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In-service and pre-service teacher education in IBSE: The ESTABLISH approach

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Summary. — One of the main goals of the ESTABLISH 7fp project (available on line at `http://www.establish-fp7.eu/`) was the development and implementation of the professional development teacher education programmes (TEP) to support teachers in adopting inquiry-based strategies in their teaching. Within the project there was a model for in-service and pre-service teacher training in IBSE designed and implemented across 12 participating countries. The programme is based on 4 core elements and 4 additional elements that are built around the IBSE teaching units developed within the project. As accepted by ESTABLISH partners, all teacher training programmes include the minimum of the four elements, *i.e.* introduction to IBSE, industrial content knowledge, teacher as implementer and teacher as developer of IBSE teaching materials. There are also four additional elements designed in detail, *i.e.* ICT for IBSE, argumentation in the classroom, research and design projects for students, assessment of IBSE. These can be added to the programme optionally with regard to the level of teachers' IBSE skills and current situation in education and teachers' professional development within the country. This ESTABLISH model of TEP was followed in participating countries in order to change teachers' attitudes from traditional ways of teaching towards adopting inquiry strategies and their successful implementation in the classroom. Within the face-to-face workshops teachers experienced and developed their inquiry based teaching strategies using specifically developed materials. In addition, the e-platform has been developed to provide on-line support. This platform provides educators and teachers with all the necessary materials for the training and IBSE teaching units and other teaching materials for teachers' ongoing help. The teacher training programme was successfully implemented in Slovakia. There were two runs of teacher training workshops on IBSE already carried out. Moreover, the additional element ICT in IBSE was developed more deeply designing a separate teacher training course for it. The contribution discusses in more details the success and problems of implementation in the context of Slovak educational environment.

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1. – Introduction

The main goal of ESTABLISH project has been the wide dissemination and use of inquiry-based education (IBSE) for second level students (aged 12–19) across Europe by bringing together, within a collaborative environment, the key stakeholders in science education. This goal has resulted in two main project outcomes: generating a suite of substantial teaching and learning materials (Units) and development of a series of educational supports for both in-service and pre-service teachers. The latter one involves development of Teacher Education Programmes (TEP) designed to promote the use of Inquiry-Based Science Education (IBSE) in classrooms across Europe. However, the challenge to develop and implement teacher education programmes in order to successfully implement IBSE in classrooms faces many obstacles. The background knowledge of inquiry varies greatly among teachers, as does the role of inquiry within the national curricula. Teachers as key elements of education are expected to change their methods of instruction towards more inquiry practices; however their strong beliefs and the way how they were educated can strongly influence their affection towards IBSE. Teachers' past education and the methods that they experienced during their own study can be strongly rooted in teachers' minds. Majority of teachers underwent traditional teaching based on transmission of knowledge rather than methods of instruction that are interactive and inquiry-based. One of the main project challenges has been to try to change teachers' beliefs and teaching strategies. As a result there has been a model for in-service and pre-service teacher training in IBSE developed and implemented.

2. – Teacher education programmes

The ESTABLISH consortium agreed to design a series of Teacher Education Programmes that have been developed around an agreed Framework for Teacher Education. The framework is based on four core elements as a minimum that all teacher programmes should include and four supporting elements that can be added to the programme optio-

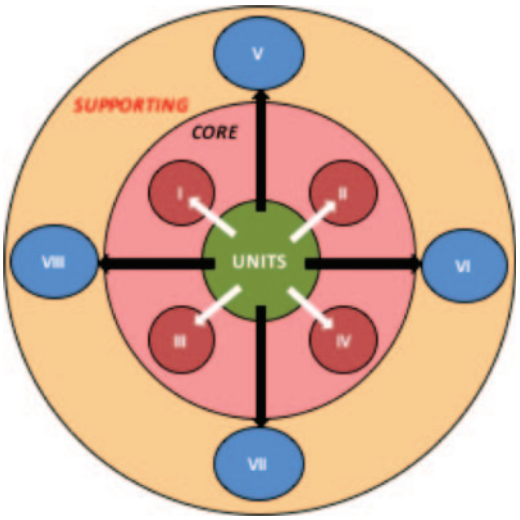

Fig. 1. – Framework for teacher education.

TABLE I. – *Elements of Teacher education programme.*

	Core/supporting	Element
I	Core	ESTABLISH view of IBSE – intro to IBSE
II	Core	Industrial content knowledge ICK
III	Core	Science teacher as Implementer – Management
IV	Core	Science teacher as Developer – Feedback, Evaluation
V	Supporting	ICT
VI	Supporting	Argumentation in the classroom
VII	Supporting	Research and design projects for students – Evaluating evidence
VIII	Supporting	Assessment of IBSE

nally with regard to the level of teachers' IBSE skills and current situation in education and teachers' professional development within the country (fig. 1, table I). The ESTABLISH framework calls for a programme of at least ten hours. However, overall duration may be dictated by the availability of participants and will also be decided influenced by the overall structure of the planned programme.

I. Introduction to IBSE

This short course presents a number of activities, scenarios and challenges to introduce IBSE. The main learning objectives of this part are to provide direct experience of inquiry, outline ESTABLISH view of inquiry and show benefits of learning by inquiry.

II. Industrial content knowledge (ICK)

This short course outlines a number of areas to show how the connection between science in the classroom and science in the real world can be strengthened, together with a number of activities to make science learning a more authentic and fruitful experience. The learning objectives are to encourage participants to be aware of the relevance and benefits of ICK in IBSE, appreciate the diversity and variation of ICK experiences and develop ICK for the inquiry lessons.

III. Science teacher as Implementer – Management

This short course should help to implement IBSE in the classroom using a number of activities and hints in order to:

– reflect on practice of inquiry within the classroom;

– become effective in asking/owning; managing/encouraging questions that can be investigated;

– design investigations that support analysing and interpreting data;

– find ways to help students to support their claims by generating/searching out evidence;

– manage and encourage communication within classroom;

– discuss different ways to perform an IBSE lesson;

– support the curiosity of students in the classroom.

IV. Science teacher as Developer – Feedback, Evaluation

This short course should help teachers in adapting or developing their own teaching materials once they reach the point of an advanced implementer of IBSE methods. In addition to the goals of the third element there are activities to:

– outline criteria for inquiry levels, recognising the different levels of inquiry available (from guided to open);

– design activities and develop lessons that are appropriate for the level of students' knowledge and curriculum content;

– demonstrate how to turn activities into inquiry;

– discuss which skills are needed for a teacher to scaffold inquiry;

– appreciate the variety of resources available online and in print media to source possible topics, scientific background etc.;

– appreciate the importance of giving time for reflection on self-developed inquiry lessons;

– outline and discuss classroom issues when teaching by inquiry;

– support colleagues to use IBSE in their own teaching and develop a community of practice to share experiences.

V. Information and Communication Technologies (ICT)

The aim of this element is to develop confidence and competence in the effective use of ICT in teaching and learning of science and in its appropriate use in inquiry-based teaching/learning.

VI. Argumentation in the classroom

This element addresses skills to develop and manage effective argumentation in the classroom.

VII. Research and design projects for students

This element is aimed at providing authentic experiences – address the development of these ideas, what aspects provide authenticity, student ownership and endorsement.

VIII. Assessment of IBSE

This element addresses assessment of many aspects of inquiry; how assessments can be changed to recognise the skills (cognitive, affective etc.) linked to IBSE.

It was envisaged that each country would implement elements I–IV in their in-service and pre-service science teacher education programmes but would incorporate elements V–VIII as required. The list of Support Elements is not exhaustive and may be added to, particularly for pre-service teachers, following experience of running these programmes. The elements of TEP are built around the units in physics, chemistry, biology and integrated science developed by ESTABLISH partners.

3. – Implementation of Teacher Education Programmes across partner countries

The ESTABLISH model of TEP was followed in participating countries in order to change teachers' attitudes from traditional ways of teaching towards adopting inquiry strategies and their successful implementation in the classroom. Within the face-to-face workshops teachers experienced and developed their inquiry based teaching strategies using specifically developed materials. In addition, the e-platform has been developed to provide on-line support. This platform provides educators and teachers with all the necessary materials for the training and IBSE teaching units and other teaching materials for teachers' ongoing help. In ESTABLISH partners have worked with teacher education in pre- and in-service programmes.

For TEP implementation there were common criteria agreed. Considering the extent of the education programme it was agreed that the minimum total time for in-service teacher training is 10 hours. It was strongly encouraged that the materials are trialled in real classroom. It was also recommended that training should be delivered over a minimum of three stages and minimum of two teachers per school should attend the workshops.

For pre-service teacher training the criteria were difficult to identify because of existing timetables for pre-service teachers. The workshops were recommended to integrate within the existing science education courses with particular module devoted to IBSE teaching. It was also encouraged implement IBSE in own teaching practice in the classrooms, or in microteaching sessions depending on the local conditions.

The number of teachers and students who have participated in programmes is shown in table II.

TABLE II. – *Number of in-service and pre-service teachers in teacher education programmes.*

Beneficiary	In-service teachers during 2011–13 Minimum criteria fulfilled	Additional in-service teachers during 2011–13 TEP shorter or lack of some Core Element	Pre-service teachers during 2011–13
Dublin City University	60	36	38 + 11 + 10
AG –Educational Services		17	0
University of Cyprus	67		33 + 29
University of Umeå	25 + 6 teacher educators	117	10 + 34
Jagiellonian University	52	150 on lectures	64
Charles University, Prague	80		50
Across Limits Malta	23		5
P.J.Šafárik University Košice	**50**	**40**	**17 + 8 + 5**
University of Tartu	59	6	8 + 15 + 5
Palermo University	57	200	17 + 26
Malmö University	59	19	20
IPN Kiel	2 + 30	146	25 + 15
CMA Amsterdam	29		27
Martin Luther University Halle	24	65	200 + 6

TABLE III. – *Elements of inquiry in science curriculum at upper secondary level, Slovakia in comparison with other countries (Cyprus, Czech Republic, Germany, Estonia, Ireland, Italy, Malta, Netherlands, Poland, Slovakia, Sweden). The elements are based on the definition of inquiry (Linn, Davis and Eylon 2004).*

Element of inquiry	CY	CZ	DE	EE	IE	IT	MT	NL	PL	**SK**	SE
Diagnose a problem		y	y	y		y	y	y	y	**y**	y
Critiquing experiment	y	y	y	y	y		y	y	y	**y**	y
Distinguishing alternatives		y	y	y		y		y	y	**y**	y
Planning investigations	y	y	y	y	y	y	y	y	y	**y**	y
Searching information	y	y	y	y	y	y		y	y	**y**	y
Constructing models		y	y	y		y		y			y
Debating with peers	y	y	y	y	y			y	y	**y**	y
Forming coherent arguments		y	y	y	y			y	y	**y**	y

4. – Case study from Slovakia

4˙1. *Background of the TEP implementation.* – The teacher education programme([1]) was successfully implemented in Slovakia. The implementation has reflected the specifities of the educational system:

– The existing system of continuous education of in-service teachers ensures a systematic approach to teachers' professional development guaranteed by Ministry of Education. Within this system teachers are awarded credits for completion of accredited teacher training courses or for successful defence of the so-called 1st or 2nd attestation thesis. Formally, teachers are allowed to take 5 days off per school year in order to participate at teacher education programmes.

– There is a long-term tradition of teacher education programmes offered by universities (teacher training faculties) or educational institutions for teachers to enrol.

– There is an educational reform running from 2008 across all levels of primary and secondary education. The reform strongly emphasizes students' active learning with implementation of elements of IBSE that is explicitly included in science curriculum (table III).

The background positive side is that the system of TEP running in Slovakia enables teachers to participate at educational courses without significant obstacles. Also, as it can be seen from table II, the current curriculum involves using IBSE teaching strategies. On the other hand, Slovak teachers are not educated in the field of IBSE and there are generally traditional methods based on transmission of knowledge used in teaching. There is also a lack of teaching materials for teachers to use and there are mainly old textbooks based on traditional approaches available at schools. This way, teachers are in a conflict between the necessity of the implementation of inquiry activities and no experience and no materials available for it.

([1]) Slovak national curriculum in physics for secondary schools, available on `www.statpedu.sk`.

TABLE IV. – *In-service teacher education programme in Slovakia.*

Session	Content
1st	Intro to IBSE, what is inquiry, hierarchy of inquiry activities, examples of good questions/problems to answer, discussion on current situation concerning the use of IBSE in classroom
2nd	Group work on selected activities at different levels of inquiry, (mainly lower level), stress on interactivity and feedback Analysis of performed activities from the point of view of inquiry skills
3rd	Group work on inquiry activities enhanced by ICT, how to implement IBSE
4th	Inquiry activities with emphasize on industrial link How to turn activity into more IBSE activity, preparation for units piloting for volunteers

4˙2. *TEP implementation and its scenario in Slovak context.* – The model of TEP designed by ESTABLISH project partners was successfully implemented with in-service and pre-service teachers.

For in-service teachers the complete designed model was used with 12 hours of life sessions with 50 participants, *i.e.* physics (19), chemistry (13) and biology (18) teachers. The course scenario followed the model involving the TEP four core elements together with ICT element (table IV). The elements were build around the existing teaching units developed within the ESTABLISH project that have been translated into Slovak and shared with teachers. Almost all of the participating teachers trialled selected activities in their own classroom. In addition, there was a single course on the role of ICT in IBSE developed in cooperation with CMA Amsterdam that has been successfully implemented with 39 participants (Ješková, *et al.* 2014).

From the original number of 50 teachers, 25 (12 physics, 7 biology and 6 chemistry teachers) of them followed on with the accredited course in blended learning environment with 40 hours of life sessions and 25 hours of distant learning. The course was supported by the Moodle e-learning platform. Each of the participant was obliged to develop his own IBSE activity on the selected level of inquiry keeping the ESTABLISH units format (involving materials for teachers as well as for students —worksheets, files for computer, etc.). Teachers' projects were presented at the final defence (15 minutes presentation followed by discussion) in front of 3-members board.

Pre-service teachers of biology (17), chemistry (8) and physics (5) participated in IBSE module within the regular science education courses with different number of lessons (biology: 16 lessons, chemistry: 10 lessons, physics: 12 lessons).

4˙3. *Results.* – All the 50 teachers enrolled in the course completed the 12-hours programme. In addition, 25 teachers out of 50 continued and finished the course in the extended format within the accredited teacher training programme. In-service teachers found inquiry teaching a rewarding experience. Based on their own experience with exemplary inquiry activities from the course teachers were highly motivated towards changes in teaching instruction. Majority of them implemented selected activities in their own classroom (fig. 2). For their final defence teachers were expected to develop their own inquiry activity that they did at good level with good understanding of what makes activity inquiry activity. However, based on observation of real lessons and videorecordings made during the lesson, it could be seen that teachers still lack the necessary skills for

Fig. 2. – Implementation of inquiry activities on sound in the classroom.

consistent application of IBSE methods in the classroom. Even after the training teachers tend to talk too much not letting students enough freedom and space to express their ideas and work on their own. The traditional methods are strongly rooted in teachers mind. The education programme motivated them towards wider use of IBSE methods; however they still need help in ongoing professional development to support the increased and correct use of IBSE in the classroom. The other important question is about the sustainability of their changing approach. Based on the interview and discussion with teachers it can be seen that teachers lack of support from the school management as well as from their colleagues. As a result, they usually remain alone in their efforts and this can lead to the loss of interest.

The course outcomes analysis resulted in general agreement on several steps that should be followed in order to provide teachers with ongoing help:

– Creating science teachers' teams with teachers educated in IBSE who can support each other within the school.

– Support in designing projects at teachers own schools aimed at innovative methods and their implementation.

– Influencing school management in order to make them supportive towards implementation of IBSE approach.

– Designing national projects on inquiry-based science education involving schools with groups of teachers of different subjects that will be educated together and implement IBSE activities regularly and systematically across several subjects. This resulted already in a national project with 6 participating schools involving physics, mathematics and informatics teachers (national project VEMIV 2013–16)([2]).

5. – Conclusion

One of the main outcomes of the ESTABLISH project is the existing model of teacher professional development. This model has been successfully implemented in all project partners' countries. In Slovakia, there were specific conditions for its implementation

([2]) National project VEMIV, available on `http://ufv.science.upjs.sk/_projekty/vemiv/`.

with respect to the current situation in the educational system. Nevertheless, the teacher education programme was successfully and effectively implemented and even developed into the existing accredited course. This course resulted in developing teachers' own IBSE activities with good understanding what IBSE means. On the other hand, there are still a lot of problems in appropriate implementation since the traditional approach methods are deeply rooted in teachers' attitudes towards students. However, the project ESTABLISH with its main outcomes (model of TEP, teaching and learning materials on IBSE) proved to be a very important milestone on the way towards changes in the Slovak classroom. Its key ideas have become not only the motivation and starting point for IBSE but also the important basis for the development of follow-up activities resulting in projects at national level that guarantee the continuation of the process towards successful implementation of IBSE approach in Slovakia.

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