Instead, this report outlines the strategies adopted by ESTABLISH beneficiaries (Table 1) to engage those stakeholders, traditionally outside the classroom, to support the dissemination of IBSE. By presenting a series of case-studies, it is hoped that the benefit in pursuing this challenge of engaging these stakeholders will become apparent and the steps taken will inform the development of similar strategies in any future attempts to do so.

Process for Engaging with Stakeholders

Identification of Key Communities and Rationale for Engagement.

At the initial phase of the project, the key communities that are stakeholders in second level science education were identified as:

- The policy makers in science at second level, including curriculum developers and assessment agencies;
- Teachers and teacher educators of science including science teacher networks;
- School management;
- The students of science in second level schooling;
- The parents of the students mentioned previously;
- National science education researchers;
- The scientific community, both local enterprises and multinational industry as well as the science research community.

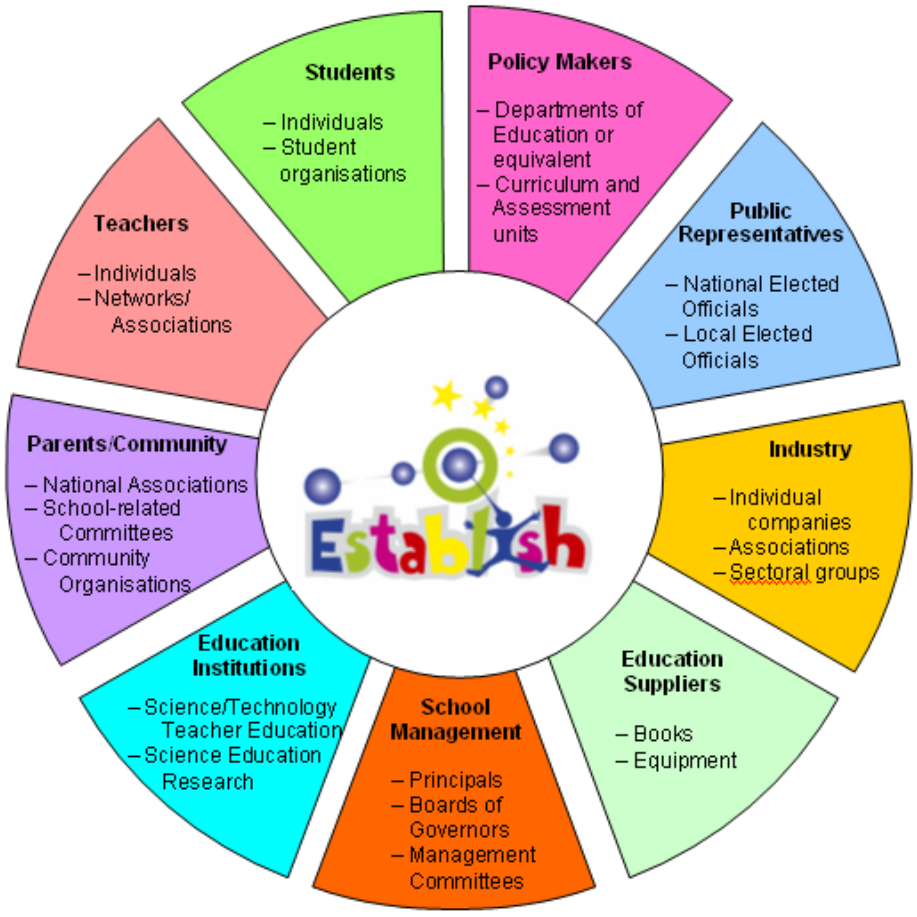


Figure. 2: The Augmented Establish Stakeholder Model

As the interim report on the key forces for driving change in classroom practice across participating countries[1] suggests these communities occupy various "power positions" and levels for participation. The rationale however for engaging these communities is that they all have interest to add to the project, whether through the development of IBSE teaching and learning units and/or support of the teacher education programmes.

A unique feature of the ESTABLISH Framework for Teacher Education ([2]REF – D5.2) is the inclusion of the core elements entitled **Industrial Content Knowledge (ICK).** This element calls for the use of industry related content and activities in science teaching practice. The ESTABLISH Units provide such materials. The ICK Element provides motivation and purpose for teachers to create relationships with local industrial settings, hence linking an important stakeholder with teachers and students. Stakeholders must perceive some rationale for their involvement in science education and ICK activities offers a compelling rationale for industry.

Implementation

As an initial exercise, nominated project participants from each beneficiary were tasked with identifying national representatives for each of these stakeholder groups which were identified as:

A. National and regional policy makers (including curriculum and assessment developers)
B. Industry (private & public)/Companies/Science research organisations
C. Science education research organisations
D. Education suppliers (publishers, resource & equipment suppliers)
E. Teacher & teacher networks
F. Students & student representative organisations
G. Parents & parent associations
H. Other

A questionnaire was distributed to these project participants, to identify "industrial partners" to become involved in the development of the IBSE teaching and learning units. It should be noted at this point that the term "industrial partners" referred to those who use science or technology as part of their daily activities or employment, for example, opticians where applications of physics and materials science are relevant, and is not refined solely to industrial examples, such as, pharmaceutical production plants, which the title may imply. Thus, the term is much broader and more inclusive than it may initially appear.

The responses outlining the national industrial partners are available in the project report MS5 and also in Appendix 1.

Following their identification, the next task of the partners was to identify how and for what purpose to engage them. The overall aims of these engagements were to stimulate learning and promote intrinsic motivation in teachers and students and to clarify the relationship between school science and career opportunities in this sector (science and technology), both for men and women. How to channel the stakeholders' input efficiently was considered to be important, so as to sustain the relationship that this engagement would enable for subsequent development in the area of science and technology.

[1] D2.2 Interim report on the key forces for driving change in classroom practice across participating countries, Aug 2011, available from http://www.establish-fp7.eu

[2] D5.2 Framework for Teacher Education Programme, Feb 2012, available from http://www.establish-fp7.eu

Results

The resulting national strategies, available in Appendix 2, indicate the different modes and considerations that are needed for each group of stakeholder. For example, the stakeholders within the "industry" sector could be engaged through actions, such as:

- Providing expertise
- Providing resources
- Providing funding
- Assisting with lobbying policy makers

It is realised that some stakeholder categories will be more dominating in some countries than in others, and/or familiar with those implementing such science teacher education programmes. Again, as an example, the strength of influence of industrial stakeholders have on science/technology education was rated low in all participating countries except in Netherlands (CMA) and Slovakia (UPJS) where certain companies seem to have greater influence.

While the "voices" of some stakeholder groups may be louder in certain national contexts than others, there were other obstacles identified by the project's participants, which might prevent industrial stakeholders from supporting the introduction or implementation of IBSE. Indicatively, specific examples are:

- Lack of funding
- Lack of commitment
- Lack of interest
- Lack of short-term return
- Lack of expertise

To balance this, there are also a number of motivations for an industrial partner to become involved in an education project, such as the ESTABLISH project.

- Many companies have a corporate social responsibility (CSR) policy, which favours involvement in education and community related projects.
- They may wish to get exposure in the classroom as a prospective employer
- They may be concerned about future scarcity of science graduates
- They may perceive involvement in science teaching as beneficial in terms of reputation

Recommendations for Communicating with Stakeholders

To realise ESTABLISH's objective of disseminating the use of IBSE in classrooms across Europe, the following guidelines can be offered, so as to gain the support of strategic stakeholders:

Identify stakeholders

- Identify which part of the ESTABLISH project you would like to promote or incentivise the stakeholder to become involved in (e.g., ESTABLISH unit or Teacher Education Programme)
- Identify the related industry and the specific organisation/s to be approached

Define these stakeholder requirements and expectations

- Conduct some initial research (e.g., review of the organisation's website) for any education or recruitment references, and to identify any social media links that might be used to promote ESTABLISH. Also, if the organisation has a CSR policy, review it for any references to education or recruitment of science/technology graduates

Develop the appropriate communication messages for each

- Prepare an introductory document, such as, a newsletter, presentation or graphics.

Define the communication channels to be used.

- Make personal contact with the organisation and arrange to email the information to the individual involved. If possible, set up a face to face meeting.
- Specifically enquire whether the organisation has provided any kind of support to education

Follow-up

This is the process that has been adopted by the ESTABLISH consortium and, in the following section, we will outline a number of examples of different communication channels that have been used by different project participants to engage strategic stakeholders in supporting IBSE.

Examples of Engaging Stakeholders in IBSE

ESTABLISH has brought together the key communities that are stakeholders in second level science education to work together, generate and implement innovation in the classroom for the teaching and learning of science and technology. The following case-studies summarise the experiences of selected project participants from four different national contexts.

Ireland (AG Education Services and Dublin City University)

Irish National Stakeholder Event, 13th November 2013

Clock Tower, Department of Education and Skills, Marlborough Street, Dublin 1

This first Irish National Stakeholder Event took place in the Department of Education and Skills (Governmental Buildings) in Dublin on 13th November 2013. This event was coordinated and hosted by AG Education Services, a partner on the FP7-ESTABLISH project, with input to programme sections from DCU.

Description of the National Context and Motivation for Engagement

In Ireland, innovations in science education at post-primary level are present, but tend to occur in pockets rather than a systematic approach to the teaching and learning of science. The purpose of holding a national event was, through dialogue, to increase the visibility of projects that support innovations in science education (innovations such as inquiry-based science education) and to show how stakeholders, those not traditionally involved in education, can become involved and support the teaching and learning of science in schools.

Structure of Engagement

In planning this event, various objectives were set out to:

- raise awareness among identified stakeholder groups of the importance of supporting IBSE, as a superior mode of teaching and learning science and related subjects;
- highlight the need for IBSE among these key stakeholder groups;
- share stakeholder views on the relevance of STEM education for personal, social, and economic development.
- inform stakeholder groups of the status of international science education projects active in Ireland (in particular ESTABLISH) and the availability of IBSE teaching resources.
- identify ways in which stakeholders can support or encourage progress in STEM education in their industry, sector or locality.
- gain commitments from stakeholders to support IBSE in practical ways.

The stakeholder groups invited to attend this event included representatives from:

- Researchers in science education,
- Post-primary teachers,
- Post-primary students,
- students' parents,
- Ministries of education/inspectorate
- Teacher professional development associations
- Industry.

Each stakeholder group was represented at the event, and there was a total of ~40 participants.

Summary of Engagement

The event was structured to allow for a combination of plenary addresses as well as interactive discussions to address the objectives set out for the event. The presence of the Minister of State highlights the importance that the government currently places on identifying and supporting innovations in science and mathematics education. The addresses from each of the other stakeholder groups (Governmental bodies responsible for curriculum and assessment; parents; industry; teachers and professional development associations for teachers) each concurred with the sentiment that in order for Ireland to have the most engaged and scientifically informed public[3].

An important part of this event was the student interview session during which the opinions of post-primary students (boys and girls) about science, their perception of the subject and engagement with it were discussed and shared with the whole group.

During the latter part of the event, the participants were invited to engage in several roundtable discussions and share their thoughts, opinions and comments of how innovations in science education can be encouraged and nurtured to create supportive environments for scientific learning. Five groups were formed with each group focusing on one of the following questions:

- What is the role of **industry** in the inquiry classroom?
- How can we **communicate information** about teacher training & education projects and where do teachers look for information?
- How can we build up **sustainable networks** of stakeholders in relation to school?
- How do we recognise and assess **inquiry skills**?

Specific notes for each of these discussions are available in the Appendix, which reveal that each of the groups was aware of certain vertical processes and networks to support innovations in science education, but perhaps communication across these networks could be increased for better impact. It was proposed that perhaps groups, such as parents (parent associations) and teacher professional development associations, could assist with the horizontal communication, to both bring school science into the real world and real world relevance back into the classroom, and to inform teacher professional development in science, so as to develop sustainable networks for implementing changes which these innovation in science would incur.

Each group went through a process of identifying roles and responsibilities for developing and improving processes appropriate for each question.

Conclusion and Next Steps

In the summation of the event, it was clear that all participants were in agreement about the innovations which inquiry based-science education projects, such as ESTABLISH, can promote and should be encouraged, supported and developed, and that communication and collaboration across each of the stakeholder groups is vital in sustaining their existence and impact.

[3] This is one of four primary objectives outlined in Science Foundation Ireland's Agenda 2020.

Further Details of Engagement Event in Ireland

Schedule for Event

Morning Session	Registration
Address by Minister Sean Sherlock	Minister of State, Department of Enterprise, Jobs and Innovation and Department of Education and Skills with responsibility for Research and Innovation
Address by Bill Lynch	Director, Curriculum and Assessment, NCCA
	(National Council for Curriculum and Assessment)
Address by Brian Coyle	Parent
Address by Matt Moran	Director, PharmaChemical Ireland
	Tea/Coffee Break
Address by Claire Scanlon	Teacher, Fingal Community College, Swords, Co. Dublin
Address by Caroline McHale	PDST (Professional Development Service for Teachers
Student Interview	Interview by Anna Gethings, AG Education Services with students of Fingal Community College
Afternoon Session	Lunch
Address by Bob Savage	Vice President, EMC Ireland Centre of Excellence
Address by ESTABLISH Partners	Introduction to ESTABLISH
Round Table Discussions and Feedback	
16.00	Finish

Notes from Roundtable discussions at Irish National Stakeholder Event

Topic: What is the role of industry in the inquiry classroom?

Various aspects of the role of industry were discussed as follows.

- It can be difficult to address the needs of industry due to practical issues relating to time, resources and materials.
- Universities drive what happens in the classroom as students/parents want to go to universities. Where is the science?
- Younger management is more helpful to inquiry based learning.(IBL).
- The teacher's perspective is very important if professional. experience colours their teaching. Can you prepare for IBL?
- Industry can provide moral and functional support via social media, videos, blogs, and market experience and encourage school to do a projects using IBL
- It may be beneficial if it were compulsory for teachers to work in industry e.g. STARS project funded by SFI (Science Foundation Ireland), universities and industry partners.
- Do teachers have to do CPD? Usually voluntary and no industry involved.
- Get network of teachers together to convene regularly. Industry could dip into this easily.
- Bringing industry experts in is good but the challenge is to ground it in the teaching in the classroom.
- Can industry to influence policy-makers? Industry may not be interested in the broad education of people. However, a lot happens at local level.
- Is it possible to create a national strategy through industry and policy-makers formalising IBL?
- Incentivise from local to national.
- Get the parents to buy-in. Can parents be encourages to live science? Start with Math's for parents e.g. parents in industry.
- Profile of teachers is very. important. Most have post-grad qualifications. Some have industry experience.

Topic: How can we communicate information about teacher training and development projects?

Looked at this from perspective of the teacher. 'Passion' emerged as an overall theme. The 'big idea' is that teachers need the passion and motivation to access this information.

Practical channels were also discussed. These include:

- Social media –Facebook, blogs – by individual or educators.
- Publication of yearly plan e.g. Malta Also in Malta there is a portal for all courses online – Frog Blog. It is also mandatory that teachers do three days retraining
- Teachers can exchange information at workshops and in-service courses and such as those delivered by the PDST, Ireland.
- Similarly for pre-service, e.g. Maynooth – Diploma in Professional Education –teacher skills can be assessed..
- Weekends programmes can be run in Trinity, DCU, St Pat's, Maynooth etc..
- Relevant professional organisations can be a good channel e.g. Royal Society of Engineers. Irish Science Teachers Association.
- Some feel that online is way forward for teacher education but others feel that physical presence is necessary - so both methods. should be used.
- Teachers themselves need to search i.e. they should use inquiry.

General points about science education were also discussed:

- Community involvement is useful e.g. Garda Band (Irish Police Force Band) visiting schools – but this was about drama and art - science was not a topic.
- Competitions such as SciFest and Young Scientists Exhibition are important, but competitions don't suit all school or pupils.
- There is a drawback with prescribed experiment. They are counter to enquiry because teacher cannot deviate from prescription.
- School Principals also need to be passionate but they are not t chosen for passion. They come through the system – counter to inquiry. Administrative skills are valued over teaching skills. Experience can kill passion.
- People who are taught badly come to secondary school with attitude that can destroy them for life.

Two contrasts emerged from these discussions - Prescription v Inquiry and Passion v Experience/Administration

All thought that the EMC input to the Conference was inspiring..

Topic: How can we build up sustainable networks of stakeholders in relation to schools?

In opening the discussion, it was agreed that the question contained many components, and that in order to answer it, it would need to be broken down into a series of shorter, more specific questions, which focused on:

Who are the stakeholders?

How are we communicating with these stakeholders?

Are there limitations to these communication strategies at present?

Can we overcome these limitations?

Is there a role for parents and parent networks in school?

What is the role of the media?

How do students feel about parents being more involved in school?

The discussions flowed from one topic to the next, with all of the group contributing to the discussions. The group contained representatives of teachers, parents, students, science educators, policy makers, industry and media.

Stakeholders

The starting point for the discussion was the identification of the stakeholders required to build up networks around schools. These were identified and defined in terms of locus to the school as being local or national:

Teachers	Local
Students	Local
Parents	Local
Industry	Local
General Public	Local
Boards of management	Local
Education providers,	Local
Researcher centres in science,	Local & National
Department of Education | Ministries of Education,	National
Media	National

Teacher education institutions,	National
Teacher Professional Development bodies,	National
Teacher Professional Association	National

In particular the network of the Teacher professional association - the Irish Science Teachers Association, was agreed to be of vital importance for teachers of science, both at primary or secondary school, as it provided both a support network (human resources) as well as teaching aids (material resources) that teachers could use.

When discussing the methods of communication it was agreed that in addition to information flowing from the ISTA out to it members that it is important that information should come back from its members to ensure that the association is serving its members' needs. It was proposed that membership of this association should be incentivised and made obligatory for those teaching science to ensure that they can access state of the art resources and supports for their teaching. It was noted that this would require implementation from governing bodies such as the Teaching Council and/or removal of membership fees to increase membership uptake.

In order to increase awareness of this teacher professional association, it was recommended that teacher education institutions should promote the presence of the ISTA as their supportive network.

It was noted that the ISTA is a member of the international science teacher association - ICASE - International Council for Associations for Science Education - and that members could benefit from the participation in this network.

Communication Strategies

It was agreed that multiple communication strategies are required to engage stakeholders and that traditional (paper/post/fax/face-to-face) need to be combined with electronic (emails) and multi-media forms (Twitter/Facebook). It was also proposed that generating online competitions can be very powerful in generating and sustaining networks.

Involving Parents in Schools

In discussing the role of parents in schools, it was noted that parents, through their employment, can often be highly experienced in science and could contribute to the teaching of science in partnership with the teacher. The information a parent can present can be inspirational and provide an intrinsic motivation for students. The learning could then be reinforced by the teacher. This can be useful for circumstances where a teacher can be fearful of the science content, but can approach scientific topic in partnership with the parent.

Also the student comes to realise that science is a part of life.

Parent Networks

In discussing the role of parent networks it was noted that these networks are at their strongest at primary school, when the students are younger as parents meet more frequently (collection/drop-off at schools), and that they tend to dissipate around 2nd year in secondary school (~14 years old).

It was noted that this network is a channel of communication that could be used by the schools more frequently to develop a supportive network around the school. Usually communications take place once annually during the Parent-Teacher meeting which is often focused on the academic, diligence and disciplinary performance of the student.

Media

It was agreed that the media has the potential to influence the public's interest and support of science both at a national level but also at a community level. It was proposed that the media should be made aware of existing school-parent-industry partnerships so as to promote their success on a national scale.

Impact on Students

When asked how these suggestions would affect students it was noted that though some could cause initial embarrassment (involving parents in the classroom) it would show students that science is an open-ended activity (to search out information and understand things) that is an inherent part of life and not a confined job or labour.

It was noted that the choice of subject selection in first year secondary school (~13 years olds) is often make in the context of job prospects and that science can often be dismissed as a difficult career path. [It is noted that the input from many stakeholders (government/funding bodies/employers/employees) is required at multiple levels in order to make any change to this perception, and not the main focus of this discussion]

If science was presented in the context of investigations and exploring concepts then it would be more favourably received by students.

It was agreed that the focus of these networks should promote curiosity in science and that though it may not be "cool" that it is good to ask questions. If those involved in the network are aware and supportive of this vision, then they are more likely to be able to work together and become sustainable.

Topic: How can we build up sustainable networks of stakeholders in relation to school?

This question was discussed under the following headings.

Networks

- Lots of local activities and general interest already exist.
- It is necessary to learn from them in a "best practice way"
- Industry already have networks.
- Science people also have their network.
- It would be important to bring these two networks together.
- Networks are recommended, because they survive (as long as people are constantly brought back into them).

Parents

- It is important to show parents how well their children are doing – how concerned you are about their education and that you care about it.
- Be conscious not needing to educate the parents, but to introduce them to the ideas behind the teaching.
- Science competitions can play an important part, as parents become aware of their children's activities, interest und success in science through prizes, awards and so on.

Students

- As inquiry needs a certain amount of engagement to be successful, it is important to be conscious of the need to maintain this engagement.
- Project Maths is already doing we;; in this respect. Nonetheless, there are still people needed who are able to do the high level maths and science.

Topic: How do we recognise and assess inquiry skills?

- To recognise inquiry skills is not an easy matter.
- There is a need to determine the width of learning involved and how it was quickly recognised that a simple cognitive examination approach will not facilitate the gains? of inquiry skills.
- The width of inquiry skills certainly involved cognitive aspects as the learning is not appropriate if it did not have meaning or required thinking.
- The intensity aspect was linked to the link of inquiry learning (and hence the inquiry skills) and aspects like independent learning, self-development, innovative skills, entrepreneurial skills (such as ingenuity and creativity), or even collaborative skills, leadership skills and teamwork. The inquiry skills in the context is very wide.
- The teaching of inquiry skills, especially if it is to relate to a capability in new situations, requires 'good' teachers who can recognise the involvement of students in the learning process (it needs to be a challenge that relates to the students level of learning).
- There is a link between recognition of inquiry skills and the role played by students, and certainly assessment needs 'overt' operations by students to exhibit their learning at a cognitive, skill and values level.
- The suggestion is this, that inquiry skills were very wide and are driven by meaningful inquiry questions. Relevance of the situation is important to give meaning for students and hence facilitate student effort (motivation). Raising questions on unfamiliar science is an issue that needs to be addressed.
- Assessment of inquiry is important and the current assessment system is inhibiting inquiry, rather than promoting it. The assessment needs to go much wider and seek to determine 'capability' in a new situation, rather than 'ability', especially if abilities are assessed as separate sub-entities rather than in a holistic situation.
- A further indicator of inquiry (may be assessable) is student self-confidence (perhaps self-efficacy is better as this can relate to self-confidence and competence).
- The final question - is any of this actually within the goal of education? It seems to be.

Some themes that arose during discussion:

- Inquiry Skills - cognitive + better with practice
- Question(s) are critical - curiosity
- Problem Solving v inquiry
- Confidence in doing
- Meaning of learning
- Recognise inquiry: student involvement, to gain confidence
- Grade level of inquiry - an assessment issue
- Motivation
- Team leadership
- Independent learning - self determination
- Inquiry by itself not enough - need consolidation for meaningful learning

- Good teachers know to handle and how to recognise what.is needed.
- Relevance of the situation to give meaning, otherwise question may not have meaning and hence not worth the effort.

Synposis of Plenary Sessions

1) Opening Address by Sean Sherlock TD

Minister of State, Department of Enterprise, Jobs & Innovation and Department of Education & Skills with responsibility for Research & Innovation

The Minister announced the launch of the 9th Edition of Science & Technology in Action – a science education resource for schools produced by AG Education Services. It was the original stimulus for the ESTABLISH project.

Having looked through the resources and noted the industry involvement in the lessons he felt it was a wonderful way of involving students in inquiry-based science education. The Department of Educations and Skills would like to move the educational landscape in this direction.

He particularly welcomed the presence of students who were engaged in this process. They were all doing STEM-related subjects, including Agricultural Science.

The more we can get students to engage with a conceptual understanding of science at a younger age the better the outcomes we will have from a social and economic point of view.

On behalf of the Government, he thanked all of the stakeholders: students, parents, science and mathematics teachers, industry. Looking at the folder (Science & Technology in Action, 9th Edition) he was impressed by the way that the work of a variety of industries was linked to the science curricula.

Being from Cork he was pleased to see EMC representatives (who are based in Cork) participating in the conference. Their business (data analytics) maps onto the Government's strategy to develop the ICT sector. Lessons such as the one on Big Data, will capture the imagination of students and hopefully inspire them to further study and work in this area. They will be the technologists and scientists of the future.

He gave a particular welcome to participants who had come from other countries.

The partnership between science teachers and industry was a wonderful model of engagement.

He thanked all involved in the conference, which was taking place during Science Week (in Ireland), and wished them well in their endeavours.

2) Address by Mr Bill Lynch Director, Curriculum and Assessment at the National Council for Curriculum and Assessment

Science and Technology education in a changing world

While the theme of this conference is *Remodelling Science and Technology Education: Building Links with Industry, School and Home*, I would like to focus on what we mean by science and technology education and what we envisage it might be in the 21st century. This may well require remodelling – and re-thinking the purposes of – science and technology education in the context of the bigger picture of education more generally.

Some see 'science' as knowledge – based on the Latin '*scientia*' – but knowledge through a specific subject lens, if you'll pardon the physics reference. Thus, in school, we have a subject called 'science' (or at senior cycle 'the sciences'). Others see 'science' as the organised study of natural phenomena or objective reality that is based on rational observation; a study which uses scientific processes and methods to investigate and explain that reality. Yet others see it in a more general sense as the pursuit of knowledge in a whole variety of forms (for example, social science, political science, computer science …)

In a similar fashion we can look at 'technology' in a variety of ways. Its origin lies in the Greek word '*techne*', meaning art, craft or skill by which something is made or achieved. Interestingly, this was combined with logos, meaning word or reason embodying an idea. It is broadly associated with the application of scientific knowledge for practical purposes; an earlier meaning of technology might have been the use of crafts and tools to solve problems. Perhaps more recently technology is seen as the application of the principles of design, production, and utilization of goods and services in the organisation of human activity. In the syllabuses for the senior-cycle technologies, technology is presented as a 'creative activity where we interact with our environment, using appropriate materials and processes, in response to needs, wants and opportunities'. Technology education is about equipping learners with the competence and confidence which comes from learning about, with and through a range of technologies.

Many see science and technology as interwoven – each complementing the other in a variety of ways[4]. Technology can sometimes be viewed as the servant of science, as an off-shoot, and perhaps of somewhat lesser standing. That said, the rapid growth of the 'new' technologies has helped to promote the status of 'technology'. Science has grown into a more formal, academic and systematic study than technology, which is often considered in terms of its practical expression and functional purposes, and thus closer to its Greek roots in the practical arts, as distinct from the liberal arts which were associated more with philosophical discourse. In this we need to be careful. The mention of philosophy reminds me of the quote which is attributed to John William Gardner, US Secretary of Health, Education and Welfare under President Lyndon Johnson:

The society which scorns excellence in plumbing as a humble activity and tolerates shoddiness in philosophy because it is an exalted activity will have neither good plumbing nor good philosophy: neither its pipes nor its theories will hold water.

So much for the past. As I said, my focus today is on what science and technology might become in the 21st century or, more specifically, on what science and technology education may have to offer the children of today who will become the leaders, developers, shapers of a future that we really know little about. They will be the citizens who will both experience and evaluate the innovations

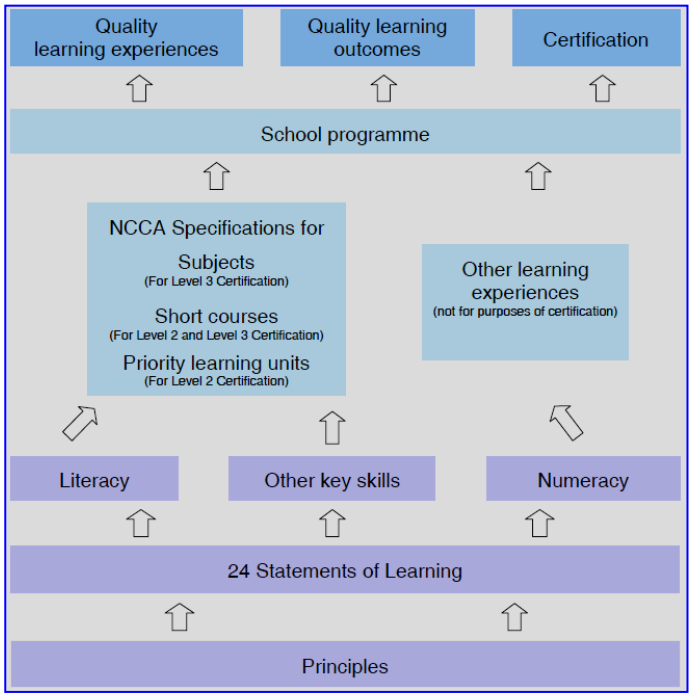
[4] Interestingly, and notwithstanding their Latin and Greek origins, the Irish terms for science and technology are quite close in meaning: *eolaíocht* and *teicneolaíocht*.

and solutions we propose. They will also be the ones to generate and develop innovative ideas, new processes, new technologies that have yet not even been imagined. [As Carl Sagan said one time: *Somewhere, something incredible is waiting to be known*. Carl was also a strong advocate of dealing simultaneously with scepticism and wonder.]

What is it about science that so captures the interest and the imagination of children? Why and how do they more easily relate to 'modern' technology that many adults do? How do we harness this interest and cultivate their natural curiosity, imagination and creativity? Maybe I should say: *Why do we not harness and cultivate these*? The levels of interest and engagement in science project competitions such as the Young Scientist, and the quality of that engagement in terms of inquiry and communication of science, points to the fact that personal interest in science and support for it will be met with an enthusiastic response from students (and their teachers!). Therein may lie the path to a different model for science and technology education.

Over the past number of years, much research in education – nationally and internationally – has sought to find out what works and what is needed to support and improve learning, and how we will recognise that improvement. Typically, the answers have been along the lines of adjusting the curriculum to take account of new developments in our world, developing more accurate and reliable forms of assessment, providing increased resources to support teaching and learning, building capacity in our schools, targeting the development of the kind of knowledge and skills that will help to keep us to the forefront in the never-ending and competitive environment of economic development. However, experience has shown that these approaches in themselves do not necessarily ensure success or even result in the intended improvements being seen in our students and our schools. They must be translated into reality in the classroom and in the minds of the learners.

Education is seen as both a process and a product. Einstein once said that *education is what remains after one has forgotten everything he learned in school.* Maybe we shouldn't take that too literally, but nonetheless there is an element of truth in it. We learn today so that we may be better able to deal with tomorrow. We are educating our children so that they are prepared as well as possible for a future that is largely unknown, but that is increasingly being influenced by science and technology. It's the skill, the understanding, the ability and willingness to learn that will be the enduring benefits of their education.



So, what do we want science and technology education to be? I think we need to see them in the bigger picture and vision of education, and figure out what role they play in achieving that vision. Just over three years ago, the NCCA launched a consultation in which two 'big ideas' were flagged: *innovation* and *identity*. Attention was focused on the school as the site of innovation and teachers and school leaders as the agents of the change process. John Henry Newman said that *to live is to change, and to be perfect is to have changed often.* This is not easily applied to education, where experience shows that constant change, even incremental change,

is challenged by the inertia of the status quo. Sometimes, a transformational change, despite its disruptive effect (or maybe because of it) is more likely to succeed.

The evolution of the *Framework for Junior Cycle* gives schools the opportunity to develop an education experience that is both a follow-on from primary schools and a preparation for senior cycle. [See Slide]

Junior cycle is a stage where students get to deepen their relationship with learning, but without losing their enjoyment of learning and the wonder that new experiences can bring to that learning. The framework provides both a *structure* to ensure consistency of purpose and *outcomes* to act as achievable targets for all, together with a *flexibility* to respond more directly and effectively to individual and local needs and opportunities. It is within this framework that science and technology education are being developed. I'd like to briefly outline what this involves; the full details can be found on the junior cycle website (refer to the slide). Since it is the more immediate of the two, I'll focus mainly on science.

The background paper for junior cycle science, which is available on the junior cycle website, is clearly moving the focus in science education to inquiry-based learning – which is consistent with the overall statements of learning and the key skills that are seen as essential to quality outcomes of learning. Science is the first of the STEM subjects to be introduced under the new framework – in the second phase of changes commencing in September 2015. [Technology education is scheduled in the final phase of change, commencing in September 2017.] Detailed specifications for science will be developed and become available in autumn next year. The focus is on students developing both knowledge and skills: knowledge *of* science as well as knowledge *about* science; thinking skills, process skills and skills of inquiry and problem solving. While these are not exclusive to science education, they are developed and reinforced through science education. Through inquiry-based learning in science, students develop an understanding of the role of evidence in confirming (or rejecting) an hypothesis and as the basis for drawing and justifying conclusions. This will enable them to be more critically evaluative about evidence and argument presented by others (Roberts, R. and Gott R. (2007)[5]), rather than unquestioning and uncritical acceptance of what is presented. Students need to become thinking and reflective learners who will continuously strive to find meaning and truth, and we need them to do so.

The change at junior cycle will also encompass a re-envisioning of assessment, both in terms of the general changes in what assessment will look like in the new junior cycle and in the specific arrangements for assessment in science. Much research has been carried out into the purposes and processes of assessment. [We have assessment for learning, assessment of learning, standards-based assessment, outcomes-based assessment.] Perhaps a revisiting of its Latin origin might shed a little light: '*sedere'* means to 'sit beside' and '*assidere'* to make a judgement by sitting beside (and evaluating). The assessor and the one being assessed are partners in the process. Assessment in education can be thought of as having two main functions: to 'prove' learning and to 'improve' learning. It is both a tool for monitoring and evaluating progress and a means of measuring achievement. To be of benefit to the learner, both purposes need to be served – and sometimes at the same point in time. In addition, and perhaps more importantly, the role of assessment in the developments at junior cycle is one of *supporting learning*.

At senior cycle, the sciences are also being re-developed and, as with the junior cycle, attention is being paid to science education as a practical, investigative experience, as well as to its assessment. Given the much higher stakes involved and the different purposes which are served by senior-cycle education, the extent to which certification at Leaving Certificate relies on

[5] *Questioning the Evidence: research to assess an aspect of scientific literacy*. Proceedings of European Science Education Research Association (ESERA) conference, Malmo, Sweden, August 2007

summative assessment is reflected in the emerging proposals for the inclusion of a second assessment component which focuses on the practical nature of these subjects and how this can be both recognised and rewarded in a high-stakes examination environment.

As Minister Quinn said in his Foreword to the Framework for Junior Cycle published just over a year ago – but equally valid for all stages of education – the needs of our students are at the core of what we do in our efforts to improve the quality of their learning experiences and outcomes. We owe this to them now as much as we owe it to their, and our, futures. Education is about preparing them for a life outside of the school, for a world that doesn't yet exist. We must enable them to become the creative problem solvers who will both shape our futures and respond to the inevitable challenges which that uncertain future will present. Science and technology education can contribute significantly to cultivating that creativity; it requires creative thinking on our part.

Schools are not the only sites of learning. New opportunities to extend our knowledge through sharing, through questioning, through seeking meaningful answers, are all around us. We all have a stake, directly or indirectly, in ensuring that these opportunities are capitalised on. A report of the European Commission in 2007[6] recognised that inquiry-based science education is more likely to encourage relationships between stakeholders of both formal and informal education. It creates opportunities for involving others – firms, scientists, researchers, engineers, local associations, parents, … the list is endless – in a collaboration that results in a much-improved learning experience for our students and young people. As acknowledged in the NCCA document on 'Innovation and Change', achieving real change, change that is lasting, takes time. This is because most real change involves adopting changed practices, and thus letting go of old ones, informed by an increasingly clearer understanding of how effective learning occurs. It involves proving and improving, making mistakes and learning from them. There is an unattributed saying that 'a mistake in just evidence that someone tried to do something'. In the context of education, change also involves altering the culture of the learning environment, changing the way things are done; in other words, to come back to the theme of today's conference, changing the model!

[6] *Science Education Now: a renewed pedagogy for the future of Europe*. Luxembourg: Office for Official Publications of the European Communities, 2007

3) Presentation by Brian Coyle (as a parent)

Brian Coyle is the father of four children: Sophie (17) studying for the Leaving Certificate, Robert (15) in Transition Year, Peter (ca.11) in First Year of secondary school and James (ca. 9) is in Fifth Class in primary school. They represent a cross-section of the school-going population.

Brian is a management consultant. He started off in marketing in the UK. He then worked with a liqueur company which was more science related, especially chemistry. He later moved into roofing and cladding business and the related physics. Next he worked with a document management company which was more IT related. These different jobs highlighted for him the need for basic science literacy. (At school he had studied physics, chemistry and biology.)

His children's experience of school science has been quite varied.

Sophie (17) felt disengaged from school science. She had done very little science in primary school. In junior secondary school she was still disengaged but still got good grades. She is studying biology now because she will need to have studied a science subject for entry to college; she chose biology because she was told it was easier than chemistry of physics.

Robert (15) remembers doing some science in primary school. He did science in junior secondary school but is disengaged form science.

Why is this happening? Does science require more time with more emphasis on problem-solving and inquiry?

Peter's (11) experience of science in primary school seemed to focus on growing things and the school garden. He remembers a one-day science workshop (with 'dancing raisins'). He is interested in doing medicine and of the four children he seems to be the most interested in science.

He is now in first year and it would be sad if his interest wanes or is not encouraged as he progresses through secondary school.

The older children have had school projects on enterprise and entrepreneurship. However, their thoughts seem to focus on apps for mobile devices.

James (9) is interested in sport. He seems to have had very little science in school. (He remembers an experiment in which the shell of an egg was removed by vinegar.)

Why is there so little science being taught in primary school? The children seem to have seen some science demonstrations but have learned little from them.

It's a shame that children's curiosity is not developed and built upon.

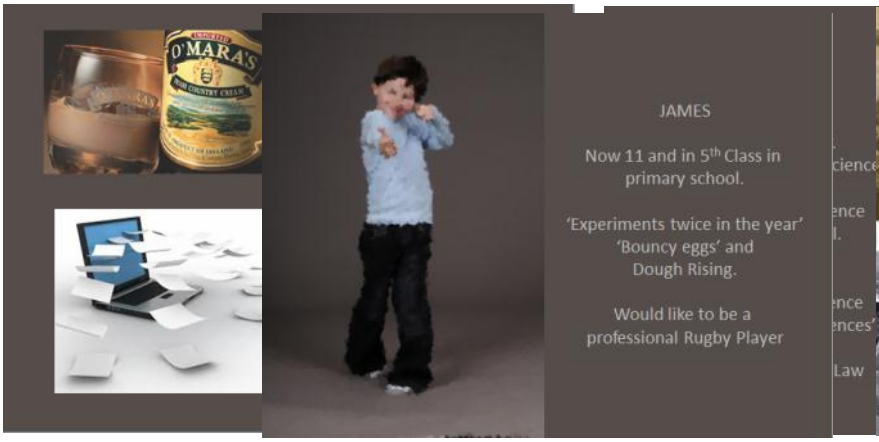
The future is one our children will create but we have to equip them with the necessary skills to create it.

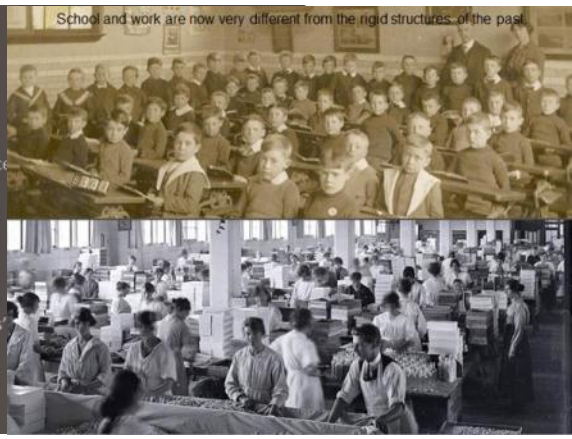
The Victorian 'factory model' of education prepared people for work in factories. This model of school still exists but the workplace is completely changed. People no longer stay in one job all their lives.

Patent filings give some indication of the level of creativity. On the table shown Ireland is in 16th place. We need more emphasis on problem-solving and creativity and on applications of science and technology. The alternative to economic growth is 'forced emigration'.

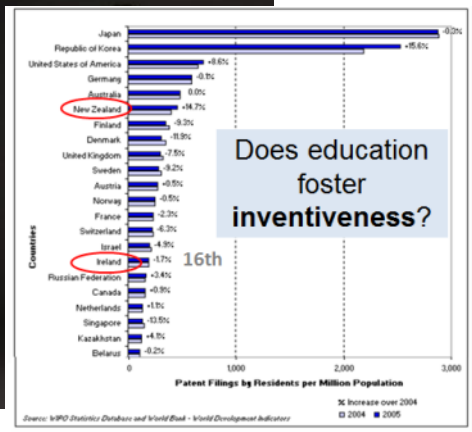
Inquiry-based learning should not be equated with looking up Google.


A Parent's Perspective
Brian Coyle
Parent
Note: We have blurred the images of the children in the these slides.


JAMES
Now 11 and in 5th Class in primary school.
'Experiments twice in the year'
'Bouncy eggs' and
Dough Rising.
Would like to be a professional Rugby Player


School and work are now very different from the rigid structures of the past.


The Facebook workplace
facebook


Does education foster inventiveness?
16th
Patent Filings by Residents per Million Population
% Increase over 2004
2004
2005

4) Address by Mr Bob Savage, Vice-President and General Manager, EMC Ireland Centre of Excellence

About me:

- Engineer by trade
- VP and General Manager at EMC Ireland
- On the board of EMC Ireland for the past 3 years
- Chair of Governing Body of CIT (Cork Institute of Technology) for past 2 years
- Board member US Chamber of Commerce
- Career and Life Planning

EMC Corporation: [with EMC for 25 years]

- US MNC based in Mass USA
- 22b Revenue for 2012
- 60000 employees
- From Storage to Cloud, Big data and Security – in our own transformation

EMC in Ireland:

- Established in 1988 (25 years ago this year) as EMC's manufacturing base in the then EEC
- 30 different business units, 44 nationalities and 26 languages
- 3000 people in Ireland

EMC Ireland as a Centre of Excellence: - not all plain sailing

- 2009 was a year of transformation.
- What is a COE (Centre of Excellence) – a definition that resonates with our people

My job description

- Build a unified team and committed leadership team
- Embrace change
- Fortify a culture of innovation
- Build strong relationships
- Connect everybody across the Organisation
- Be 'Employer of Choice' or GPTW ('Great Place To Work')
- Communicate in a single voice

The power of networks and connecting people:

What is happening in our business:

Cloud, mobile ICT, social media and Big Data

Our values: [Values guide behaviour]

Our People

- TCE (Total Customer Experience)
- Always innovating
- A better tomorrow – our focus in the community.

Our work in the primary education sector – CoderDojo (www.coderdojo.com)

The Establish Project – Innovation in Education

The key phrase for me: "decline in young people's interest for key science studies and mathematics".

Inquiry Based Learning

- Inquiry-based learning describes approaches to learning that are based on the investigation of questions, scenarios or problems – often assisted by a facilitator. Inquirers identify and research issues and questions to develop their knowledge or solutions.
- Field work, case studies, investigation, research, individual and group projects

What EMC looks for in our recruits

- Problem Solvers
- Team Players
- People who are results driven
- People who are show initiative
- People who are creative

The skills we need for EMC in Ireland to grow and prosper

- STEM – Mathematics is critical
- Science and Engineering
- Entrepreneurship
- Innovation
- Software Development and complete solutions development
- Be able to build relationship with customers

Cloud and Big Data

- An opportunity not just EMC but for Ireland
- The necessary ecosystem is here
- Cloud is transforming IT
- Big Data will transform business
- People with Big Data skills: statistician, mathematician, computer programmer, futurist and story teller.

Critical Areas for us in Second Level

- Great and passionate **mathematics** and **science** teachers
- World class career **guidance**
- Make **transition year** a year of innovation and entrepreneurship and technology focus
- Think to the future and be **visionary** – prepare students for **jobs that don't exist** yet. **This is where IBSE approach will be really beneficial.**
- Areas of emotional intelligence: self-awareness, and motivation.

EMC and many other companies will help with this and we are delighted to be involved with many schools in our own area.

So what do we do at present

- Host 8-10 local secondary school visits each year.
- We have worked with AG Education Services for the last 2 years on ***Science & Technology in Action*** program to create teaching resources in areas such as cloud and big data. In fact, we have gone out to some schools to deliver those lessons or work with teachers to help deliver them. [my big learning]
- EMC is a Silver Sponsor of BT Young Scientist Competition for the past number of years; this was an amazing experience for all of us. Les Gosnell commented: "It is clear to us the schools who put most into passionately fostering an innovative approach do best year after year."

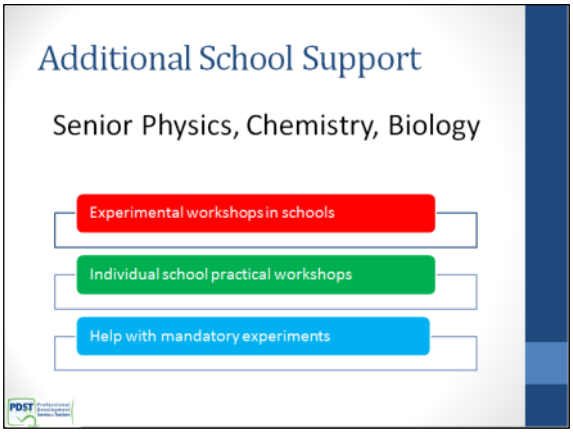
Establish is an example of innovation in education and I fully support it. As the proverb goes: "Tell me and I forget, show me and I remember, involve me and I understand". Inquiry not only leads to better understanding but it imparts skills and attitudes that permit students to seek answers, to solve problems and construct new knowledge. These are very important skills in today's workplace. Inquiry develops a **new mind-set** that can last a lifetime and **guide learning and creative thinking**.

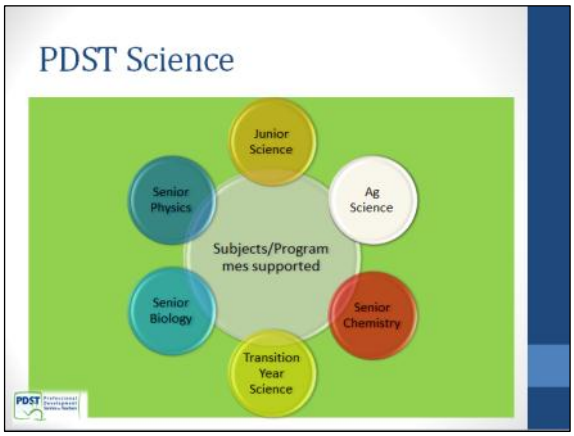
Many job interviews today are more than the traditional 30 minute conversations of the past; many include aptitude tests and problem solving. The skills gained from inquiry-based learning could be a differentiator for interview candidates.

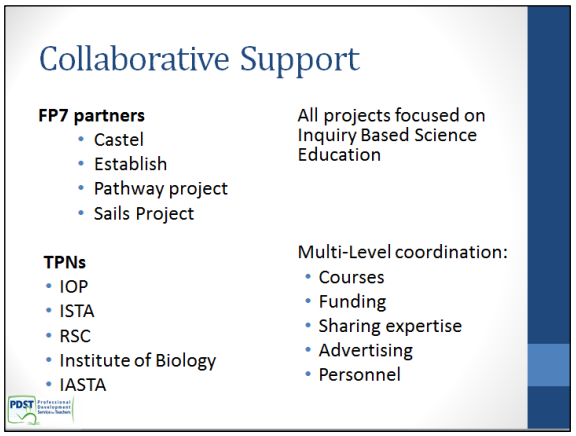
To Finish

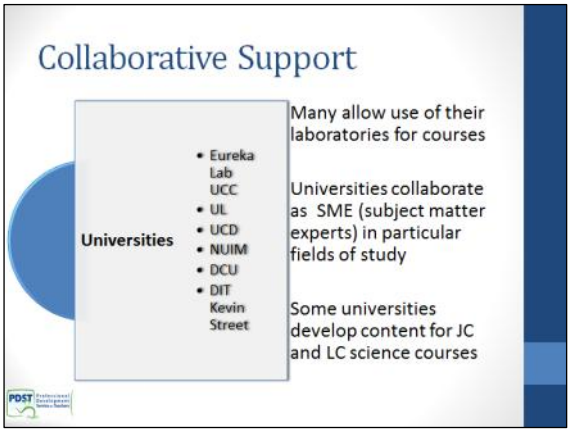
As industry leaders, we can't change everything — we know that. But we can **influence policy makers**; we can support teachers and parents; we can enable Guidance Counsellors. We can all make a **commitment** today to work with thought leaders like DCU and AG Education Services to change how Ireland and Europe teaches, and how students learn science and technology today so that it is a more rewarding and successful experience for everyone. EMC will do whatever it can to support this process.

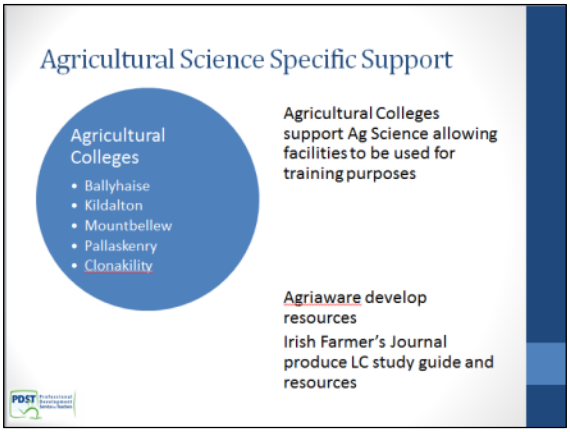
5) Presentation by Caroline McHale, Team Leader Post Primary at PDST (Professional Development Service for Teachers)



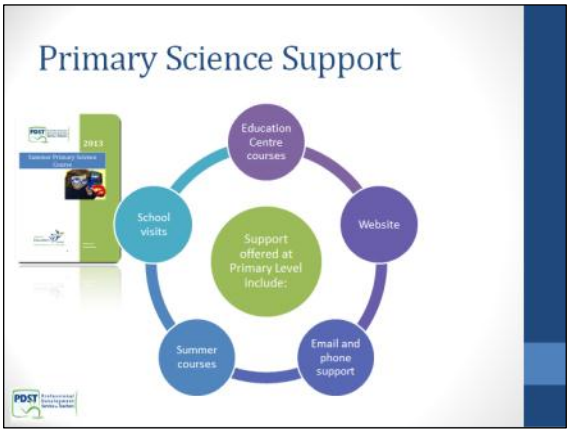





Collaborative Support
Universities
Eureka Lab UCC
UL
UCD
NUIM
DCU
DIT Kevin Street
Many allow use of their laboratories for courses
Universities collaborate as SME (subject matter experts) in particular fields of study
Some universities develop content for JC and LC science courses


Agricultural Science Specific Support
Agricultural Colleges
Ballyhaise
Kildalton
Mountbellew
Pallaskenry
Clonakility
Agricultural Colleges support Ag Science allowing facilities to be used for training purposes
Agriaware develop resources
Irish Farmer's Journal produce LC study guide and resources


Other organisations include:
Discover Science and Engineering
STEPS
Resources and Courses
Discover Sensors (no longer active)
STA (science and technology in action)
Resources
European Schoolnet
Remedi
Courses
Debates
RDS
Open discovery space
Science Week and talks
Resource sharing and hosting of our resources


Primary Science Support
Education Centre courses
Website
Email and phone support
Summer courses
School visits
Support offered at Primary Level include:


PDST Websites STEM
Agricultural Science
Applied Maths
Biology
Chemistry
Junior Science
Physics
T4 Technology subjects (Senior Cycle)
T4 Technology subjects (junior Cycle)


Thank you

6) Presentation by Matt Moran, Director, PharmaChemical Ireland

PCI employs about 24,000 people directly and about as many again indirectly.

About 60% of employees are have third level science qualifications from Certificate and Diploma to PhD level.

It was evident in the 1990s that fewer secondary school students were studying physics and chemistry for the Leaving Certificate. In response to this PCI appointed a Science Education Officer to see how the industry might promote the physical sciences. This was, and still is, very challenging. The fact that students might study chemistry in school does not mean that they will seek jobs in chemical industry.

Awareness of the information technology sector is much greater among young people; most of them now seem to have smartphones. The ICT sector is more real to them; people tend to use pharmaceuticals when they are unwell.

The best way for the pharmaceutical and chemical industry to raise students' awareness of the industry is through science teachers and parents and by getting people who work in the industry to act of ambassadors and to inform them of the available career opportunities.

Where did I get my interest in chemistry? As a child I got a chemistry set and became interested in the bangs and smells associated with various reactions. I believe it important for teachers to help students make the connection with the science (not just dry theory). This can be done through supporting proper practical teaching in the subject.

We support the Irish Science Teachers' Association through awards for teachers and through sponsorship of an annual national science quiz. I was Honorary President of the association for a number of years and it struck me that support for science teachers in secondary schools is still inadequate in Ireland. The Government should help through providing laboratory assistants and properly equipped laboratories. This would make it easier for teachers to bring science to the student. Resources are required to implement effective inquiry-based science education.

As an industry association we have just recently launched our science volunteers programme in collaboration with the Royal Society of Chemistry (RSC) and Science Foundation Ireland's Smart Futures Initiative. We have identified what we call 'science volunteers' in the industry and we are providing education support for them to enable them to go into the schools and interact directly with the students.

6) Presentation by Claire Scanlon, Science Teacher

At the height of the boom I moved from a good job in industry to teaching, to the surprise of many of my colleagues. However, I did always want to teach science and to encourage students to explore and appreciate the world around them – to find their 'inner nerd', embrace it and be proud of it.

Six of my students have come along to participate in and contribute to the conference today.

We try to encourage the sciences and applied sciences as much as possible. Our school has a practical focus and our students can study Engineering, Construction Studies and Agricultural Science as well as Biology, Chemistry and Physics.

We encourage our students to study these subjects because they improve their problem solving skills. They may find that a problem may have many solutions. Even a 'failed experiment' is still a result and may be an important learning opportunity.

In the assessment for Engineering, Construction Studies and Agricultural Science a significant proportion of the marks are allocated for the student's practical work. However in Biology, Chemistry and Physics a student's marks are completely determined by an end-of-course written examination. This kind of assessment may suit some students but it does not suit most of them. As Einstein said "Everybody is a genius. But if you judge a fish by its ability to climb a tree, it will live its whole life believing that it is stupid."

Assessment should give students the chance to show the skills that they have. Students with dyslexia or other learning difficulties are further disadvantaged by our narrow form of assessment.

Some of the students here today have participated in the Young Scientist competition and all of them have taken part in SciFest@School which in of great value to them.

Students often want to know about topics that are not on our current science syllabi. Science is constantly expanding and we need to keep our science relevant. One solution would be to include a 'special topic' every year or two; this might reduce the need for frequent changes to the syllabus. We need to move with the times.

While the Government would like to promote STEM education it has seriously reduced investment in science education. Some school have had to drop physics or chemistry from the school curriculum because of lack of resources.

While science teachers in Ireland have the same amount of teaching hours as teachers of say English or Mathematics, they also have to prepare solutions and experiments, maintain equipment, order chemicals and other consumables, ensure that equipment is returned to storage in working order etc. The lack of laboratory technicians places a serious extra burden on science teachers.

The 2003 revision of the Junior Certificate Science introduced specified practical work (called 'Coursework A') and practical investigative work (called 'Coursework B'). This welcome development encouraged students to carry out research, conduct experiments, gather and analyse data and write up reports. There is a need to include practical work in the assessment of the sciences at Leaving Certificate level.

There has been an increase in third level applications for science and applied science courses in recent years, especially Agricultural Science. Areas such as food processing, alternative energy and biofuels are becoming more important.

The very successful Young Scientist competition which has been running for fifty years hosts about 500 projects every year. A few years ago Sheila Porter started SciFest in order to give a much

greater number of students the chance to participate in a science fair and at little or no cost. (In 2013, more than 5,300 students took part in SciFest.). This encourages students to take a topic they are really interested in and to explore it in depth in their own time. An added advantage is that judging is done at regional venues and so students do not have to travel long distances.

Local industry can help, for example by providing prizes, refreshments, mentors or judges for the day and by encouraging schools in their area to take part in SciFest.

In our school last year we had 83 SciFest projects involving 155 students out of a student population of 550.

One big advantage of such involvement is that when the students are doing 'Coursework B' in Third Year they are much more aware of the steps involved.

Science is a powerful expression of two of the defining qualities of humans — our creativity and our curiosity. It is more than a collection of facts and figures but rather a remarkable way of thinking. It is the only method that can truly satisfy our inherent curiosity. It literally allows us to reach for the stars.

Summary of Students' Responses to Key Questions

What you like about science?

- Science gives us a **framework** of how our world works. Science enables us to out about the details that make up our **bigger picture** of the world.
- With knowledge of science I can look at an object and think about the kind of **relationship** it has with all of the other objects around it.
- Science teaches me to demand **evidence** and **think critically**.
- I love science; it satisfies my **thirst for knowledge**.
- I like doing **experiments**. I also like the **theory**. I like finding out how things work or **why things are the way they are**.
- I like to be able to figure out the **unknown**, and science allows me to do that.
- I like how science relates to **everyday life**, and has many practical **applications**, but can also be **incredibly interesting**.

When you are doing a project, how do you decide what to inquire into?

- I look at my interests and what I feel I will be most interested in. **If I enjoy it I will work hard at it**.
- I choose something I am interested in so it makes it easier and **more fun to discover** more things on the topic.
- I think about what interests me, and what I think may be difficult to explain, then **break it down into simpler steps**.

How do you learn to work in a team?

- When working in a team you need to be aware of the **skills of your team mates**; you can learn a lot from them.
- **Communication** is important in learning how to work with your team.
- In a team you can **divide out the work** or let people choose parts they are interested in.
- When we are doing projects in a group I like to work with people who can bring something to the project. It's a lot like football; we all work off **each other's strong points**.
- Working in a team **can be hard** because everybody has their own opinions, but over time **you learn to get along** and to listen to everybody's opinions.

Will you continue to study technical subjects when you leave school?

- There are many areas of science that I would love to study but my first choice would be medicine.
- I have two main ideas of what I want to study. I would like to be a **woodwork** teacher or **metalwork** teacher.
- I do hope I will continue to study technical subjects as **I enjoy learning and doing technical work**.
- Yes, I would love to study technical subjects after I leave school. (× 3)

What area would you like to work in when you have finished your formal education?

- I would like to work in **medicine** when I finish my formal education. (× 3)
- I would like to work in **education**.
- I would like to do something involving science or maths.
- I would like to work with computers or computer programming. (× 2)

Are you familiar with the term Inquiry Based Learning?

- Yes I am familiar with the term Inquiry based learning.
- It's when the teacher gives the students a **question** and the students think about the **different answers** themselves. So they don't just learn from the book, but from each other.
- It means that you learn by **asking a question** on something you don't know about and you learn by **figuring out the answer**.
- I believe it to be a **more efficient method of learning**, as you are more likely to remember the results you discovered than those you read in a book.
- No, I am not familiar with inquiry based learning. (×1)

If so, do you think it is effective and why?

- I think that inquiry-based learning is very effective in both teaching a person **to think independently** and also **learn the material** that one requires to know. When a person enquires about something, they are more likely to learn it better because they have **answered their own questions** and not learned off something that they don't understand.
- Yes I do think it is effective. I think it **should be used more** because it allows students to learn in a more beneficial way. It also allows them to know what questions to ask in the future and **how to look for the answers**.

Why did you choose to do the three science subjects? (one student)

- I chose **Physics, Chemistry and Biology** in school because I love science and with three science subjects I have science every day. Because the sciences are inter-related studying all three of them gives me a greater understanding of how the world works; it feels **complete** just like science should be.

Why did you choose to do Engineering and Agricultural Science? (one student)

- Personally I learn well in practical subjects. I find Engineering and Agricultural Science are very enjoyable.

Some of the posters used at the conference

ESTABLISH Consortium

The ESTABLISH consortium of over 60 partners from 11 European countries have worked together on this four year project to encourage and promote the more widespread use of Inquiry-Based Science Education (IBSE) in second level.

Country	Institution
IRELAND	Dublin City University (DCU) - Coordinator
	AG Education Services (AGES)
NETHERLANDS	Centre for Microcomputer Applications (CMA)
CYPRUS	Frederick University (FU)
SWEDEN	Umeå Universitet (UmU)
	Malmö Universitet (MaU)
POLAND	Jagiellonian University in Krakow (JU)
CZECH REPUBLIC	Charles University (CUNI)
MALTA	Across Limits (AL)
SLOVAKIA	Univerzita Pavla Jozefa Šafárika v Košiciach (UPJS)
ESTONIA	Tartu Ulikool (UTARTU)
ITALY	Università degli Studi di Palermo (UNIPA)
GERMANY	Leibniz Institut für die Pädagogik der Naturwissenschaften und Mathematik an der Universität Kiel (IPN)
	Martin-Luther-Universität Halle-Wittenberg (MLU)

ESTABLISH is committed to being an open-access project. Further information together with educational and training materials from the project are available on our websites:

http://www.establish-fp7.eu

http://ibse.establish-fp7.eu

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Establish

European Science and Technology in Action: Building Links with Industry, Schools and Police

Outcomes

The ESTABLISH project has received funding from the European Union's Seventh Framework Programme [FP7/2007-2013] under grant agreement n° 244749

WHAT IS INQUIRY?

The ESTABLISH project has received funding from the European Union's Seventh Framework Programme [FP7/2007-2013] under grant agreement no 244749. The views and opinions reflect those of the authors and the European Union is not liable for any use of the information that may be contained therein.

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Photo Gallery

Minister of State, Sean Sherlock, Department of Enterprise, Jobs and Innovation and Department of Education and Skills with responsibility for Research

Mr Bob Savage

Vice-President and General Manager

EMC Ireland Centre of Excellence

Louise Bindel presenting feedback

Jack Holbrook presenting feedback

Student interviews

Bob Savage, Martin Lindner and Miia Rannikmae

Bob Savage, Brian Mooney, Dr Eilish Mc Loughlin, Dr Leos Dvorak, Caroline McHale

Having a break

Some feedback received since the Conference

'*Bringing together students, teachers, industry leaders and policy makers to examine and sharer their views on science teaching and learning was, in itself a model exercise in inquiry based education.*'

'*It was very interesting to have a range of stakeholders in the room together and, especially, to see the commonality of interest between teachers and parents. There was also a sense of the mismatch between the speed wanted by teachers and parents and the actual pace of change at institutional level which seemed slow in comparison, There was a that much is happening on the ground and that there need to be a way of harnessing this and the conference was an excellent beginning*.'

'*If we can convey the enthusiasm which was generated by the conference to the teachers and parents then the excitement of science and technology will be passed on to the children. Teaching facts and figures is not enough; the inculcation of the scientific method is required - developing enquiring minds, enabling children to question unfamiliar phenomena, devise experiments, reach and defend conclusions:*
that should be our educational goal.'

Germany (Martin Luther University Halle-Wittenberg)

Description of the National Context and Motivation for Engagement

The national structure of education in Germany is very much bound to the 16 states ("Länder"). On this background, any national strategy is on the one hand observed by all, on the other hand limited by the engagement of persons from the state administration, who are able and willing to participate.

Good experiences were made during the period of the SINUS programme, which started in 1998 and last until 2007. SINUS was a collaborative program to change mathematics and science lessons by collaboration between teachers, schools, teacher educators and administration. It involved more than 2000 schools in Germany. The work was organized in local or regional working groups collaborating for at least 2 years on practical questions of classroom teaching.

After a new administrative regulation, no more national programs were launched after that date. However, the 10 years of national collaboration created an informal network which lasts till today. Persons involved in SINUS activities are driving forces of change in science education with a special focus on STEM. IBSE was the underlying understanding of Science Education in SINUS.

The very positive results of SINUS influenced on national level the release of national standards in Mathematics and the Sciences in 2004. On international level, SINUS became a model for many FP7 programs, after being mentioned as one example in the Rocard report.

A few offspring of SINUS could also be found in the national programs "Chemistry in Context", "Physics in Context" and "Biology in Context." All these lead to a new "culture" of teaching. One of the characteristics of these programs (as well as SINUS) was the involvement of teachers, researchers and persons from school administration in the working teams. We spoke of "symbiotic implementation," because everyone in these teams could profit from the others´ contribution.

This change of culture changed also the way in which modern approaches (like IBSE) were implemented in school curricula. A good example is the implementation of the standards: it was not done by order, but by an offer for working groups, teams and professional development courses. A lot was delegated to school level. The teachers did not only warmly welcome this work: it was a new task, which was uneasy to do at the beginning. But along with a strengthening of collaboration into schools´ subject groups, the teachers learned to deal with the new "freedom" and organized their own curricula.

This background helped a lot to deliver ideas and materials from ESTABLISH. As IPN was responsible for SINUS and the programs "Chemistry, Physics, Biology in context," the network already existed. On national conferences, in workshops or in meetings, the ESTABLISH approach could easily been distributed.

During the ESTABLISH project, members of the regional group from MLU joined several conferences on national level, which dealt with IBSE orientated STEM-Education. These include conferences organized by a big German publisher of school books (KlettVerlag, Stuttgart), conferences of funding organisations (private and public), and conferences of chambers of commerce and industry. By these activities, an informal network was built including many persons, who were invited to the regional conference in November 2013. This conference was held in the south-eastern State Saxoy-Anhalt.

Structure of Engagement

A **conference** was selected as the mode for engagement in this case-study. The conference was held on two days (21./22. November 2013) at the Martin-Luther-University in Halle. This gave the opportunity to invite persons from organisations in greater distance. The name of the conference was "MINT-Forum Mitteldeutschland" (STEM-Forum in Central Germany). This indicates a more open conference, like an ancient forum, the market place of a town, it allows to join the central discussion or be a more remote observer of things going on.

The central goal was to create an opportunity to build a regional network in Science Education between educational institutions, companies and funding agencies. The program included various formats to enable exchange between the participants:

- lectures
- open podium discussion
- gallery-walk
- workshops
- world-café

Invitations were sent to several people in organisations dealing with Science and Maths Education, in companies, in chambers of commerce and in funding agencies. We had 68 participants, of which the majority came from Science education (including Technical, Maths and Geography-Education). 10 Persons came from organizations, like networks for vocational trainings, funding agencies, chambers and Ministry of Education. These persons are seen as very influential on regional and on national level. Only three persons came from companies.

Table 1: Distribution of attendance at MLU Conference

Science Educators	Teachers (pre- and in-service)	Chamber of commerce/ Funding organisation/ Professional Networkers
20	33	15

The speakers represented various programs running on school level, local level, state level or national level. One presentation was on media and STEM, focusing on radio as STEM-fostering media. The opening lecture was on a national study on the mathematical competencies of Germans.

Summary of Engagement

The invitation was everywhere welcome and we got many positive responds on them. Many people who could not manage to come wanted to be included in further information, but nearly everyone responded by: "this is really an important initiative," "this should have been organized much earlier," "in our region conferences like this are really necessary," and so on.

The main result was the establishment of a network. This network is based on personal contacts, but is supported by electronic media. A new website is under construction, which combines persons and organizations. (is it still under construction?)

The main finding in the open plenary discussion was the overcome of hindering facts of teachers realizing IBSE -oriented STEM teaching. The in-service-teachers contributed by good experience of

STEM projects, like being supported by companies, collaborate with the university, being supported by the principal etc.

Conclusion and Next Steps

Through the forum, a number of actions were agreed to foster collaborations between university, schools and companies:

1. The leader was invited to a regional forum organized by the national board of chambers of commerce to improve collaboration between schools, companies and universities, especially in the field of vocational training.
2. A second improvement was the collaboration of university departments with a privately organized summer academy on Science.
3. And, as a third consequence, university students will cooperate with this summer academy to offer teaching/learning modules in IBSE way.
4. The fourth development will be a research on the effects of activities of companies. These research activities will be designed by teacher students during their project module and guided by doctorate students. It is expected to have a closer look to the quality of the offers of companies.
5. The next forum will be organized in March 2015.
6. A small group of professional networkers will start their search for funding organizations by March 2014.

The key messages that emerged from this event were: the region waited for an initiative like this. Many actors in STEM education felt isolated. In their daily work, actors have no opportunity to network, to communicate, to learn from each other or to get connections on national or international level.

A university is an adequate organization to be a crystallisation point for a STEM network involving all stakeholders, as it does not have “personal” interest. The scientific orientation of universities is seen as an important factor for independence.

The following actions were offered to anyone who is looking to implement changes, such as, inquiry-based science teaching (or any other type of change to science teaching and learning).

1. Influential persons are not attracted by long term invitation, but by interesting questions. So it might be possible to invite these persons for short term involvement.
2. It is not necessary (and of course not possible) to invite all stakeholders or even persons from all relevant organizations. Usually these persons know each other or at least know the strategies, the results and also crucial points of the national/regional STEM activities. This means, a few persons could give sufficient information on the process.
3. On the other hand, our information will spread easily in the existing networks.
4. As all networks, STEM-networks have “hubs,” persons or organisations with a lot of information, with close insight into the crucial processes going on in a region, a nation, or in outstanding companies. It would be helpful, to identify these hubs (either persons or organizations) and involve them into the process.

5. Be flexible in your strategy. If you cannot reach the most important people, ask them to send at the conference a substitute or any person being able to inform you and take the information along from there. Sometimes these persons are even more influential, because they are closer involved into the practical work.
6. Numbers do not count, even if it seems more rewarding to have a "crowd." The results of a discussion with 5 or 7 persons are sometimes much more powerful.
7. And, last but not least: a network is not an abstract system. It is based on personal contact. So you need a lot of time to meet people, speak to them and keep the contact through mails, newsletters and upcoming events.

Further Details of Engagement Event in Germany

Website: http://www.biodidaktik.uni-halle.de/mint_forum_2013/

Program MINT Forum Mitteldeutschland

Thursday, 21. November 2013		**Friday, 22. November 2013**	
Time	**Program**	**Time**	**Program**
		09:00 – 10:00	Plenary lecture IIEva Viehoff, National Pact for Women in STEM: "Women in STEM careers"
		10:00 – 10:30	Coffee Break
until 13.00	Arrival	10:30 – 12:00	Workshops
13:00 – 13.30	Welcome and Overview (Prof. Dr. Martin Lindner)	12:00 – 13:00	Lunch (Cafeteria)
13.30 – 14:30	Lecture I und Discussion (Prof. U. Kortenkamp, Uni Halle) Mathematical Competencies of Germans	13:00 – 14:30	Lectures
14.30 - 15.00	Coffee-Break	14:30 – 14:45	Coffee-Break
15.00 – 17.00	Open Plenary on STEM in Central Germany	14:45 - 15:30	World – Café
17:00 – 18:30	Gallery – Walk,	15.30- 16.30	Summary
17:30 – 19:00	Dinner (from 18:00 h Dinner parallel to the walk)		Coffee and Departure
19.00 – 20.00	Lecture: STEM and Media		

Topics of the Gallery Walk (Posters)

Christian Kubat + Louise Bindel (University of Halle)	*Science Camp der Uni-Halle: Theorie, Experimente und Ergebnisseaus 2013* Science Camps of the University of Halle: Theory, Program and Results from the 2013 Camps
Dr. GerdRiedl (University of Halle / Science and Maths Teachers Organization)	*SchülerlaborHaENTeL* Students´ Lab HaENTeL (Of the Universtiy Halle)
Dr. GerdRiedl	*MNU Landesverband S-A* Science and Maths Teachers Organization in Saxoy-Anhalt
HannesKönig SchülerinstitutfürTechnik und angewandteInformatikSITI e.V	*Schülerfirmenprodukten/Technik-Projekten* Students´ companies: Technical Design
Frank Müller (DomgymnasiumNaumburg)	*PlantVitalVorstellung* Collaboration between Companies and School
Stephan Domschke	ESTABLISH
Astrid Ilgenstein (University of Magdeburg)	*Blitzlichter MINT Magdeburg* Flashlights on STEM at Magdeburg
Prof. Dr. Elke Hartmann (ZentrumfürIngeneiurwissenschaften, Martin-Luther-Universität)	*DidaktischesKonzept des SalineTechnikums* Pedagogical Concept of the SalineTechnikum Academy for Students
Prof. Dr. Elke Hartmann	*KleineIngenieurebaueneinPrüfgerät* Little Engineers construct a Testinstrument
Elke Arnold (ProjektleiterinKinderstadt)	*Vorstellung der Kinderstadt und ihrer Highlights* Introduction to the Project „Kinderstadt“ (Childrens´ Town)
Marion Kallas (NetzwerkaußerschulischeLernorte - Schülerlabore Sachsen-Anhalt)	*Wissenschaftfasziniert!* *Na LoS! NetzwerkaußerschulischeLernorte - Schülerlabore Sachsen-Anhalt* Fascination Sciences: NaLos!, the network of Student Labs in Saxoy-Anhalt
Martin Talanow (Elisabeth-Gymnasium Halle)	*MINT in der Schulpraxis: NaturwissenschaftlichvernetzterUnterricht am Elisabeth-Gymnasium Halle* STEM at a School: How to combine Subjects in Science Teaching
Susann Loelke (Uni Halle)	*Vorstellung der Lernsoftware PRONAS* Introduction to the Online Based Learning Software PRONAS

Members of the STEM-Talk

PD Dr.GerdRiedl – MLU Didaktik der Physik and President of the Science and Maths Teachers Organisation

Albrecht Lattermann – BeauftragterfürBegabtenförderung des KM –Ministry of Education

Dr. Matthias Pötter – Professional Development for Science Teachers in Saxony-Anhalt

Dr. Ulrich Müller – Principal of the Cantor-Gymnasiums, Halle

Stephan Domschke – Coordinator of the EU –Projektes ESTABLISH

Martin Talanow – Teacherat the Elisabeth-Gymnasium Halle

KatrinHinze –Network School-Vocational Training Dessau/Roßlau

Moderation: Prof.Dr. Martin Lindner – Didaktik der Biologie/Geographie MLU

Topics of the Lectures

Prof. U. Kortenkamp, (Uni Halle)	*BürgerkompetenzRechnen - gibtes die?* Mathematical Competencies of Germans
Eva Viehoff, (National Pact for Women in STEM)	*NationalerPaktfür Frauen in MINT-Berufen* Women in STEM careers
Dr. GerdRiedl (University of Halle / Science and Maths Teachers Organization)	*Der Förderverein MNU. Ziele&BilanzeneinerGemeinschaft von MINT-Akteuren und möglicheAktivitäten in einemregionalenNetzwerk* The Teachers´ Organisation MNU: Topics of an Organization in STEM and Options for a regional Network
Dr. HannesKönigSchülerinstitutfürTechnik und angewandteInformatik SITI e.V	*"WennLernennachUnterrichtsschlussauchnochSpaßmacht" - MittechnologieorientiertenSchülerfirmenwirtschaftlichhandeln und technischesInteressewecken*. “When learnig is fascinating after School” – Technology Students´ Companies work in Technology and Economy
Frank Müller (DomgymnasiumNaumburg)	*ZurLage der Naturwissenschaften in einem Gymnasium des ländlichenRaumes - Lage, Ursachen, Perspektiven* The situation of Science Teaching in a rural School
Kurt Lausch (TGZ Bitterfeld-Wolfen GmbH)	*Das Schülerlabor „ABI Lab“ des TGZ Bitterfeld-Wolfen* The Stundents´ Lab at the Technology Founder Center in Bitterfeld
Prof. Dr. Wolfram HergertInstitutfürPhysik, Martin-Luther-Universität	*HaSP - HallesSchülerlaborfürPhysik: Enwicklung - Ziele – Nutzungsformen* The Students´ Lab in Halle for Physics
Prof. Dr. Elke Hartmann ZentrumfürIngenieurwissenschaften, Martin-Luther-Universität	*Das SalineTechnikum - NetzwerkerzwischenSchule und Unternehmen in SachentechnischerBildung* The Saline Academy for Students: an opportunity to network between Schools and Company on Technical Education

Topics of the Workshops

Linda Vieback (University of Magdeburg)	*ego.-MINT - TechnikorientierteGründungssensibilisierung an allgemein- und berufsbildendenSchulen in Sachsen-Anhalt* ego—MINT – Positive Attitudes towards Technology Start-Ups at Schools
Stefanie Hauffe(HANDS on TECHNOLOGY e.V.)	Robotikprogramm FIRST LEGO League
Sandra Heidemann(Deutsche Telekom Stiftung)	Junior-Ingenieur-Akademie
Renate Dorn (Sekundarschule Saale-Elster-Auen)	*Netzwerk der Sekundarschule "Saale-Elster-Auen" SchkopauzurFörderung des Berufsnachwuchses in MINT-Berufen.* Network of a School to foster STEM Careers
Stephan Domschke (University of Halle)	*ForschendesLernen in MINT* IBSE in STEM-Teaching
Christian Kubat + Louise Bindel (Uni Halle)	*Science Camp der Uni-Halle: Theorie, Experimente und Ergebnisseaus 2013* Science Camps of the University of Halle: Theory, Program and Results from the 2013 Camps

Topics of the World Café Tables

1. Out of the classroom Acitivities (Labs, Camps, etc.)
2. Universities and Applied Universities
3. Acitivities for In-Service Teachers
4. Acitvities with Students at Schools

Photo Gallery

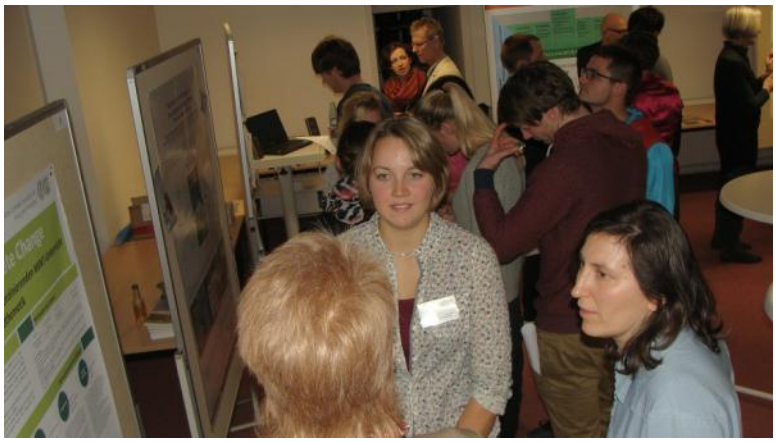

Gallery Walk

Plenary on Media

Gallery Walk

Coffee Break

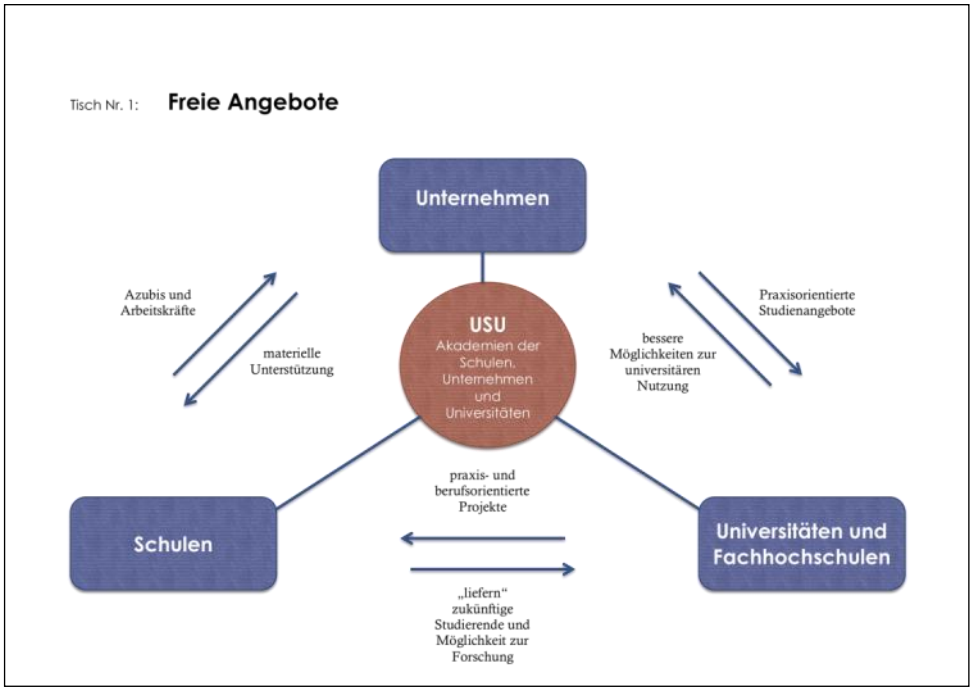

Open Plenary Discussion


Gallery Walk


Plenum


Gallery Walk

Example of Results of the World-Café – Table for Students´ Labs



Poland (Jagiellonian University)

Description of the National Context and Motivation for Engagement

Collaboration and communications between particular stakeholders is usually manifested in Poland in the following forms:

1. Top-down and unidirectional communication: Ministry -> the Central Examination Board ->school superintendent->school head master->teacher. Public consultations are mandatory, but usually they are very superficial. Teachers are members of the body called the school board, and, this way, they take part in many decision-making processes.
2. Nearly unidirectional communication: Educational researchers and teachers educator -> teacher relies mainly on the organization of training courses. Any scientific journal, which publishes educational research results in Polish, and can be used by teacher at schools, does not exist in Poland.
3. Industry is uninterested in cooperation with the educational system, and even Polish subsidiaries/branches of international companies that publish educational materials on their web pages, organize visits, workshops for students and teachers, and support schools in terms of equipment in the countries of Western Europe, do not undertake this type of activity in Poland.
4. Generally speaking lack of nationwide, or even regional organization, gathering parents, apart from very specific ones, for example, associated with a specific type of children'sdisability.
5. Due to the specificity of Polish law and organization of higher education, teacher can start work in school without visiting any industrial plant (when a person obtained the degree in pedagogical studies) or after 1-month practice/internship in the course of study (when graduated from, e.g., chemistry), only a small number of teachers start their work in school with longer experience in work outside the educational system.

Thus, while we have identified a number of communication channels, because of their isolation from one another, are inefficient in supporting changes in the educational system, which the implementation of IBSE would entail. Thus, a **forum** where teachers could meet on an equal footing with teacher educators and educational researchers was formed. In addition policy makers were engaged in the process of publishing books for teachers to promote IBSE (the Ministry of Education) and also to recruit teachers to participate in the ESTABLISH Teacher Education Programme (Department of Education of the Municipal Office of Krakow).

Structure of Engagements

The forum was structured following the meetings of two organizations: the Chemical Education Division of the Polish Chemical Society and the Polish Association of Science Teachers.

Additional information related to TEP

The process of building up the professional/educational relationship was to both develop the units by strengthening the Industrial Content Knowledge, as well as hosting the event

Due to lack of previous cooperation and lack of knowledge about IBSE in Poland, we decided to approach in the framework of ESTABLISH project as many various types of stakeholders as possible. We considered to engage participants in that cooperation, in such way that required:

1. To send general information about the project to a head of particular institution and a person responsible in such institution for public relation or cooperation

2. To mention and jusify a reason why particular institution has been chosen to establish cooperation
3. To send to chosen representatives personal invitations to cooperate
4. To discuss and decide the most suitable way of cooperation

Summary of Engagement

Engaging with Policy Makers

We began the cooperation with the **Ministry of Education**, at first by sending them information about the project, promotional leaflets, etc. Then, we extended correspondence by asking questions about things necessary for the implementation of the first deliverables, describing the status of IBSE application in Poland. Two books released within the project were also sent to the Ministry, and the Ministry representative was invited to one of our conferences with teachers. The process was similar with the of another central institution - the Educational Research Institute (ERI). Initially, the contact was limited to sending information from our site, but after mutual visits and establishing of more formal cooperation, the representative of (ERI) gave a lecture on the assessment of selected skills within the winter school of the ESTABLISH project in February 2013.

As a result of personal visits to the Małopolska Education Superindendence (Kuratorium) and the **Department of Education of the Municipal Office of Krakow**, we received permission to use their information channels to promote the awareness of the project among teachers. Unfortunately, it turned out that both of the above-mentioned institutions were not particularly interested and competent in terms of changes in curricula in the field of natural sciences. Therefore, we started cooperation with the educational advisor of the Municipal Office of Krakow from the field of chemistry and the biology advisor employed by the Malopolska Teacher Training Centre. In the case of chemistry, thanks to this cooperation, we carried out workshops on the development of inquiry skills within the trainings for teachers organized by the Municipal Office of Krakow, and the above-mentioned biologist reviewed the Disability unit. In addition, we sent to those educational advisors in major Polish cities an invitation for the summer school for teachers. Advisors from Wroclaw and Gliwice decided to participate in this event. As a result, a cascade system was developed – on the basis of the materials of the ESTABLISH project, received from us and tested during the summer school, these advisors carried out their own trainings for teachers from their regions, sharing their experience, inter alia, during the SMEC conference in Dublin in 2013.

Because IBSE had not been known in Poland ina form adopted by the ESTABLISH project (there is even no equivalent of this term in Polish language), JU team took extensive actions in order to identify individuals or institutions dealing with IBSE in Poland. This way, we found a biology education advisor from Warsaw, who was running a pilot project in her town funded by AMGEN , in collaboration with the University of Warsaw. Exchange of experiences was very important. Dr. Iwona Maciejowska presented the solutions of the ESTABLISH project during the conference summarizing that project and Urszula Poziomek (biology education advisor) reviewed one out of two guidebooks for teachers developed within the ESTABLISH project. In a similar way, the representative of the project Fibonnaci and SECURE Dr. Dagmara Sokołowska from the Faculty of Physics, Astronomy and Computer Science JU, were found. Product of one of those projects - self-assessment sheet for teachers in terms of the use of IBSE was also used in the winter school of the ESTABLISH project.

Collaboration with industry was a big challenge for us from the beginning. Referring classes to the industry or the context of everyday life as well as examination and introduction of the technological process or a given product in the curriculum were the smallest problems, as this topic dominates in the chemistry curriculum for the first year of general education upper-

secondary school, covering such issues as food chemistry, drugs, cosmetics. Similarly, in the curriculum for the level of lower secondary school it is recommended to introduce new knowledge on the basis of students' everyday experiences. The biggest problem is in later years of upper-secondary school, where learning is rather of a purely academic nature. Therefore, during the preparation of the Photochemistry unit, prepared mainly for extended chemistry courses, special emphasis was put on indications for application of the discussed topics.

The model covering the teachers' visits in the plants of widely understood industry was chosen to be developed and introduced in our case. It was implemented during the three schools for teacher-participants in the project. The classes began with a discussion about the methods of preparing students for visits in the industry and the organization of such scientific excursions. Teachers were invited based on their own experience and on our previous publication. Then, following the developed guidelines, the stage of preparation of such visit started, through familiarizing with the information published on the websites of the particular company and preparation of a list of questions that visitors would like to ask.

Because for the majority of cases, a group of teachers visited various places, such trips were followed by a summary session. Teachers shared their impressions in a structured discussion by answering the following questions:

- What did they see, what did they experience, did they find answers to the questions set before the visit?
- Did the earlier image of the industry appear to be consistent with reality?
- To what rate is the particular industrial plant suitable for trip with students in terms of the subject matter, "visibility" and safety?

Taking into account the extension of the list of stakeholders including educational publishers proposed in the ESTABLISH project, we have established cooperation with the ZamKor Publishing house. Thanks to this, in their guide for teachers on the teaching of chemistry during the first year of upper-secondary school, a chapter concerning the possibilities of developing inquiry skills during the implementation of nine (recommended at this stage) chemistry experiments was included. On the other hand, during the first summer school, a representative of the publishing house conducted classes for teachers on the project method.

Forum – Engaging Teachers with other Stakeholders

The meeting of stakeholders was held on 22 November 2013. The meeting was attended by nearly 30 representatives of various interest groups that have or could have an impact on the system of education in Poland identified at the first phase of ESATBLISH project. These included:

- representatives of industrial plants, which were visited by teachers during the summer and winter schools (Water Treatment Plant in Dłubnia, Coca-Cola company in Niepołomice),
- government (the Municipal Office of Krakow),
- pedagogues and teacher educators of physics, biology and chemistry from the Jagiellonian University, the AGH (University of Science and Technology in Krakow), the Pedagogical University of Krakow, and the University of Wroclaw,
- practicing chemistry, physics and biology teachers
- as well as educational advisers from Krakow and Wroclaw.

The forum consisted of a number of presentations from researchers in science teacher education, policy makers who govern teacher education, followed by a discussion forum and perusal of teachers' posters, which described scenarios of IBSE and problem-based lessons/classes.

The meeting began with the presentation on the objectives and outcomes of the ESTABLISH project, in particular, the analysis to what extent IBSE is implemented in the countries from which

the projects partners come from, the results of studies of factors favoring or hindering introducing changes in education and the need for cooperation in this the field (including experiences in cooperation between education and industry). The development process of ESTABLISH's teacher education programme with results of studies on its effectiveness in the case of the Polish teaching staff was also presented.

The next speaker was the Deputy Mayor of Krakow for Education, who discussed the system of supporting teachers in the city and possibilities of cooperation with universities in this field.

Then, there was a discussion on the basis of the questions addressed to the participants:

1. How to introduce innovation to education and further trainings of teachers?

2. Who and how could participate in this process?

- In the field of pre-service (according to Polish law- universities),
- in-service teacher trainings: training centers? Educational advisors? universities? publishers?,

Conclusion and Next Steps

The conclusions drawn from the presentations and discussions should be used for the development and guidance of further cooperation between the particular institutions, as well as for more effective introduction of innovations in education and further training of natural science teachers. In these conclusions, the following issues were included in terms of:

1. **Education of future teachers (pre-service teacher training)**
   - Cooperation of university-wide units of a type "pedagogical centre" with subject education departments is essential for the consistence of the process of future teachers' preparation.
   - Education of future teachers at universities should include a formation element - shaping attitudes.
   - The process of education of future teachers should indicate, inter alia, the need of teachers work in teams consisted of teachers of particular subject and in teams consisted of teachers of various subjects
2. **In-service teacher training**
   - Further training of teachers cannot consist of detached, one-time, often conducted by commercial companies in a schematic way boring trainings, but, instead, it should constitute a systematic, comprehensive and long-term action based on the activity of the participants and their reflection on their own experience.
   - The work educational advisers cannot be replaced by a set of trainings; it is required to develop a new formula of systematic support of teachers.
   - Universities should play a greater role in teachers training
   - In order to effectively introduce innovations to education, the following elements are necessary: conviction of the school principal/headmasters, teachers and parents to proposed changes (positive attitude), adequate knowledge, and above all, well-developed skills in this field of the teaching staff development and systematic support (not just teaching materials, but also easily available consultations, forum for exchange of experiences, *so-called* community of practice).
   - In the process of teachers preparation for introducing proposed in the core curriculum, the learning "context" (indicating the relationships of the acquired knowledge with students' everyday life) and for the implementation of one of the basic principles of

teaching "combining theory and practice," an important role is played by the environment outside the school, including, e.g., industry, agriculture, health institutions and environmental protection organizations. In order to enable teachers' enthusiastic presentation of the application of, for example, chemistry in human life, they should be personally acquainted with it during education (industrial practices/internship during studies) and further trainings (study visits: real or virtual).

- Postgraduate studies focused on providing the students with subject knowledge should cover to higher extent issues connected with the methodology of teaching particular subject, especially in the case of integrated subject, such as 'science' in elementary school and upper-secondary school.

3. Introduction of IBSE

- Before the teachers can use an inquiry-based teaching approach in the subjects from the field of natural sciences, they should gain personal experience in the methodology of research/inquiry in life sciences in the course of preparation for the profession during studies 'pre-srevice teacher training' (e.g., research project) or further training.
- Special attention should be paid to the proper understanding of the idea of IBSE, including, among others, prevention of the replacement of teaching through scientific inquiry (students experiments: formulating the research questions and hypotheses by students, planning of the experiments, the determination of the dependent, independent and controlled variables, standardization of the measurement conditions, discussion of errors, presentation and critical analysis of the results, etc.) by only passive demonstrations of experiments carried out by the teacher on the basis of instructions from the textbook.
- It is worth to organize joint meetings of educators from various life science subjects (Chemistry, Physics, Biology). On the one hand, we have, in many cases, a similar methodology and innovations, such as, basic knowledge of the experiment, constructivism, IBSE, and - the need for integration and correlation.

Cyprus (University of Cyprus and Frederick University)

Description of the National Context and Motivation for Engagement

Cyprus is a very small country and the educational system is extremely centralized. Nevertheless, the inspectorate, who supervises and controls any curriculum changes or new curriculum development and any other innovation, heavily depends on teachers who are invited to work under the supervision of chemistry, physics, or biology supervisors for developing new curricula and/or classroom materials aligned with a new philosophy or orientation. The pre-service or in-service teachers are at least holders of a BA/BSc from a variety of foreign Universities, mainly from Greece, UK, USA, Germany, and other countries as well. This is clearly understandable, taking into consideration that the first University was recently established in Cyprus (1993), and, obviously, the first physics, chemistry, and biology graduates from the University of Cyprus are rather a minority among the in-service teachers. The wide variety of teachers' background is also undeniable, since they studied abroad and brought back to Cyprus a variety of experiences and innovative ideas from mature educational systems, such as, USA, UK, and Germany. Knowing however that a lot of other teachers come from different European and/or other countries, no claim is made that all of them were equally trained or equipped. It was also evident from several national reports or from the results of several international reports that there were gaps in the teachers' pedagogical training education. The majority of them have university degrees in physics, chemistry, and biology from the respective departments and no training to become teachers of the respective discipline. In reality, only few have been trained in pedagogy and students' ways of learning. Few years ago, the legal framework for appointing physics, chemistry, and biology teachers has changed and demands that no one can be appointed as teacher by having studied only the subject matter at any university. Those holding a BA/MSc or even a Master or a PHD in Physics, Chemistry, or Biology cannot be appointed as teachers unless they successfully complete a one-year pedagogical training, under the auspices of the Cyprus Ministry of Education and Culture. The prerequisite pedagogical training is offered in collaboration with the University of Cyprus and, recently, with other private Universities in Cyprus.

Another important issue relates to the consensus of the Chemistry, physics and Biology Associations of teachers for implementing these and other changes, while the prerequisite pedagogical training was also a heavy demand coming from teachers' associations. Finally, we should also stress that there is a surplus of unemployed physics, chemistry and biology teachers, and only few of those pre-service teachers trained in IBSE aligned with ESTABLISH enter or will soon enter the teaching stall, since the number of students is progressively diminishing due to various factors affecting the country (Cyprus), after the Turkish invasion in 1974 and its serious consequences on the Cyprus demographics that are still continuing.

Structure of Engagement

We initially sought and had the consensus of the Ministry of Education and Culture, who asked the respective inspectorate of Physics, Chemistry, and Biology to offer any kind of help, assistance and collaboration to the ESTABLISH coordinator (N. Valanides), so that the objectives of the ESTABLISH could be promoted.

We thus organized a series of specific and separate **meetings** with each inspectorate of Physics, Chemistry, and Biology. In addition we engaged the Chemistry inspectorate of the Ministry of Education and Culture in recruiting and hosting **workshops and seminars** for in-service science teachers.

Summary of Engagement

Engaging with Policy Makers

During these extensive meetings we explained and exemplified the objectives of the ESTABLISH project and we propose to each group to collaborate with us, and even take the initiative to promote these ideas among in-service teachers and encourage them to voluntarily involved.

The Chemistry Inspectorate of the Ministry of Education and Culture enthusiastically embraced the objectives of ESTABLISH and we collaboratively started preparing materials for training chemistry teachers based on the ideas of ESTABLISH or its materials that we started localizing and transforming based on the needs of our national curriculum.

The ESTABLISH Cyprus Chemistry group organized in June 2011, in collaboration with the Chemistry inspectorate of the Ministry of Education and Culture, workshops for all the in-service Gymnasium Chemistry teachers (teaching seventh- eighth- and ninth-grade students).

Promotion of IBSE Teacher Education

A series of workshops and seminars were carried out throughout Cyprus, with workshops in Nicosia, Limassol, Larnaca and Paphos. The workshops were based on the inquiry-based learning and teaching and covered the units “Invisible Holes and Mixtures / Separation of mixtures”, while the seminars focused on other scientific experiments such as the flame test. The participants worked in groups and the cooperative method of teaching , named “working in stations,” was followed. Different working stations were used, and the different groups of teachers were rotating from one station to the other.

The participating teachers enjoyed the workshops and commented that what they learned was useful, and could help them to accordingly transform their classroom teaching and orientation towards their students. The working conditions were really collaborative and the attempt was to make the teachers feel comfortable, despite any difficulties and gain real ownership of all the activities and attempts to improve their own classroom performance, accountability and effectiveness. We also attempted to exemplify to them the necessity to move beyond cold cognition and take into consideration not only cognitive outcomes, but to also infuse in their teaching, for example, social objectives (i.e., working together, collaboration and communication), and affective objectives (i.e., curiosity interest, motivation) or societal objectives (solving problems in their homes and communities) and or cognitive skills (such as, controlling variables, reflection, critical thinking, and other habits of mind) connected with the real nature of science.

We tended to involve teachers in learning situations resembling the learning conditions that should prevail in IBSE, so that they internalize the important ingredients of IBSE in cultivating public understanding of science and the catalytic nature of science as an important tool and lever for social and economic development.

Further information on the implementation and impact of these teacher education workshops will be available in the project deliverable report D5.6 – Case-studies of ESTABLISH Teacher Education.

Impact of Engagement

This collaboration and mutual responsibility of the ESTABLISH group, coordinated by Professor N. Valanides, with the chemistry inspectorate in the Ministry of Education and Culture, guided by LoukiaAnastasiadou, was extremely beneficial and influential. Most of the teaching materials that have been developed have already influenced the classroom environment, since the materials were translated in Greek, they were piloted and are integrated in the official chemistry curriculum

and appear on the official website of the Ministry of Education and Culture (chemistry inspectorate).

http://www.schools.ac.cy/eyliko/mesi/themata/chimeia/drastiriotites-programmata.html

The specific website highlights a number of issues/activities linked to the ESTABLISH project, such as:

- Introduction to European project ''Establish''
- Establish Teachers' Conference in Dublin
- Workshop on "Invisible Holes and Mixtures / Separation of mixtures".
- Workshop on "Solar energy and Energy from Hydrogen (Fuel Cells)"
- Students apply IBSE in classroom: slow and fast reactions
- Students apply IBSE in classroom: soaps – pH

Conclusion and Next Steps

The mutual trust and productive collaboration between the ESTABLISH group and the Ministry of Education and Culture triggered a number of other initiatives that can continuous infuse the IBSE in the official chemistry curriculum in Cyprus.

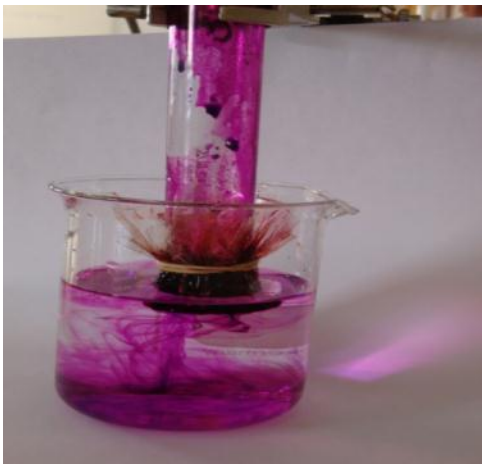
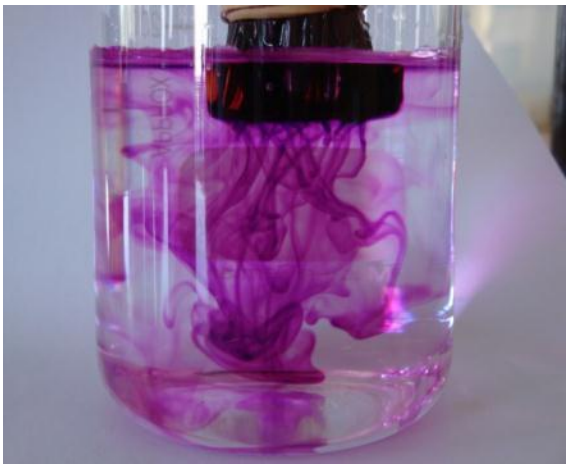
- An Establish Webpage in Greek language with all the ESTABLISH materials activities, units of training teachers, etc. is planned to be designed and developed in the near future. The specific website will make these materials accessible to the Chemistry teachers of secondary level schools.
- There is also in progress to establish a Chemistry Summer school for teachers and students who have already expressed interest to continue working to strengthening the IBSE approach for teaching science in Cyprus.

Similar approaches were also followed to develop collaborations with the physics and chemistry inspectorate and some really important lessons have been also learned. The focus on chemistry education was our preferred starting point for exemplifying our way of working and the importance of close collaboration with the officially responsible for curriculum development and the evaluation of physics, chemistry and biology. This can be transferred to other scientific disciplines and does not imply that the ESTABLISH project and its IBSE philosophy on physics and biology teaching were not important

Further Details of Engagement Event in Cyprus

The activities were carried out by the teachers themselves and constant support, scaffolding and information were offered by the inspectorate and other personnel from the ESTABLISH group. Teachers faced even unexpected difficulties, but we tried to make them feel comfortable and consider similar situations facing their students and how to move on, providing similar support and scaffolding



A number of Chemistry teachers working either in the Gymnasium or in Lyceum enrolled for further seminars on the inquiry-based learning and teaching. They were recruited from the whole number of chemistry teachers, who were informed that they could be acquainted with a new teaching approach aligned with the IBSE of ESTABLISH. They, express their interest to attend seminars on the implementation of the inquiry-based method in the teaching of Chemistry and to become acquainted with the three different levels of inquiry-based teaching/learning approach, namely, structured, guided and open. They wanted as well to be involved in the design and development of their curriculum and other classroom or teaching materials aligned with the IBSE approach.

In these seminars, the teachers were first presented with example worksheets for promoting the IBSE teaching/learning approach using **the flame test. They were first introduced to the philosophy of IBSE and its three different levels of progressive implementation and the associated skills and advantages. They were then presented with examples of worksheets aligned with the** three levels of the inquiry- based approach and were instructed to collaborate and solve the following problem:

> *Bags of fertilizer containing potassium nitrate (white solid) were stolen from a farmer's storeroom. The police arrested a suspect. On the shoes of the suspect were traces of a white dust. The suspect however claimed that the white solid on his shoes was salt (sodium chloride) and he explained how this was justified. The students were asked to provide evidence using their knowledge of chemistry to investigate whether the suspect's claims were correct and to judge whether he was guilty or innocent.*

After completing the specific tasks, the participating teachers discussed in a plenary session their ideas and their new insights with the chemistry inspectorate and the ESTABLISH group, and clarified all the related issues. Then, the participating teachers were self-organized in small groups for designing and developing IBSE worksheets and materials for teaching a unit from the Chemistry curriculum in Cyprus. The different groups developed teaching materials (worksheets and organized experiments) either for a unit from the Gymnasium Chemistry curriculum (8^{th} or 9^{th} grade), or for a unit from the Lyceum core Chemistry curriculum (11^{th} grade).

Two specific exemplary cases from those activities are presented from two specific groups (A or B) of teachers:

Group A: **Fast and slow reactions – rate of chemical reaction**

The problem that teachers instructed their students to solve was, as follows:

> *A group of children visited two villages, both famous for their metallic bridges, which were constructed by a famous architect in 1985. The first village was located 6 km east of an industrial area, while the second was located 60 km west of the same industrial area. These bridges were exactly the same and were made of the same material, but had never been maintained. The children discovered that one of the bridges was corroded to a much greater extent than the other one. Both villages were located at the same altitude and had the same temperatures during the year. They were however affected by a wind that blows towards the east. The students as young scientists need to find out which variables / factors led one bridge to be more corroded than the other one.*

Group B: **Natural and synthetic soaps – pH**

The problem that teachers instructed their students to solve was, as follows:

> *The beauty column of a weekly magazine advises its young readers to pay attention and care for their skin: If you have a sensitive skin, never use soap on your face. Although the high pH of the soaps may cleanse the face thoroughly, it may also severely irritate or harm your skin.*
>
> *The students are consequently asked to investigate whether the advice given by the column's consultant to the magazine readers, is phrased in a scientifically correct way. It is known that soaps which have a high pH value do irritate the skin. Yet, many companies advertise that their products are suitable for use on the face.*

Evidence collected from both teachers and their students via interviews and questionnaires provided support indicating that the specific approach was both more interesting and effective for attaining cognitive and affective gains among the students. Some indicative comments from students concerning the topic **"Natural and Synthetic Soaps" that was used** in Secondary School classrooms are presented as representative students' reactions:

- Florentia: "*Our chemistry lesson today was very constructive. We had the chance to research and to investigate on our own, to cooperate with fellow students, to experiment and, at the same time, we had fun*" (open inquiry was implemented).
- Eleni: "*Our chemistry lesson today was different. We learned that there are different types of soaps, that their pH varies and that soaps with a high pH can affect our skin. It was enjoyable*" (guided inquiry was implemented).
- Charalambos: "*Our lesson was very pleasant. We cooperated with our fellow students, we learned about the use of soaps and that we need to make the right choice of soap. We also had fun*" (structured inquiry was implemented).




1. Participation to the teacher conference organized by the European project ESTABLISH in Dublin, 7 - 9 June 2012

The spirit that was constructed during the training and workshops was very productive and different groups of teachers presented their IBSE materials and curriculum units at different local (national conferences). Two other groups of teachers were selected and presented their work in the poster session of the teachers' conference in Dublin.

- Group "A" developed teaching materials (worksheets and experiments) for a unit from the Gymnasium Chemistry curriculum (9th grade)
- Group "B" for a unit from the Lyceum core Chemistry curriculum (11th grade).

Evaluation based on the answers of the students and teachers questionnaires:

- students enjoy the IBSE lessons that really increase interest for science learning and provide enough opportunities for cooperation
- these approaches foster more positive attitudes to science
- IBSE teaching/learning are more effective in attaining the objectives of science education
- IBSE teaching/learning support the development of critical and scientific thinking

The involved teachers also identified several Challenges/issues/constrains associated with IBSE that should not be neglected as well. These are, for example

- Curriculum constraints
- Lack of time to implement inquiry
- Limited knowledge of teaching by inquiry
- Classroom management issues
- Lack of supportive school management

2. The ESTABLISH Cyprus Chemistry group organized in June 2013, in collaboration with the Chemistry inspectorate of the Ministry of Education and Culture, workshops for all the in-service Chemistry teachers of Gymnasium and Lyceum (teaching years 7th, 8th, 9th 10th, 11th and 12th).

The workshops were carried out in Nicosia (two workshops) and Limassol (one workshop). The workshops were based on the inquiry-based learning and teaching and covered the units “Solar energy and Energy from Hydrogen (Fuel Cells)” with emphasis in Hydrogen Cars – generating Hydrogen from Water electrolysis / generating electricity from Hydrogen. A total number of 71 teachers, 48 teachers participated at the two workshops in Nicosia and 23 at the workshop in Limassol. The participants worked in groups.






Slovakia, (UPJŠ Košice)

Summary of Engagement

Within Establish project activities in field of in-service teacher training we realised the series of coursers oriented on IBSE. As teacher training faculty we maintain relations with schools due to many reasons: pre-service teacher training practice, recruit of future students, popularisation of science and further teacher education through Ministry of Education certificated courses. Long-time interactions with teacher with both sides benefits creates credit of our faculty, which was strongly improved also by Establish project activities.

Our IBSE teacher training activities shows importance of inquiry in science education, the role of educated teacher with inquiry skills and practical experiences from educational activities. Our teacher also recognised importance of team work at school, as minimum we recommended cooperation of science teachers (Physics, Chemistry and Biology or Mathematics, Physics and Informatics) under the school management umbrella. Our support is focussed on teachers` team cooperation and on IBSE idea understanding by school principals. For school directors our faculty organise the **Club of school directors**, where once per quarter the meetings oriented on actual educational topics are organised. Nowadays, we can see the real impact of all our partial Establish activities on project dissemination.

Teachers trained within Establish IBSE courses initiated **school projects** through different agencies. Project goals are focused on inquiry, modernisation of education, using of modern technologies in education, computer based science education, assessment of inquiry activities, etc. Its pleasure for us, schools not only purchase equipment, but also plan to organise teacher training activities. We will participate as external lectors, reviewers of materials, tutors. For the next few years after the Establish project, the inquiry ideas and its realisation will have real support within following school projects.

The next dissemination impact we can see through **teachers' seminars** and science days at schools. We are invited by our trained teacher to lead the seminars for other teachers at school, oriented on inquiry activities, active learning and computer based measurements. We hope, step by step, the groups of teachers at school will be more positively inclined to the modern trends in science education.

Finally we can mentioned our success with **research project**: Research on the efficiency of innovative teaching methods in mathematics, physics and informatics education, which we obtained from Slovak research and development agency, for the next three years.

Strategy for Sustainable Impact

A primary output from the ESTABLISH project is the suite of 18 substantial IBSE teaching and learning resources, which are available in print and online through the e-learning platform. The following approach is suggested to sustain and support IBSE while generating wide use of the ESTABLISH e-learning platform.

All stakeholder groups

Policy makers and the representative bodies of all stakeholder groups should be informed by means about the advantages of IBSE and the content of the platform. This can be achieved by orchestrated email campaigns and other forms of dissemination.

Parents

In particular, parents should be asked to raise the topic of IBSE at parent/teacher meetings and boards of management meetings if they serve on such boards.

Teachers and school management

Teachers, school principals and their professional representative institutions should be presented with detailed information concerning the content and utility of the e-learning platform.

Teacher training institutions

The well recognised problems effecting the employment of IBSE in the classroom – dense syllabus content and tight time schedules will not be resolved in the short term. Accordingly, it also makes sense for the professional teacher training institutions continue to delivery of IBSE related teacher training programmes designed on the ESTABLISH model, in a manner that makes them clearly relevant to the existing class conditions in each country. Science education as a whole will only change significantly when a critical mass of teachers use inquiry methods.

It must be concluded that the type of transformational change that is desirable is unlikely to occur in the short term. However, constant incremental changes are possible and could be achieved by skilful teachers blending elements of inquiry with the other more traditional methods.

In the meantime, teacher training institutions are best placed to influence policy makers and other public representatives. Generally located in, or associated with, third level colleges and staffed with highly qualified experts, they have both the credibility and the contacts to exert serious influence. Collaborative effort among these institutions would create a serious force for change.

In addition, teacher training institutions are best placed to strengthen the link with science education research bodies, especially since such research is often carried out by the institution themselves.

Industry

The industry bodies, previously identified by ESTABLISH partners in each country, should be contacted and informed of the novel modes available for them to support IBSE. The communication around this can be pursued as described in the chapter Communication for engagement above.

In addition, some industries may be willing to operate as a hub or centre at which teacher training sessions could be delivered and stakeholder meetings could take place. In this way, an effective network of schools and teachers can be established. A plan to pilot this approach in Ireland is currently under discussion with the EMC Centre of Excellence, Cork.

However, if any of the above actions are to have sustainable long term impact, some form of national or regional oversight will be necessary.

Students

It is doubtful if student pressure can be organised in favour of science education change as such but representative bodes should be informed as stated previously.

Education Suppliers

Similarly, suppliers are likely to have little influence but will respond with products if demand is present.

Inter-project Collaboration for Sustainable Progress

Sustained change requires leadership and 'change champions'[7]. Such leadership could draw on the learning from the most relevant projects (e.g. SINUS, SINUS Transfer, and Pollen) and coordinate efforts to achieve the objectives of improved science education via IBSE.

Collaborative initiatives such as ***ProCoNet,*** endeavouring to '*reach the objectives of Europe 2020*'[8], and ***INSTEM***[9]could fill this role and offer the stage for powerful and coordinated stakeholder engagement and dissemination programmes.

In addition, such forums could follow up on the recommendation of the ***Working Group on International the Evaluation of Inquiry-Based Science Education (IBSE)*** concerning the establishment of local evaluation teams to monitor and assess the impact of programmes in those countries implementing IBSE initiatives.

[7] For a review of several change models see D.D. Warrick Developing Organization Change Champions: A High Payoff Investment in OD PRACTITIONER, Vol. 41 No. 1, 2009 (http://www.polytechnic.edu.na/centres/docs/coll/ODChange/ContentServer2.pdf)

[8] ProCoNet Interim Report, June 2011

[9] *www.* **instem**.tibs.at/

Overall Conclusion

Following many of these stakeholder events it was clear that the communities that surround the classroom are keen to support innovation within, though often they are unaware of how to carry this out. By providing channels and opportunities for different communities (in particular those who use science and technology), ESTABLISH has been successful in fostering mutually beneficial relationships between industry, research and teaching communities. This has contributed not only towards the promotion of using IBSE in classrooms, but also towards increasing the understanding of the relevance of school science amongst students which may assist them to identify career opportunities in science and technology. It is clear that in order to generate a systematic change in the teaching and learning of science that collaboration and engagement of and between all these stakeholders is required.

The conclusions drawn from these case-studies can be used to inform the development and guidance of further cooperation between the particular institutions, as well as for more effective introduction of innovations in education and further training of natural science teachers. In these conclusions, the following issues were included in terms of:

1. **Education of future teachers (pre-service teacher training)**
   - Cooperation of university-wide units of a type "pedagogical centre" with subject education departments is essential for the consistence of the process of future teachers' preparation.
   - Education of future teachers at universities should include a formation element - shaping attitudes.
   - The process of education of future teachers should indicate, inter alia, the need of teachers work in teams consisted of teachers of particular subject and in teams consisted of teachers of various subjects
2. **In-service teacher training**
   - Further training of teachers cannot consist of detached, one-time, often conducted by commercial companies in a schematic way boring trainings, but, instead, it should constitute a systematic, comprehensive and long-term action based on the activity of the participants and their reflection on their own experience.
   - The work educational advisers cannot be replaced by a set of trainings; it is required to develop a new formula of systematic support of teachers.
   - Universities should play a greater role in teachers training
   - In order to effectively introduce innovations to education, the following elements are necessary: conviction of the school principal/headmasters, teachers and parents to proposed changes (positive attitude), adequate knowledge, and above all, well-developed skills in this field of the teaching staff development and systematic support (not just teaching materials, but also easily available consultations, forum for exchange of experiences, *so-called* community of practice).
   - In the process of teachers preparation for introducing proposed in the core curriculum, the learning "context" (indicating the relationships of the acquired knowledge with students' everyday life) and for the implementation of one of the basic principles of teaching "combining theory and practice," an important role is played by the environment outside the school, including, e.g., industry, agriculture, health institutions and environmental protection organizations. In order to enable teachers' enthusiastic

presentation of the application of, for example, chemistry in human life, they should be personally acquainted with it during education (industrial practices/internship during studies) and further trainings (study visits: real or virtual).

- Postgraduate studies focused on providing the students with subject knowledge should cover to higher extent issues connected with the methodology of teaching particular subject, especially in the case of integrated subject, such as 'science' in elementary school and upper-secondary school.

3. Introduction of IBSE

- Before the teachers can use an inquiry-based teaching approach in the subjects from the field of natural sciences, they should gain personal experience in the methodology of research/inquiry in life sciences in the course of preparation for the profession during studies 'pre-service teacher training' (e.g., research project) or further training.
- Special attention should be paid to the proper understanding of the idea of IBSE, including, among others, prevention of the replacement of teaching through scientific inquiry (students experiments: formulating the research questions and hypotheses by students, planning of the experiments, the determination of the dependent, independent and controlled variables, standardization of the measurement conditions, discussion of errors, presentation and critical analysis of the results, etc.) by only passive demonstrations of experiments carried out by the teacher on the basis of instructions from the textbook.
- It is worth to organize joint meetings of educators from various life science subjects (Chemistry, Physics, Biology). On the one hand, we have, in many cases, a similar methodology and innovations, such as, basic knowledge of the experiment, constructivism, IBSE, and - the need for integration and correlation.

Through these engagement a number of recommendations can be offered to foster collaborations between university, schools and companies. A key message that emerges from these engagement events is that they are welcome and receive positive feedback from participants. Many stakeholders in STEM education felt isolated. In their daily work, these stakeholders have no opportunity to network, to communicate, to learn from each other or to get connections on national or international level.

A university is an adequate organization to be a collaboration hub for a STEM network involving all stakeholders, as it does not have "personal" interest. The scientific orientation of universities is seen as an important factor for independence.

Thus the following actions are offered as suggestions to implement changes, such as, inquiry-based science teaching (or any other type of change to science teaching and learning).

- Influential persons are not attracted by long term invitation, but by interesting questions. So it might be possible to invite these persons for short term involvement.
- It is not necessary (and of course not possible) to invite all stakeholders or even persons from all relevant organizations. Usually these persons know each other or at least know the strategies, the results and also crucial points of the national/regional STEM activities. This means, a few persons could give sufficient information on the process.
- On the other hand, our information will spread easily in the existing networks.

- As all networks, STEM-networks have "hubs," persons or organisations with a lot of information, with close insight into the crucial processes going on in a region, a nation, or in outstanding companies. It would be helpful, to identify these hubs (either persons or organizations) and involve them into the process.
- Be flexible in your strategy. If you cannot reach the most important people, ask them to send at the conference a substitute or any person being able to inform you and take the information along from there. Sometimes these persons are even more influential, because they are closer involved into the practical work.
- Numbers do not count, even if it seems more rewarding to have a "crowd." The results of a small group discussion (5 or 7 persons) can often be more powerful and informative.
- And, last but not least: a network is not an abstract system. It is based on personal contact. So you need a lot of time to meet people, speak to them and keep the contact through mails, newsletters and upcoming events.

In addition, there are many resources available for informing and developing effective dissemination and knowledge exploitation strategies and these should be utilised to improve the impact of stakeholder engagement. One such tool, the Desire Reach Out Toolkit is highlighted in the next section. Comenius network projects such as the INSTEM project (http://instem.tibs.at/ref:527333-LLP-1-2012-1-DE-Comenius-CNW) which brings together the experience and learning of a wide range of projects in European STEM education to link research, practice and policy in a unique way are very powerful in providing platforms for collaboration and communication at European level. The INSTEM project includes two of ESTABLISH partners (DCU and MLU) as consortium partners to contribute insight and outcomes from ESTABLISH for the development of accessible synthesis reports and briefings at Pan-European level. In particular the FP7 funded Scientix project (2009-2012, 2013-2015) promotes and supports a Europe-wide collaboration among STEM teachers, education researchers, policymakers and other STEM education professionals. (http://www.scientix.eu/) The Scientix online portal collects and presents European STEM education projects and their results and hosted a major networking event (Scientix conference) held in May 2011 in Brussels, to which the ESTABLISH Coordinator contributed. Now in it's second phase, Scienctix aims to engage national teacher communities, and contribute to the development of national strategies for wider uptake of inquiry-based and other innovative approaches to science and maths education.

DESIRE REACH OUT TOOLKIT:

The European project DESIRE (Disseminating Educational Science, Innovation and Research in Europe) (2011-2013) offers relevant insight into models of diffusion and exploitation to ease the spreading of science education projects results to teachers. The recently published "DESIRE REACH OUT TOOLKIT – A GUIDELINE ON HOW TO REACH YOUR STEM EDUCATION STAKEHOLDERS EFFICIENTLY" (available from http://desire.eun.org/toolkit) is an invaluable resource for teachers, project managers, policy makers and others involved in organising STEM events and activities.

This Reach Out Toolkit is based on two years research and is intended to project managers and project coordinators running initiatives to improve learning and teaching of STEM in formal education (schools) and informal education (science centres, museums, fairs, events). It gives information on how to plan and implement dissemination and exploitation strategies.

This toolkit proposes that when designing your strategy to disseminate results of STEM education projects to teachers, a number of elements are recommended:

- Make sure your strategy is participatory
- Make teachers actors of the dissemination, involve local institution, and use a decentralised model
- Identify how to communicate in a relevant and effective way
- Investigate on the STEM curricula of the involved countries upstream
- Use incentives to engage and encourage teachers and schools to participate in your projects

This toolkit proposes that when designing your strategy to disseminate results of STEM education projects to project managers, a number of elements are recommended:

- Attend and disseminate through traditional events on STEM education that project managers usually attend
- Break old habits regarding communication channels and investigate new ones
- Give space to informal dissemination and be open to adapting your strategies depending on each context
- Reach out beyond your network by making use of experts who have large networks in the STEM formal and informal education worlds

Advisors of policy makers involved in the DESIRE activities shared useful recommendations that project managers should bear in mind, referred to as MICE rule:

- M (mass media and multi-channel strategy): improve the use of mass media to reach the general public, not only relying on the Internet which is of course the first means of dissemination.
- I (involvement): stakeholder involvement at early stages of the projects (policy makers at all level, teachers, local communities, etc.).
- C (clarity and crucial information): communication should be clear, mainly using brief messages (better in native language) and crucial evidence on which policy makers can their plans and measures.
- E (evidence): dissemination strategies should communicate clearly how theory and practice can be bridged, for instance between pedagogical theory and teachers' practice.

Recommendations for how to disseminate STEM education project results to STEM event organisers:

- Choosing a broad and transversal topic
- Suggesting several ways of using the material
- Explaining a method to adapt the resource to any situation, ideally already tested and evaluated
- Presenting the material as an inspiration, encouraging users to adopt it while adapting it adding a local character

Based on the experiences of ESTABLISH and informed by international practices the following actions are offered as suggestions to implementing change in STEM education, such as, inquiry-based science teaching (or any other type of change to science teaching and learning).

- Influential persons are not attracted by long term invitation, but by interesting questions. So it might be possible to invite these persons for short term involvement.
- It is not necessary (and of course not possible) to invite all stakeholders or even persons from all relevant organizations. Usually these persons know each other or at least know the strategies, the results and also crucial points of the national/regional STEM activities. This means, a few persons could give sufficient information on the process.
- Appropriate information will spread easily in existing networks.
- As all networks, STEM-networks have "hubs," persons or organisations with a lot of information, with close insight into the crucial processes going on in a region, a nation, or in outstanding companies. It would be helpful, to identify these hubs (either persons or organizations) and involve them into the process.
- Be flexible in your strategy. If you cannot reach the most important people, ask them to send at the conference a substitute or any person being able to inform you and take the information along from there. Sometimes these persons are even more influential, because they are closer involved into the practical work.
- Numbers do not count, even if it seems more rewarding to have a "crowd." The results of a small group discussion (5 or 7 persons) can often be more powerful and informative.
- Remember, a network is not an abstract system. It is based on personal contact. So you need a lot of time to meet people, speak to them and keep the contact through mails, newsletters and upcoming events.

Overall, the core concept for success in implementing change in STEM education is the facilitation of continuous engagement with and between the key stakeholders in STEM education, at regional, national or international level.

Appendix 1 – Identification of Industrial Stakeholders

The following table outlines the industrial partners initially identified for Milestone 5 (MS5) and updated to reflect the engagement activities of the project.

Country	Proposed at start of project	Engaged during ESTABLISH
Ireland	Intel, PharmaChemical Ireland, STEPs to Engineering (Engineers Ireland) Discover Science & Engineering (DSE) HP, IBM, Environmental Protection Agency (EPA), Sustainable Energy Authority of Ireland (SEAI), Electricity Supply Bord Networks (ESB Networks) Teagasc, NCTE, Marine Institute, Science Gallery	Abbott (Abbvie), Amgen Foundation Inc., Bord Gais Networks (Irish Gas Bord Networks), Bord na Mona (Irish Turf Bord), Boston Scientific, BT, Comreg (Communications Regulator), Cordis, CRH, Department of Agriculture, Food and Marine, Discover Science & Engineering (DSE), EMC, Energia, Environmental Protection Agency, Eirgrid, GE, Food Research, Genzyme, Irish Cattle Breeding Association, Institute of Physics (IOP), Intel, Irish Marine Development Office, Leo Pharma, Merck Sharp & Dohme (MSD),

		National Immunisation Office, National Council for Curriculum and Assessment (NCCA), National Children's Research Centre, Novartis, Ordnance Survey Ireland, Pfizer, PharmaChemical Ireland Shell, Radiological Protection Institute, Royal Society of Chemistry (RSC), Stryker, Science Foundation Ireland, Siemens, Sustainable Energy Authority of Ireland (SEAI), Teagasc (Irish Agricultural Support Agency), TEVA,
Germany	Chamber of Commerce, German Chemical Industry Association, Bund, Students labs VCI, FCI, Cheminord, Greenpeace, Telekom Stiftung BASF, Nordmetall, KorberStiftung, LandesarbeitsgemeinschaftSchulewirtschaft	Henkel AG & Co KGaA; as a global company Co. BioNova in Büsum and the Seehof Laboratorium in Wesselburen; both as local companies Collaborative Research Center - Function by Switching; as a research center Klett Publischer Company Bayer AG DOW Chemical AG The association of Science Centers in Central Germany.
Estonia	Chemistry STA, Telecommunication	Telecommunication, Health Service Industry, SME cosmetics enterprise, Pathology laboratory, Rakvere SPA Medical High School, Biology STA, Chemistry STA,

		Institute of Technology, Total AS, Estonian Energy
Netherlands	Unilever, Butter Essence BV, Fujifilm, NS (National Railways), Marine (Navy), NFI (Dutch Forensic Institute), WETSUS , Philips, Corus, Shell, Metaalunie, NIOZ	Shell, JetNet Network (many companies teaming up with schools), Brains Unlimited
Malta	NSTF, MCST, DQES, MATSEC, MASE	
Czech Republic	CEZ Group, The Academy of Sciences of Czech Republic, MEOPTA, CEZ group, Skoda Auto, Merkur Toys, The Academy of Sciences of Czech Republic	Ministry of Education, Youth and Sport (MEYS) – National Institute of Education; Science center IQ Park Liberec; National Technical Museum Prague; MEOPTA; CEZ group; Coca-Cola Czech Republic; Silon Planá; Prague Water Supply and Sewerage Company, Foundation Depositum Bonum; AV-Media, Edufor (Vernier reseller), Profimedia (Pasco reseller)
Poland	Polish Chamber of Chemical Industry, Polish Chamber of Pharmaceutical Industry and Medical Products, Society of Engineers and Technicians of Chemical Industry Azoty Tarnow, Synthos S.A. Oswiecim, ABB Krakow, Polish Chemical Society, Polish Physical Society, Polish Botanical Society, Polish Zoological Society, Polish Academy of Sciences	Coca-Cola Company, Niepołomice, Zywiec Brewery, BASF the Chemical Company Myslenice, Trzebinia Refinery, Institute of Ceramics and Building Materials Krakow, Water Treatment Plant ‘Dłubnia’, the Municipal Office of Krakow, Zamkor Publishing House,

		Educational Research Institute, Warsaw
Italy	FIAT, TELECOM, ENEL, ENI, CNR- National Institute of Education	CNR, National Institute of Education, Instituto Giordano S.p.A.
Slovakia	U.S. Stell Kosice, Siemens Slovakia, Kosice IT valley ScholaLudud, Slovak Physical Society, Slovak Academy of Science	Methodology and Pedagogy Centre, State pedagogical Institute, SteelPARK
Sweden	The Association of the Swedish Engineering Industries, National Farmers Organisation, Energy Companies, Forest Industry, Swedish Educational Broadcasting AB, Swedish Agency for Economic and Regional Growth, The National Food Administration, The National Board of Health and Welfare, Swedish Centre for School Biology and Biotechnology, Swedish Centre for School Physics, The National Resource Centre for Chemistry Teachers, The Centre for School Technology Education (CETIS), Swedish National Association for Research in Science	The National Food Administration, The National Board of Health and Welfare, Swedish Centre for School Biology and Biotechnology, Swedish Centre for School Physics, The National Resource Centre for Chemistry Teachers
Cyprus	The Association of Physics Teachers The Association of Chemistry Teachers The Association of Biology Teachers Cyprus Pedagogical Institute Inspectorate of science (physics, Chemistry and Biology) Curriculum Development Unit National Examination Unit Cyprus Winery Company Electricity Authority National Association of Parents	The Association of Physics Teachers The Association of Chemistry Teachers The Association of Biology Teachers Cyprus Pedagogical Institute Inspectorate of science (physics, Chemistry and Biology) Curriculum Development Unit National Examination Unit Cyprus Winery Company Electricity Authority National Association of Parents

Appendix 2 - National Strategies to Engage Stakeholders

The following tables were completed during the General Assembly Meeting (GA2) hosted in Dublin, September 2010. Presented in alphabetical order

CYPRUS:

STAKEHOLDER	ACTIONS PLANNED / MADE
A: National and regional policy makers (including curriculum and assessment developers)	Close collaboration and mutual support To diffuse IBSE materials and approaches in the national curriculum and assessment
B: Industry (private & public) / Companies/ Science research organisations	To be involved in informal education activities and support To closely cooperate and be supportive to schools and visits to their factories and headquarters To disseminate and exemplify their future science-related jobs etc
C: Science education research organisations	To provide support and funding for IBSE initiatives
D: Education suppliers (publishers, resource & equipment suppliers)	
E: Teacher & teacher networks	To encourage their professionalization and responsibility for continuous learning To provide continuous support for daily work and problems. To institutionalise incentives for their development. To empower them for further and continuous professional development To foster their ownership of materials etc. To foster the formation of learning communities among teachers, supervisors, science education and researchers
F: Students & student representative organisations	To cultivate their own responsibility for their own education and development. To encourage them to be involved in and participate in related IBSE activities, such as, summer schools, competitions etc.
G: Parents & parent associations	To encourage their involvement and active support to schools and teachers. To strengthen their responsibility for their children's education
H: Other	Political Parties Influence their educational policies and educational reforms

	Strengthen their responsibility for educational issues and policy.

CZECH REPUBLIC:

STAKEHOLDER	ACTIONS PLANNED	ACTIONS MADE
A: National and regional policy makers (including curriculum and assessment developers)	Try to contact Minister of Education (there is a new Minister) via the institute for Information on Education	Cooperation with National Institute of Education has been established, participation in expert groups in science branches
B: Industry (private & public) / Companies/ Science research organisations	CEE can support module on electricity Meopta can support module on light Also some chemical companies Czech Academy of Science can help develop materials.	Knowledge support in preparation of units, supply of material for science education
C: Science education research organisations	-Charles University in Prague -Faculty of Maths and Physics -Faculty of Sciences (Department of Education)	Education of students (especially pre-service teachers), courses for in-service teachers, expert support, using institutions equipment and information sources
D: Education suppliers (publishers, resource & equipment suppliers)	Company Edufor may popularize the use of dataloggers in IBSE way	Datalogger resellers were contacted and cooperation has been established, these companies in their courses popularize IBSE approach
E: Teacher & teacher networks	We will try to directly influence as many teachers as possible (e.g. via teachers in the Heureka project)	Influencing via Heureka project, national workshops, help in creation of network of regional centres under Foundation supported by Depositum Bonum
F: Students & student representative organisations		Influencing of students through courses with IBSE Establish units, workshops for students

G: Parents & parent associations		Contacting parents through in-service teachers
H: Other	Union of Czech Mathematicians and Physicists Czech Chemical Society – Section of Chemical Education	Organization of conferences for teachers (for example , Markets of ideas of chemistry teachers and Fair of ideas of physics teachers) in cooperation Union of Czech Mathematicians and Physicists, Czech Chemical Society and Section of Chemical Education

ESTONIA:

STAKEHOLDER	ACTIONS PLANNED	ACTIONS MADE
A: National and regional policy makers (including curriculum and assessment developers) National Examinations and Qualifications Centre	Effect a paradigm shift not only for Centre personnel but for those who support and effect (this includes University personnel)	ESTABLISH materials were recommended to include to the optional courses in National curriculum ESTABLISH approach, materials were included into pre- service course Based on ESTABLISH materials a credited in service course was proposed and administered A chapter was included at tertiary level Science Didactics Course book
B: Industry (private & public) / Companies/ Science research organisations	Production: The industry/company etc need to hear views expressed by multinational organisations such as those expressed by Intel. The crucial action is the dissemination of such views by means of ESTABISH publicity materials.	ESTABLISH materials introduced to industrial partners prior to their lectures to teachers or during the process of adaptation /development of teaching/learning materials The structure and key components of ETABLISH were introduced to Chemistry STA, Biology STA Questionnaire was administered in order to find out industrialist views about the competencies needed at workforce

		ESTABLISH booklet was disseminated widely ESTABLISH posters were introduced during the STA meetings
C: Science education research organisations Only Science Education Centre in the University of Tartu	The centre is the driver of ESTABLISH and its goals.	ESTABLISH project and its outcomes were discussed during the joint research seminars between 2 Estonian universities 2 PhD students and 2 MSC students are completing their thesis based on ESTABLISH, their work has been disseminated during the research conferences
D: Education suppliers (publishers, resource & equipment suppliers)	Seek comments on science education by means of a questionnaire as part of the PhD study	Publishers attended twice STA meetings , where also ESTABLISH was introduced Agreement was made with on publisher (intre- universities publishing company) to publish an introductory book which includes short versions ESTABLISH materials Resource providing company TOTAL collaborated with project team over 3 years (gave advice related to the equipment and materials), they came up with several new offers to schools
E: Teacher & teacher networks	To make them aware of ESTABLISH and its goals in an attempt to move their beliefs and policies in a forward direction and assist in gaining evidence of the forward path.	ESTABLISH project has been introduced and materials disseminated during the STA annual meetings, regional seminars. Questionnaires were administered among teachers to find out their opinions about industry ESTABLISH materials were duplicated and disseminated among teachers networks Special in service group was formed based on open call

F: Students & student representative organisations	Dissemination	If any than non formally , no evidence During some of the in service trainings students were present and act as “participants”
G: Parents & parent associations	Dissemination and seeking comments	NIL Opinions related to ESTABLISH materials from parents working in the university were orally asked
H: Other	Schools themselves are influenced through teacher involved in the project as part of in-service and guided plus impact on others in the school	Several schools formed during the second CPD school teams Several teachers were providing information about ESTABLISH success among the collegues in their school

GERMANY: IPN

STAKEHOLDER	ACTIONS PLANNED	ACTIONS MADE
A: National and regional policy makers (including curriculum and assessment developers)	Ministry SH - personal contact	Ministry SH - personal contact
B: Industry (private & public) / Companies/ Science research organisations	IHK, Nordmetall, ?? personal contact	Henkel AG & Co KGaA; as a global company Co. BioNova in Büsum and the Seehof Laboratorium in Wesselburen; both as local companies Collaborative Research Center - Function by Switching; as a research center
C: Science education research organisations		Presentations at conferences (MNU, GDCh)
D: Education suppliers (publishers, resource & equipment		Papers published (NiU-Chemie; Chemkon in prep)

suppliers)		
E: Teacher & teacher networks	Landesfachbrater Teacher Associations MNU GEW Philologencarband - Invitation for IPN	Teacher Workshops through concept of Stützpunktschulen
F: Students & student representative organisations	(Student organisations – Landeschubrat?? (Roundtable with project partners	--
G: Parents & parent associations	(Parents Associations – Landeseltbamlcitab	--
H: Other		Saturday Morning Physics; public outreach

GERMANY: MLU

STAKEHOLDER	ACTIONS PLANNED	ACTIONS MADE
A: National and regional policy makers (including curriculum and assessment developers)	Creating projects, personal contact (time limit) e.g. Summer Camp	Five conferences with regional subject coordinators were attended and the core ideas of ESTABLISH were presented. National policy makers were informed on three national conferences, e.g. the board of German schools in foreign countries
B: Industry (private & public) / Companies/ Science research organisations	Personal Contact Ministry of Economy	Four conferences of Chambers of commerce were informed at teacher conferences on STEM. The contact to four companies was established on personal level.
C: Science education research organisations		Five times the annual and biannual national conferences were attended and topics of

		ESTABLISH were presented.
D: Education suppliers (publishers, resource & equipment suppliers)		The contact to the largest German publisher of school books was established. He created a newspaper on STEM education, in which the editorial board was attended by persons from MLU.
E: Teacher & teacher networks	(→ Union Invitation: (→Subject Associations – MNU (→Landesfachsercher	Several national and regional STEM teacher conferences were attended, materials and ideas of ESTABLISH were presented in oral presentations, posters and workshops. 4 years of pre-service teachers were engaged by using ESTABLISH material for designing lectures, seminars and projects.
F: Students & student Representative organisations	→ Information ↓ Roundtable with us (Project Partners) ↓ → Information	The ESTABLISH material and ideas were fully implemented in sevaral pre-service teacher seminars, lectures, internships and projects with students.
G: Parents & parent associations		
H: Other		An ongoing series of summer camps was established, engaging young people into IBSE orientated science learning on renewable energy, healthy food, flying and climate change.

IRELAND:

STAKEHOLDER	ACTIONS PLANNED	ACTIONS MADE
A: National and regional policy makers (including curriculum and assessment developers) DES, Dept. of Education and Skills, Civil Service PDST: Professional Development Service for Teachers SEC: State examinations Commission	Engage the Minister for Education and Skills through briefing materials, in person and by engaging the Minister in activities that promote the use of IBSE. Have a forum for all stakeholders at a high level. Brief ministry officials about the IBSE approach and seek to increase awareness with the Inspectorate and the NCCA on its introduction into the curriculum Seek opportunity with the PDST to introduce the IBSE method into in service training with the teachers. Promote IBSE through Science and Technology in Action and other National Programmes Brief State Examinations Commission and build influence with them through the Department officials and other channels	Engaged the Minister for Education and Skills to launch the project; engaged other ministers (Minister of State, Department of Enterprise, Jobs & Innovation and Department of Education & Skills with responsibility for Research & Innovation) where he was invited to attend and address the general assembly. Forum held as National Stakeholders Conference 13 November 2014. Engaged with members from NCCA to generate awareness of IBSE teaching and learning materials and education programmes. Ministry officials and NCCA briefed and attended conference. Engaged with the Inspectorate to generate awareness of IBSE teaching and learning materials and education programmes and also to build up professional working networks Briefed PDST officers. ESTABLISH information included in four annual editions of STA.
B: Industry (private & public) / Companies/ Science research organisations	Build on existing industry links eg. Science and Technology in Action, Intel activities, Scifest, Intel Educator Academy, Discover Science and Steps to Engineering, IBEC/ Pharmachem. Use speaking and demonstrating opportunities at conferences and appropriate forum.	Engaged with industrial partners (including Intel, SEAI and Amgen) to develop IBSE teaching and learning materials and educational programmes All industry supporters of STA briefed and updated at face to face meeting and via STA Newsletter.. These industries are listed in Appendix 1.

		Invited representative from industry supporter of STA to attend and address the National Stakeholder Event, (keynote speaker was VP EMC Centre of Excellence, Ireland.) Engaged with industries (including EMC) to develop networks with local schools to support the use of IBSE in the teaching and learning of science Engage with researchers at multiple science education conferences (GIREP, ECRICE, ICPE, ICEP, ESOF, etc.)
C: Science education research organisations	Identify appropriate channels for highest impact and develop lines of influence/ activities with them. For example SFI do not have a remit with Secondary schools and a huge amount of funding is channelled through them, can this be influenced in any way to impact on use of IBSE?	Disseminated project activities and outputs with national science education research groups, including NCE_MSTL, LIT, NUIM, CICE. Briefed SFI on the importance of supporting the development of good IBSE resources and educational programmes for teachers in addition to engagement and outreach activities currently supported.
D: Education suppliers (publishers, resource & equipment suppliers)		AG Education services core business is publishing educational resources.
E: Teacher & teacher networks	Promote IBSE at ISTA conferences and through the PDST in-service training. Pre-service through the various teacher training Colleges.	Participated at multiple national science teacher conferences (ISTA) by conducting workshops and interactive demonstrations; Also distributed ESTABLISH flyers and recruited teachers for participating in ESTABLISH Teacher Education Programmes Posters displayed and flyers distributed at BT Young Scientist and Technology Exhibition, Dublin – January

		2013 and 2014. School Principals association informed re ESTABLISH and representative attended National Conference. Facilitated multiple in-service teacher training programmes at multiple locations nationwide
F: Students & student representative organisations	Through the implementation of the method in the classroom by the teachers and other relevant methods of dissemination, e.g e-communication and social networks. Discover Science has experimented with social networking methods, investigate the outcome and learn from it to adapt an appropriate approach. Promotion through the Young Scientist Exhibition and other existing promotional programmes.	Posters displayed and flyers distributed at BT Young Scientist and Technology Exhibition, Dublin – January 2013 and 2014. ESTABLISH promoted to teachers/students at STA School Quizzes – October 2011, April 2012, May 2012, March 2013. Participated at multiple public science events including BT Young Scientist Exhibition, European Science Open Forum
G: Parents & parent associations	Dissemination of information to National Parents Council and Principals forum.	National Parents Council informed re ESTABLISH. Engaged representatives of the National Parents Council in the national stakeholder event
H: Other	Social Media	Advertised ESTABLISH events and Teachers Education programmes through website, twitter and facebook feeds

ITALY:

STAKEHOLDER	ACTIONS PLANNED	ACTIONS MADE
A: National and regional policy makers (including curriculum and assessment developers)	Put into evidence different results in methods for teacher preparation and different kinds of curricula	Put into evidence different results in methods for teacher preparation and different kinds of curricula
B: Industry (private & public) / Companies/ Science research organisations	Put into evidence advantages of a skill-based education instead of traditional knowledge-based one	Put into evidence advantages of a skill-based education instead of traditional knowledge-based one
C: Science education research organisations	Discussing evidence-based results	Discussed evidence-based results
D: Education suppliers (publishers, resource & equipment suppliers)	Making evident the role of tools like ICT equipment and other IBSE based resources	Made evident the role of tools like ICT equipment and other IBSE based resources
E: Teacher & teacher networks	Presenting and discussing evidence-based results of IBSE	Presented and discussed evidence-based results of IBSE
F: Students & student representative organisations	Discuss the advantages of IBSE in learning	Discussed the advantages of IBSE in learning
G: Parents & parent associations	Discuss the advantages of IBSE in learning	Discussed the advantages of IBSE in learning
H: Other	Dissemination of IBSE idea at Science Exhibitions	Disseminated IBSE idea at Science Exhibitions

NETHERLANDS:

STAKEHOLDER	ACTIONS PLANNED / MADE
A: National and regional policy makers (including curriculum and assessment developers)	1. Government needs to understand "continuous" change is necessary, Informed based "Continuous" is say once/10 years a formal change in curricula MOST IMPORTANT: 2. Assessment has to follow curriculum, including the changes
B: Industry (private & public) / Companies/ Science research organisations	NOT IMPORTANT, ONLY INDIRECTLY: Try to involve them, use their experience, use their Influence on government
C: Science education research organisations	Need to give clear signals to policy
D: Education suppliers (publishers, resource & equipment suppliers)	Should have no influence. They have to follow!
E: Teacher & teacher networks	Team up with S. E. Research Clear signals Claim more influence Support them with information from project(s)
F: Students & student representative organisations	Not important
G: Parents & parent associations	Have to be informed Should demand 21st Century Education: curriculum/tools/ Should demand quality teachers
H: Other	Politicians /other political parties/members of parliaments School boards & School Directors: Important, have to be informed, regional network of schools

POLAND:

STAKEHOLDER	ACTIONS PLANNED / MADE
A: National and regional policy makers (including curriculum and assessment developers)	Letter and leaflet (Regional Office, Ministry) Meeting/on-line discussion Identification of key person
B: Industry (private & public) / Companies/ Science research organisations	Selection of industry branches according to developed units Searching for existing contacts (industry→university→education system) Development of new contacts Establishing networks
C: Science education research organisations	Approaching central institution via regional one
D: Education suppliers (publishers, resource & equipment suppliers)	Contact to reviewers (Polish Academy of Sciences & Art) Joint events – promotion of resources and IBSE (ESTABLISH)
E: Teacher & teacher networks	Meetings, face-to-face Publications (e.g Chemistry in School, Newsletters and teachers associations)
F: Students & student representative organisations	
G: Parents & parent associations	Press releases, STO – contact with a board/headquarters Newsletter
H: Other	

SLOVAKIA:

STAKEHOLDER	ACTIONS PLANNED / MADE
A: National and regional policy makers (including curriculum and assessment developers)	To promote the key ideas and the project results to responsible persons at State pedagogical Institute, Teacher training faculties, Ministry of Education, Regional pedagogical representatives, Add responsible people to project meetings and conferences, seminars, project promotion activities, To attract and motivate the responsible persons for these ideas. To promote good examples from school practice, how inquiry works, what we can obtain, short case studies.
B: Industry (private & public) / Companies/ Science research organisations	To have good contacts with people working in industry, science and research organisations in order to get their support To have common projects to promote science in public Scientists needs help from didactics about the modern science education, popularisation of science, …. where inquiry can play the key role. For Industry people is important to see in the near future, positive attitude to science and technology, well-educated and creative young people.
C: Science education research organisations	Inquiry based science education in Slovakia conditions is as new wind for the science education research. Its new topic, well-adjusted with national educational strategy.
D: Education suppliers (publishers, resource & equipment suppliers)	Equipment suppliers (e.g. for computer based measurements, school science laboratories) can be involved as an external experts for technical support of IBSE activities and sponsors for dissemination.
E: Teacher & teacher networks	All teacher educated within Establish will organise as IBSE teacher team, for peer cooperation, school projects, further education.
F: Students & student representative organisations	Students Parliament – we do not think these will be of significant help. Pre-service students is one of our target group, where strong impact will be possible.
G: Parents & parent associations	Parents have happy when their children come home from school happy, motivated, satisfied, and their results are good. We don't think that the parents can have a big influence, only we can create step by step the positive attitude to science education in society.
H: Other	

SWEDEN:

STAKEHOLDER	ACTIONS PLANNED	ACTIONS MADE
A: National and regional policy makers (including curriculum and assessment developers)	Sweden has a national curriculum where IBSE and industry are incorporated i.e. no need to change curricula. Assessment developers, National agency, Test developers Meeting to exchange information/experience	Sweden has a national curriculum where IBSE and industry are incorporated i.e. no need to change curricula. Meetings with people who develop assessment to support teachers, people who develop national tests for school year 6, Information given to the National agency for Education,
B: Industry (private & public) / Companies/ Science research organisations	Industry very positive to school and IBSE. A lot of initiatives are taken from industry. Need of exchange of experience	Industry very positive to school and IBSE. A lot of initiatives are taken from industry. :Meeting with Teknikföretagen
C: Science education research organisations	Old academic traditions within science faculty. Need to be educated about IBSE.	Malmö University Umeå University
D: Education suppliers (publishers, resource & equipment suppliers)		
E: Teacher & teacher networks	(LMNT - Biol.lárforenig (CETIS - Ovrigaresurscentra (Sc. Centers &kontch Important to distribute information and “success stories”	National Resource Centre Biology and Biotechnology (CETIS National Resource Centre Tecjnology Sc. Centers &kontch Headmasters
F: Students & student representative organisations		
G: Parents & parent associations		Meeting with parents and retired teachers
H: Other		